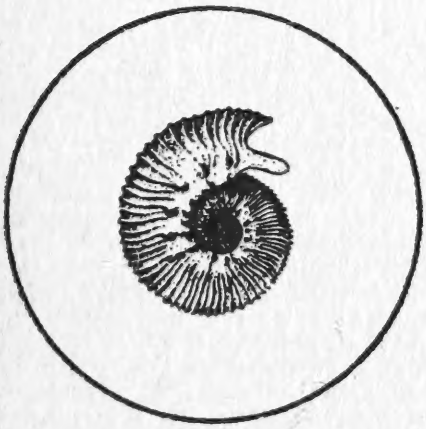
ANNUAL REPORT
1966-1967

MUSEUM OF COMPARATIVE ZOOLOGY

The Agassiz Museum



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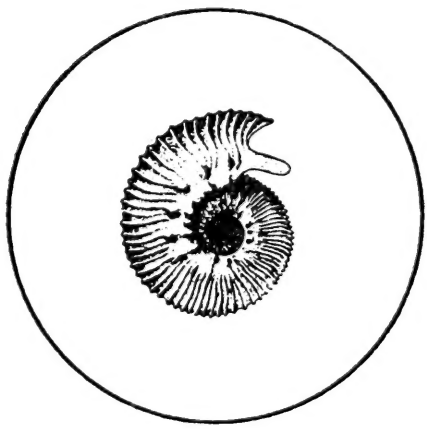

Kosmoceras, a Jurassic ammonite

HARVARD UNIVERSITY
CAMBRIDGE, MASSACHUSETTS
1968

MUSEUM OF COMPARATIVE ZOOLOGY

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MUSEUM OF COMPARATIVE ZOOLOGY

REPORT OF THE DIRECTOR

1966-1967

The amount of diversity in the living world is staggering. About one million species of animals have already been described, and estimates on the number of still undescribed living species range from three to ten million. An estimate of half a billion for the extinct species is consistent with the known facts. The branch of biology dealing with the describing and ordering of organic diversity is taxonomy, which is usually defined as the theory and practice of classifying organisms. Most of the research in taxonomy has been traditionally conducted in museums. Classical taxonomy was largely descriptive; but science is more than mere description—it attempts to explain by searching for underlying causes. As taxonomy has become more and more scientific, it has become increasingly an interpretive discipline. This broader and deeper approach has been designated as *systematics,* which Simpson has defined as "the scientific study of the kinds and diversity of organisms and of any and all relationships among them."

The modern systematist is interested in the origin of diversity. He investigates the changes in diversity through geological time and through geographical space. He knows that natural selection must be ultimately responsible for all its aspects, but he asks, for example, what factors of the environment are responsible for the richness of faunas in certain areas or for the extraordinarily rich development of such groups as the insects or bony fishes? All search for the causes of diversity must be based on facts, and it is evident that

descriptive taxonomy remains the solid basis for all interpretive theory. The need for sound taxonomic revisions remains as great as ever.

The study of the factors influencing diversity is a major concern of the working systematist. This includes the study of the species-specific behavior of animals; the study of interactions between species, whether competition, predation, or parasitism; the study of all the adaptations which permit an organism to live where it occurs; in short, it encompasses the entire range of areas broadly defined as systematics.

To carry out such studies successfully requires a far broader grasp of wide areas of biology than does purely descriptive taxonomy. The modern animal taxonomist must collaborate closely with botanists and with other biologists who are concerned with ecology, behavior, or other aspects of organismic biology. To give such collaboration visible expression, a *Center for Environmental and Behavioral Biology in the Faculty of Arts and Sciences* was established this year at Harvard. It brings together all those interested in these areas, whether they are in the Department of Biology or in the museums and other associated institutions. It is our hope that the Center will play an important role in curriculum planning, in making recommendations for future appointments, and in providing support for research in environmental and behavioral biology.

It is with great satisfaction that I can report the successful establishment of the Concord Field Station. The matching of the $150,000 grant from the Ford Foundation for land purchase was completed during this academic year, and the total of nearly 700 acres now belongs to the Field Station. Reconditioning of the Nike Site at Bedford as a field laboratory is far advanced, and the station is now occupied by investigators. Further financing will be necessary in order to permit the appointment of a resident director, but it is hoped that in the meantime temporary appointments will be possible.

It will be evident from this report that the Museum is advancing on many fronts. Our old building on Oxford Street is, however, unbelievably crowded and quite unsuited for many of the studies that are an indispensable part of modern systematics. Plans were begun several years ago for the construction of a new wing, paralleling the Hoffman Laboratory of the Department of Geological Sciences, to house various laboratories and to relieve the crowding in various departments; these plans are completed. The financing is in part assured; when it is completed, ground will be broken. The new wing is by far the most urgent current need of the Museum. Without it, we will not be able to maintain our leadership in systematic and evolutionary biology.

To broaden the base of the Museum's support from the community at large, an informal organization has been established, known as the Friends of the MCZ. We are particularly indebted for its formation to Mr. Herbert Pratt, a member of our Overseers Visiting Committee, whose enthusiasm and diligence are in large part responsible.

STAFF

After forty years of dedicated service, Dr. William J. Clench retired in August. Through his efforts as its Curator, the Museum's Mollusk Department has become one of the world's outstanding centers for malacological research; its collection is now one of the most extensive in this country. Dr. Clench's studies have been responsible for major advances in our knowledge of this important animal group, and, no longer burdened with administrative duties, he plans to pursue with undiminished enthusiasm his research on the systematics of the Mollusca.

We sadly record the death of Dr. Tilly Edinger, Honorary Associate in Vertebrate Paleontology. Miss Edinger was an internationally known paleoneurologist and had been associated with the Museum for more than twenty-five years.

Five new staff appointments were made this year. Ken-

neth J. Boss (A.B. Central Michigan University 1957, M.Sc. Michigan State University 1959, Ph.D. Harvard 1963) was appointed Assistant Curator of Mollusks; Henry F. Howden, of the Entomological Research Institute, Canadian Department of Agriculture, was an Alexander Agassiz Visiting Lecturer in Zoology; Vojislav Jovanovic (University of Belgrade, Yugoslavia) and Mary Jane West (University of Michigan) were appointed Research Fellows in Biology. Dr. Levi was promoted from Associate Curator to Curator in Arachnology.

Some of the awards and honors received by our staff merit special mention. Professor Mayr received an Honorary D.Sc. from Oxford University, England, and the Daniel Giraud Elliot Medal from the National Academy of Sciences; both he and Professor Simpson were among the recipients of the Verrill Medal from Yale University. Professor Simpson also received an Honorary Sc.D. from York University, Toronto, Canada, on the occasion of the first granting of degrees by this young university. Last November Dr. Romer received the Medal of the Paleontological Society; he was the first vertebrate paleontologist to receive this recently established award.

Various organizations, both national and international, have, as always, claimed the services of our staff members. To mention but a few of these: Professor Mayr served as President of the Society of Systematic Zoology, and was Chairman of the National Academy of Sciences' Panel on the Diversity of Life. He and Dr. Mead were appointed Honorary Research Associates of the Smithsonian Tropical Research Institute, Panama. Dr. Kummel has continued as Treasurer of the Paleontological Society; Dr. Lyman is a member of the Scientific Advisory Committee, Cape Cod National Seashore. Dr. Levi is a Councillor of the Society of Systematic Zoology and is Vice-President of the Centre International de Documentation Arachnologique. Dr. Paynter served on the Editorial Board of the Wilson Ornithologi-

cal Society. Dr. Romer retired in December as President of the American Association for the Advancement of Science, and is now Chairman of the Board of that organization.

More than thirty outside lectures were given by our staff members this year, in all parts of the United States, including Alaska, as well as in Canada, South America, Africa, and Europe.

The Museum has for some years sponsored weekly Natural History Seminars. Speakers at these lunch-time meetings this year included staff members and graduate students of the Museum, and guest speakers from other institutions, both from this country and from abroad. The talks ranged widely in content, including such diversified subjects as "The reproductive biology of pseudoscorpions," "Aspects of the evolution of behavior of sand wasps," "Population studies of Arctic shore birds," and "Paleoentomology in the Soviet Union, with irrelevant comments." (A complete list of these lectures is given in Appendix A of this report.)

TEACHING

Two new undergraduate courses were initiated and staffed by members of the Museum. *Biology of the Invertebrates* (Biology 10a), with Dr. Levi in charge and various staff members as guest lecturers, including Drs. Turner, Boss, and Evans, emphasized the structural, functional, and behavioral adaptations of invertebrates, and discussed parasitism and phylogeny. *Biology of the Vertebrates* (Biology 10b) was offered by Dr. Williams, again with assistance from Museum colleagues, including Drs. Lyman, Mayr, Mead, Patterson, and Paynter. Evolution, basic characters, ecology, behavior, population biology, speciation, and zoogeography were discussed in terms of vertebrates.

The *Biology of Fishes* (Biology 130) was taught again this year by Dr. Mead. A highlight of the course was the use of the spring recess for field work in Panama. Through the support of the Museum and certain of its friends, the entire

class collected specimens and made observations on the vastly different fish faunas of Atlantic and Pacific Panama. The material was subsequently studied during the final weeks of the course in Cambridge. The Smithsonian Tropical Research Institute in Panama was host to the group, and the participating professional biologists, equivalent in number to the undergraduate students, included invertebrate zoologists and botanists, as well as ichthyologists.

Dr. Fell again offered two undergraduate courses, *Biology of Marine Invertebrates* (Biology 122) and a freshman seminar on the *Biology of the Sea-Floor.* With the help of a National Science Foundation grant, new microscopes were purchased and a complete reorganization of aquarium facilities for teaching purposes was undertaken. Students were thus able to verify statements in their texts and to carry out much practical field and laboratory research in connection with their studies. Student participation in trawling at sea, begun last year, continued throughout this one, providing students with practical experience in offshore collecting methods.

Dr. J. Lawrence gave an informal course on the *Classification of Coleoptera* in the fall and spring terms. A brief history of ideas on the subject and a survey of the fossil record were followed by an examination of representatives of most of the beetle tribes and a study of the current literature. Emphasis was placed on recent developments in the classification of beetles and problems for future work.

Other courses offered or participated in by staff members included a *General Survey of the Invertebrates* (Fell, Kummel, Levi, Turner); *Biology of Insects* (Carpenter); *Biology of Amphibians and Reptiles* (Williams); *Evolution and Classification of the Insects* (Carpenter); *Biogeography of Animals* (Darlington, Fell, Mayr, Patterson, Simpson, Mead, Williams); *Principles of Evolutionary Biology* (Mayr, Simpson); *Introduction to Invertebrate Paleontology,* and *Stratigraphy* (Kummel); *Vertebrate Paleontology* (Patterson).

Graduate research courses were offered by Carpenter, Darlington, Evans, Fell, Kummel, B. Lawrence, Levi, Lyman, Mayr, Mead, Patterson, Paynter, Simpson, and Williams.

Of the thirty-nine students doing their basic research in the Museum this year, six were awarded the Ph.D. degree: Richard Coles, *Thermoregulation of the beaver;* Vida Kenk, *A revision of Brachidontes (Mollusca: Bivalvia)*; Basil Naf-paktitis, *Taxonomy and distribution of the lantern-fishes, genera Lobianchia and Diaphus, in the North Atlantic;* Charles Porter, *A systematic revision of the South American species of the genus Trachysphyrus Haliday (Hymenoptera: Ichneumonidae)*; Roy Smith, *Studies on the reproduction of two species of oviparous lizards from Costa Rica (Teiidae: Ameiva festiva, Ameiva quadrilineata)*; François Vuilleumier, *Speciation in high Andean birds.*

EXPEDITIONS AND TRAVEL

Field work is always an important part of the activities of staff and students, and this year was no exception. There were field trips to many places in the United States and several much farther afield. Dr. Kummel, for example, spent a month in Afghanistan, studying and collecting ammonites from Lower Triassic formations at Kotal-e-Tera, 90 km south of Kabul. Then, after attending the Pacific Science Congress in Tokyo, he spent two weeks visiting the major outcrop areas of Permian and Triassic strata in Japan. Dr. Turner's extensive travels took her on oceanographic research cruises from Bermuda to Woods Hole, and from Dakar, Senegal, to Recife, Brasil; she also participated in scuba investigations on offshore reefs in Puerto Rico, and maintained a program of research on the larval biology of *Teredo* and allied genera there. Dr. Evans took the second of a proposed series of collecting trips to the West Indies, leading to a monograph of the wasps of that area. This trip took him to Puerto Rico and the U.S. Virgin Islands, where an effort was made to recover

some of the species described by Fabricius, around 1800, which have not been recovered since; in this respect the trip was unsuccessful, but, as often happens, a number of unexpected records were obtained. Dr. Chickering was also in the West Indies, spending three months mainly in the Lesser Antilles. He returned with twenty-five to thirty thousand specimens of spiders, scorpions, and other animals! Dr. Mead accompanied the R/V *Anton Bruun* during her final cruise, from the Bartlett Deep in the northern Caribbean, to collect material for the Museum and for his course on the biology of fishes. Dr. Williams visited Barro Colorado Island and the tropical areas of Brasil. Emphasis was on the genus *Anolis* and on diverse vegetational types and associated faunas. Areas in and near Belém, Pará, and Manaus, Amazonas, were studied as representative of the eastern and western portions of the Amazonian forest, respectively. The Atlantic forest was examined at Sooretama in Espirito Santo and the characteristic highland savanna of central Brasil at Aruana on the Araguaia in Goias. Both live and preserved lizards were brought back for study. The trip was particularly valuable for its demonstration of the diversity of ecologies and faunas within the tropics.

George Gorman, a student of Dr. Williams's, completed his survey of the West Indies during the year, revisiting the Lesser Antilles but also completing his acquaintance with the Greater Antilles, all four of which he visited. The climax of his operations was a six weeks' study-tour of Cuba, during which he succeeded in obtaining material for study of the karyotypes of most Cuban species of anoles.

Collections in other museums and institutions, again both in the United States and abroad, were studied by both staff and students. One of the many who engaged in such research was Dr. Kummel, who examined the ammonite collections of the British Museum (Natural History) and the University of Copenhagen. A particularly interesting expedition was made by Dr. Carpenter. He first spent about three

weeks at the National Museum in Paris, finishing up illustrations of the Protorthoptera from the Commentry Shales. Then he went to Czechoslovakia, where he visited Paleozoic insect localities and studied the Permian insect collections at Charles University. The greater part of his summer he spent at the Institute of Paleontology at Moscow, examining the increasingly extensive collections of Mesozoic and Paleozoic insects from numerous localities in the Soviet Union. The visit was particularly valuable in that it enabled him to examine much material closely related to that found in Permian deposits of the United States. Ronald Baird, a student in Dr. Mead's group, examined hatchet fishes in sundry institutions in California, Hawaii, Tokyo, Bombay and Poona, India, Copenhagen, and London.

RESEARCH

Much of the research that is conducted in the Museum is of interest only to a limited number of specialists. As indispensable as is the revision of families and genera for our understanding of evolution, zoogeography, and indeed of numerous aspects of biology, such research does not provide material for interesting abstracts. A list of published taxonomic revisions is provided in the Bibliography at the end of this report. Here, the emphasis will be placed on findings of more general interest, particularly those which are unpublished.

Evolution

Almost all the research carried out in the Museum produces results of interest to the evolutionist. Perhaps the most spectacular discovery made during the past year was that of a fossil insect, from Cretaceous amber from New Jersey. This is the oldest known ant and and is, indeed, virtually a missing link between ants and wasps. These fossils were studied by Professors F. M. Carpenter and E. O. Wilson of Harvard, and W. L. Brown, Jr., of Cornell University. The

presence of worker characteristics in these insects demonstrates clearly the existence of social Hymenoptera as far back as about 100 million years.

In a study of some of the spider wasps (Pompilidae) collected by Charles C. Porter in Argentina last year, Dr. Evans discovered several examples of dual, sex-limited mimicry, a phenomenon that may be widespread and have considerable bearing on wasp systematics. Porter collected a series of wasps belonging to a complex of species of males unassociated with any females and unassigned to any genus. All species of this complex (five are known) have a color pattern strongly resembling that of certain social wasps, and (like a diverse assortment of other insects) are assumed to be mimics of these abundant, aggressive, stinging insects. Study of Porter's material indicated that the female must be a black-bodied, orange-winged wasp of the genus *Chirodamus.* Wasps with this color pattern occur in several genera and are regarded as "*Pepsis*-mimics"; that is, they are believed to mimic and to assume the aposematic coloration of tarantula hawks of the genus *Pepsis.* This instance of marked sexual dimorphism might be termed dual mimicry, since the males belong to one mimetic complex and the females to a very different one.

Recognition of this phenomenon in an Argentinian species led to further studies of other members of the complex, with the result that two more sex associations were made; in each case the male mimics a social wasp common within the range, and the female is a "*Pepsis*-mimic." These associations suggested a study of other genera containing several species known only from one sex, with the result that dual, sex-limited mimicry is now believed to occur in at least two other genera unrelated to *Chirodamus.* Examples of marked sexual dimorphism in certain other groups of wasps, notably the Scoliidae and Ichneumonidae, are probably also to be explained in this way. In each case in which this occurs, the female spends most of her life close to the soil, attacking

soil-inhabiting arthropods, while the males occur well above the ground and behave very differently—visiting flowers and honeydew and undertaking searching flights for females. These habitat differences are apparently sufficient to have caused divergence in color pattern, so that each sex resembles quite a different model which is strongly protected against predators.

Dr. J. Lawrence, in collaboration with Hans Reichardt, completed a revision of the interesting myrmecophilous (ant-associated) beetles in the family Ptinidae. This includes speculations on the origin of myrmecophily in these beetles, and a reclassification of the Australian species. Formerly, the 35 species of Australian myrmecophiles were placed in 14 genera, based primarily on a single character, the conformation of the antennae; utilization of additional characteristics leads to the recognition of only four genera. Dr. Lawrence concludes that at least five different lines have become associated with ants: two in the New World tropics, one in South Africa, one in the East Indies, and one or possibly two in Australia. The life with the ants has resulted in numerous interesting parallelisms within the Ptinidae and convergent developments between this family and other myrmecophilous beetles, such as the Paussidae and clavigerine Pselaphidae.

The discovery of several new specimens has enabled Dr. Simpson to start work on the evolution of an extinct family of South American marsupials, the Argyrolagidae. These animals have been so little known that until recently it was not even certain whether they were marsupials; they have been referred by various authors to three widely different orders of placental mammals. Apart from the mystery that surrounds their relationships, these little fossils are extraordinarily interesting because they represent an ecological specialization unique among marsupials or any other South American mammals, and convergently resembling the unrelated "kangaroo" rats of North America.

Dr. Eviatar Nevo, a post-doctoral Fellow working in the Museum under the sponsorship of the Committee on Evolutionary Biology, completed his monumental study of certain pipid frogs from the Cretaceous of Israel. In a thoroughgoing analysis, he traced the evolution of the family and endeavored to determine the significance of this family for our understanding of the early evolution of frogs. According to his interpretation, the strongly aquatic adaptations of pipids supports the assumption of a primary aquatic stage in frog evolution.

Behavior

The study of the living organism is a major concern of the modern systematist. Not only do behavioral attributes sometimes supply important taxonomic characters; the study of behavior also tells us much about the role of a species in the economy of nature, and comparative behavior studies reveal evolutionary trends and selective forces.

Dr. Levi's group has been successful in raising the peculiar *Sicarius* spiders in the laboratory. The observations of the behavior of these spiders, which bury themselves in sand in South America and Africa, will perhaps help to clarify their taxonomic position. While revising the genera *Argiope* and *Araneus,* Dr. Levi noted that a sclerite always breaks off during mating from the taxonomically important palpi and gets stuck in the female genital duct system. But males of *Argiope* lacking the sclerite are never found; this seems to support the hypothesis that they do not survive mating, but die during mating or shortly afterwards, thereby providing an immediate fresh food supply to the developing eggs. *Araneus* males lacking the sclerite are more commonly found; they probably survive mating. However, males with and without this sclerite have been described as different species. Numerous new questions have now been raised: How is the sperm transmitted—perhaps within the sclerite? Can males mate only once? Does the male sclerite match the female's

orifice? Is the detailed structure of the palpus, different in each species, of importance to mating success and of selective value? Though now largely abandoned, some aspects of the lock and key theory of genital armatures may have validity.

Fred Coyle, while making a film of antrodiaedid trap-door spiders, found that they carry sand grains between their jaws during the digging operations. This transportation of objects by these primitive spiders is, perhaps, a pre-adaptation to the labidognath functioning of the jaws (moving sideways against each other) of all higher spiders.

Robert Matthews (working with Dr. Evans), during his two-month stay in Costa Rica, made some quite new and unexpected discoveries with respect to the behavior of a small wasp of the family Sphecidae, actually an undescribed species of the genus *Microstigmus*. Wasps of this genus were known to attack springtails (Collembola) and to construct curious, pendant nests on the under side of leaves in the rain forest. Few details were known, however. Matthews found a large number of nests and made many observations on nest construction, provisioning, and defense. Furthermore, he found that both sexes of adult wasps occur in one nest, and the females appear to cooperate in certain aspects of nesting and brood rearing. This is one of the very few examples of subsociality occurring in Sphecidae, and, indeed, it is possible that these wasps are truly social (i.e., that one female assumes the role of egg-layer and the others feed larvae other than their own). Matthews hopes to clarify this point by dissecting females in various nest series to study the development of the ovaries and the presence or absence of sperms in the spermathecae. The *Microstigmus* is attacked by a braconid wasp, also of an undescribed species; this relationship is also unusual.

Dr. Turner, while observing living *Neoteredo reynii* (shipworms) at Cananeia, Brasil, discovered that the elaborately branched ciliated incurrent siphon acts as a filter-feeding

mechanism. This method of food gathering is unique for the Bivalvia, and was previously unrecorded.

Dr. Paynter made a special study of the very rare bunting *"Rhynchospiza" stolzmanni,* known only from a limited area of arid southern Ecuador and northern Peru; he had observed these birds during his recent field work in Ecuador. Although the species was discovered nearly a century ago, nothing was known about its biology. His studies led Dr. Paynter to conclude that it is actually a member of the genus *Aimophila,* which is otherwise represented by a number of species in the United States, Mexico, and northern Central America, and by a species isolated in northern Argentina. The strange isolation of the two South American species indicates that they are relicts of a formerly much wider distribution of the genus. *Aimophila stolzmanni* developed in its isolation a number of differences in size, proportion, and color pattern that set it apart from other members of the genus.

Ecology

Dr. J. Lawrence (with J. A. Powell) completed a study of the host relationships of North American fungus-feeding moths. Of the two families of moths involved, the Oecophoridae are probably general scavengers, whereas the Tineidae encountered in this study appear to be restricted to wood-rotting fungi. A few of the tineids, such as *Morophaga cryptopori,* are host-specific, but most of the species have broad host ranges and may occur on both whitish and brownish fungi, in contrast to the Ciidae. Even though these moths are not host-specific, they were found to be ecologically limited in other ways. *Nemapogon defectellus,* for example, occurs only in semi-arid regions, where it feeds on various polypore fungi growing on *Salix* and *Populus* along river beds.

Dr. Chesher, in his studies of the classification and variation of heart-urchins (Spatangoida), has found indications

that some of the features hitherto used in the classification of these animals may be subject to non-genetic modification by the environment. As a deep-sea diver of long experience and acquainted with a wide variety of underwater procedures, he was able to pursue his investigations by carrying out experiments on the sea floor itself, where these animals live. This entirely new approach in systematic studies may lead to a significant reappraisal of our understanding of the variation and classification of these animals.

Thomas Schoener, in Dr. Williams's group, has been working for some time on the significance of size differences within and between species in the lizard genus *Anolis*. Recent field studies on Grand Cayman Island have permitted him to show that sexual dimorphism in size in the species *Anolis conspersus* reflects differences in the size of perches utilized and size of insect food taken. Schoener and George Gorman completed a study of co-existing populations of *Anolis richardi* and *A. aeneus* on Grenada. The two species differ in dimensions, in size of insects taken, and subtly in habitat occupation within the same woodland. The difference in microhabitat is reflected in modal difference in the temperatures preferred by individuals of the two species, though taken at the same hour on neighboring trees.

W. Eberhard has been studying the preferential orientation of *Uloborus* spider webs in Arizona, analyzing the conditions that make the spiders prefer certain exposures. Factors appear to be wind, sun, and weather.

Zoogeography

Dr. Fell extended the biogeographic investigations reported last year, when attention was mainly given to developing a means of tracing former ocean currents and using these to plot former equators of the earth. The study was initially empirical, and involved tracing the distribution of related marine organisms across the globe, at various epochs, on the assumption that ocean currents were probably re-

sponsible for the distribution patterns noted. When sufficient data had been accumulated, it became possible to determine the nature of the relationship between the observed distributions and the current mechanisms which brought the dispersal patterns into existence. The observations showed that when a shelf-dwelling organism is accidentally carried to sea by a current, the subsequent journey which the organism performs (if it survives) can be predicted from the equations which determine the movement of water particles across the surface of a rotating sphere. In other words, if sufficient information is available on the trans-oceanic dispersal of shallow-water organisms, it can be analyzed statistically to disclose the equations of motion of the inorganic particles, whose movements produce the ocean currents. As these equations are a direct consequence of the rotational motion of the earth, the positions of the poles can be determined for various epochs in the past if the fossil record is appropriately investigated.

The program of study was then reorganized, to make use of the computer facilities available at Harvard, enabling more exact statistical treatment of the data. The results of this inquiry disclose no evidence of change in the positions or sizes of the continents or oceans over the past 600 million years, but there is abundant evidence that the poles of rotation have changed. The pattern of the motion of the poles proves to be complex, with cyclic variation in the rate of movement and the direction of movement. A mathematical study of the wandering of the poles has led to the conclusion that the rotational axis is slowly precessing westward around an axis of symmetry of mass of the earth. A period of 1500 million years is required for one revolution. Each cycle contains about five subsidiary cycles of 300 million years, in the course of each of which the rotational axis performs a rhythmic swing towards and away from the axis of symmetry. Characteristics of the curve disclosed by its rhythmic to-and-fro motions enable the cause of the

precession to be traced to tidal stresses produced by the moon and the sun, these stresses having a 300-million-year variation in intensity, as can be determined from growth characteristics of fossil corals.

An unexpected result of the inquiry was the finding that all three of the known glacial epochs, recorded in the past 600 million years of the fossil record, have coincided with epochs when the lunisolar torque was undergoing maximum rate of change towards its minimum value, and when the rotational poles were nearly stationary and deflected towards the axis of symmetry of the earth. These facts seem to indicate that a significant part of the earth's surface heat comes from the interior of the planet, and that tidal forces are partly responsible for the flow patterns of the molten materials beneath the crust. It appears that epochs of high surface temperature occur when the tidal cycle is changing most rapidly towards its maximum torque (or braking) value. Thus, climate would seem to follow a 300 million year cycle of waxing and waning temperatures, in sympathy with the tidal cycle of the same period, and always keeping a constant relationship to the pattern of movement of the poles of rotation.

A theoretical treatment of these inferred cyclic phenomena has been prepared by Dr. Fell and will be published shortly. A more detailed analysis of the problems of population dynamics in an oceanic environment, and their relationship to the astronomical factors which determine the orientation of the earth in space and hence the pattern of oceanic flow, is now in process of development and is planned for publication in book form. The central thesis of the study is that organic entities are subject to the same physical laws that determine the predictable motions of inorganic particles in a gravitational field and, given the appropriate equations of motion, the former distribution patterns of extinct marine animals automatically demonstrate

the changes in orientation of the earth in space and the changes in the orbit of the moon.

Many taxonomic studies conducted in the Museum have resulted in new insights into causes for the distribution of animals. A number of new species of the wood-boring mollusk genus *Xylophaga* from deep-sea stations throughout the world led Dr. Turner to conclude that unlike the shipworms (Teredinidae), the Xylophaginae tend to possess relatively poor powers of dispersal and therefore are more easily isolated, with the result that genetically and morphologically distinct populations are formed. Species of *Xylophaga* are in direct competition with the teredinids for wood in the sea, and Dr. Turner's studies have shown that *Xylophaga* occur in the sublittoral zones in the colder waters of the higher latitudes, where teredinids are less abundant. This type of distribution also agrees with the tropical submergence exhibited by other groups of marine invertebrates. In addition, field work on board the R/V *Atlantis II* again indicated that the paucity of wood in the deep sea is an important factor in the discontinuous distribution of some species of *Xylophaga.*

Dr. Boss, in his studies of the marine clams of the family Tellinidae in South African waters, discovered distinct zoogeographic affinities between the species living on the southern end of that continent and those now living in the Great Australian Bight and New Zealand.

Dr. Williams continued his taxonomic analysis of the lizard genus *Anolis* in the endeavor to elucidate the path of colonization and patterns of differentiation. Recent work on South American species sheds new light on the history of the South American segment of this genus. Thus, a new species, *Anolis chocorum,* described primarily from Darien specimens, is of interest as a rare example of a species of one of the truly South American endemic groups extending even a small way into Central America. The more usual pattern

is a widespread invasion of Central American anole groups into South America.

Anolis transversalis, a species related to *A. chocorum*, showed a characteristic South American pattern. A forest lizard of western Amazonia, its differentiation and history are apparently correlated with former cycles of dry and wet climates which broke the Amazonian forest into fragments and then reunited it.

The converse of the history of the forest anoles is found in the grass anoles. Two species of ultimate Central American origin, *Anolis auratus* and *A. meridionalis*, appear to represent successive invasions into Amazonia during dry periods. *Anolis meridionalis*, now well south of Amazonia, represents an earlier invasion. *Anolis auratus*, which, in addition to its more extensive areas of occurrence in Panama, Colombia, Ecuador, and Venezuela, has populations in isolated grasslands near the Amazon itself, is a much more recent invader, whose once continuous or nearly continuous range has been broken up by a resurgence of the Amazonian forest.

Dr. Kummel brought to completion his remarkable analysis of the complete ammonite fauna of the world in a single subdivision of the geological time scale. A study of all collected taxa of ammonoids for the uppermost zone of the Scythian (Lower Triassic) shows that the total fauna consists of 65 genera and 155 species. The Tethyan region contains 57 genera, of which 24 are endemic to that region. The eastern and western Pacific realms (localities between 60° N and 50° S latitude) contain 25 genera each, and each has only two endemic genera. The fauna of the circum-Arctic region for this zone is represented by only 16 genera, of which two are endemic. The geographical distribution of species reflects much the same pattern. The data suggest a true diversity gradient, most probably reflecting a latitudinal change in climate. With due consideration to factors of preservation, collecting, etc., the faunas of the Tethyan region are rich in numbers of individuals as well as in species; the

Arctic region, on the other hand, is poor both in number of specimens and in species.

The foregoing data support the thesis of continental and oceanic permanence for this short segment of time. The various reconstructions of the earth's past geography advocating continental drift or wandering are inconsistent with these data.

Physiology and Biochemistry

Dr. Lyman continued his research on the hibernation of mammals. Recent findings indicate that a hibernating mammal is not at all like a chilled, cold-blooded vertebrate, but remains in remarkably delicate physiological balance. It is extremely sensitive to certain external stimuli. If the fur is touched, even only lightly, the animal responds with a burst of muscular activity, similar to shivering, and the heart accelerates. If the stimulus is continued, the complex process of arousal begins, and the animal returns, within two to four hours, to the active state. Intra-arterial infusion of very small amounts of various chemicals, particularly the neuromuscular transmitting substance acetylcholine, causes a similar reaction. Dr. Tashima, working in Dr. Lyman's laboratory, demonstrated that carbohydrate metabolism is markedly different during hibernation than during arousal.

Dr. C. R. Taylor, financed by a grant from the National Institutes of Health to the Museum, is bringing to an end a four-year study of the metabolism of East African ungulates. He has focussed his attention on the diversity of physiological responses by animals of different sizes and from different habitats. He compared kidney function in species from well-watered and from arid habitats, and the correlation of intestinal length with the digestive ability of various species. This work is of more than purely academic interest, considering the importance of these native ungulates for the nutrition of African peoples.

Dr. Coles, also in Dr. Lyman's group, completed his work

on thermoregulation in the beaver, and in particular, the role of the tail in this regulation. Beavers are unable to lose much heat from their bodies because of their heavy fur cover; when they are exposed to heat, the naked tail is the main avenue of heat loss. When they are exposed to cold, however, little heat is lost from the tail, due to a countercurrent heat exchange system among the arteries and veins.

Roy Smith, of Dr. Williams's group, studied the reproductive physiology of two Costa Rican lizards of the genus *Ameiva*, both experimentally and in the field. He was able to show that even in these tropical lizards, fat bodies are needed as energy reserves, since during rainy periods these thermally demanding animals are quite inactive.

Taxonomy

As always, taxonomy has played an important role in the research of nearly all staff members. Dr. Darlington completed the last major part of his *Carabid Beetles of New Guinea*, covering 87 genera and 336 species. This one single beetle family alone has about as many species in New Guinea as does the whole class of birds, and no one knows how many more species remain to be discovered. Dr. Darlington also completed a manuscript on the Carabidae of Micronesia. These small islands have but few endemics, although there is a remarkably distinct genus on Ponape Island. Some of the geographic patterns of the man-dispersed species are surprising and informative. For example, one small fossorial carabid, *Clivina fasciata* Putzeys, is native in Mexico and is common there, but occurs also on Guam and on several islands in the Philippines. It was probably carried by the old Spanish galleons, which made the run from Mexico to Guam and the Philippines over a period of 250 years or so, as described by Merrill in *The Botany of Cook's Voyages*. It might have been carried in earth with sweet potatoes. Another Central American species, *Selenophorus pyritosus* Dejean, is now known from Tahiti and one or two other

islands in that part of the central Pacific, and from Guam. It too may have been carried by the Spaniards. In the other direction, a small carabid that Dr. Darlington described many years ago from the Dominican Republic in the West Indies, but which has turned up in New Guinea and is probably actually native there, has now been found also on Guam, the Palau Islands, Yap Island, Kusaie Atoll, the Marshall Islands, and the Gilbert Islands. This species is *Tachys yunax* Darlington. It is probably somehow associated with wood—the long series taken in the Dominican Republic were all found at one place in masses of wood debris thrown up at the mouth of a river—and it seems likely that the species has been carried from the Indo-Australian region across the Pacific and to America in wood.

Dr. Carpenter's most recent study on the Lower Permian insects of Kansas deals with the Permian Thysanura, formerly thought to comprise a distinct order, Monura. It now turns out that these Permian Thysanura are very similar to the nymphal stages of the members of the living family Machilidae. The complete absence of cerci in the early nymphal stages of the Machilidae and in the Paleozoic Thysanura, so far as is known, points to the conclusion that the cerci were developed in the insects independently of those present in other classes of arthropods, such as the Symphyla.

In a study on Carboniferous insects from various North American deposits, Dr. Carpenter examined the type specimens of several species which formed the basis of new orders established by Handlirsch. In the light of the greatly increased knowledge of Paleozoic insects, it is now evident that the majority of these orders are more closely related to living orders or other extinct orders than was realized by Handlirsch, and do not deserve recognition as distinct taxa.

Merrill Foster is rapidly making the MCZ a center for the study of modern brachiopods. On Cruise XXVII of the USNS *Eltanin* to the Ross Sea, Foster collected and preserved approximately 10,000 specimens of brachiopods. To the best

of our knowledge, this represents the largest number of brachiopods collected on an oceanographic expedition. The fauna includes 11 genera and approximately 13 species, and the study of this material should result in a significant contribution to our knowledge of the Brachiopoda.

Dr. Turner discovered a remarkable new genus of Xylophaginae from deep-water test panels. The two new species of this genus are long, wormlike animals with calcareous tubes, and are strikingly shipworm-like in appearance. This has necessitated a redescription of the family Pholadidae and a re-examination of the fossil record. She is also studying the anatomy of some new species of deep-water giant clams of the genus *Vesicomya*, taken in the Caribbean by research vessels of the University of Miami and the Department of the Interior. The relationships of these organisms with the better known families from shallow water are not yet understood. Preliminary embryological and chromosomal studies of species of Teredinidae and Pholadidae in Puerto Rico show promise that cytological characteristics may prove useful in determining the evolutionary relationships of these two aberrant families.

Dr. J. Lawrence is completing a series of revisionary papers on North American fungus beetles (Ciidae). One paper in this series deals with host preference in these beetles. Dr. Lawrence has analyzed about 1700 host records, representing 100 species of fungi and 80 species of Ciidae, showing to what extent the evolution of the beetles parallels that of their relationship to the host fungi.

Mr. P. San Martín from Montevideo, while working here for two months, found a new subfamily of tiny buthid scorpions in the Chickering Antillean collection. Another species belonging to the same new subfamily has since been reported from Trinidad. The scorpion family Buthidae contains all the poisonous species; as far as is known, the other five families of scorpions are all nonvenomous.

Allen Greer, in Dr. Williams's group, has made significant

contributions to the classification of the large and difficult lizard family Scincidae. Using a combination of external and skull characters, he has been able to propose a new and better-documented division into subfamilies. Similarly, a combination of various characters has permitted a clarification of the relationships of numerous Australian species, some of which had previously been placed in artificial genera based on single character differences. Mr. Greer's study of the collections made by Fred Parker in New Guinea and the northern Solomon Islands has resulted in the description of numerous new species, some of them with highly peculiar characteristics. Among the new characters employed in skink taxonomy are some that are non-morphological; Greer has found reproductive data especially valuable. For example, the number of eggs or young in a clutch is constant and therefore diagnostic in some skink groups; in others, clutch size is variable but is positively correlated with the size of the mother. In a survey of reproductive habits in the Anguidae, he showed that the mode of reproduction is sometimes directly adaptive, and in other cases it is a good indicator of phylogenetic relationship.

With Richard Highton and Donald Cooper, Dr. Williams has finished a paper on the color phases of the salamander *Plethodon cinereus* on Long Island. In this peripheral region, this usually polymorphic species shows, over extensive areas, only one or the other of the two color phases which, moreover, tend to coincide with different forest types. In these apparently pure areas, vertebral number is strongly correlated with the particular color phase, whereas it tends to vary almost randomly in the remainder of the species range. A hypothesis of Pleistocene isolation of the Long Island populations of *Plethodon cinereus* and of strong selection and genetic reorganization of these populations is presented.

Dr. Williams, with Archie Carr and Alice Grandison, has redescribed the sea turtle *Chelonia depressa*, a strongly differentiated green turtle population apparently restricted to

The proximity of Boston harbor offers our students frequent opportunities to gain an acquaintance with practical oceanographic methods. A freshly trawled sample of the bottom fauna and flora is here seen on the deck of the *Salvatore*, as sorting begins. (Photo J. H. Dearborn.)

Dr. Kummel and colleagues collecting ammonites in East Greenland, summer, 1967. 74° North Latitude. (Photo, V. Kohler.)

waters off the north and northeast coasts of Australia. The green turtle complex tends to show well-marked local breeding sites persistently revisited, and consequently tends to break up into more or less well-defined local breeding populations that show some degree of morphological difference. *Chelonia depressa* is the most differentiated of these populations, having probably reached species level.

George Gorman brought major aspects of his work on Antillean *Anolis* to completion during the year. His results illuminate a good many parts of the history and taxonomy of this group of lizards. Using modern biochemical and cytological techniques, he has been able to sort out rather definitively the relationships, colonization routes, and evolutionary history of the Lesser Antillean *Anolis*. The species of this area, which had proved confusingly similar on the basis of external morphology, were demonstrated by karyotypes and lactodehydrogenase electrophoresis to be separable into two major very distinct groups and several well-defined subgroups. The species on the northern Lesser Antilles (the Leeward Islands) were found to be connected, by species with intermediate karyotypes on Puerto Rico and St. Croix, with more primitive species also on Puerto Rico. On that island, all the successive steps in the origin of the very modified karyotypes of the Leeward species could be found, and there was even a parallel karyotype radiation within Puerto Rico, differing in minor cytological features. On this evidence, it is possible to show with a clarity not at all possible on external morphology that the Leeward Islands must have been colonized from the north and were, in fact (the additional biochemical evidence indicates), so colonized twice. The terminal (most southerly) species of the sequence is the most specialized karyotypically.

The anoles of the southern Lesser Antillean Islands were even more elaborately studied by Gorman, and he has been able to show by the congruence of karyotypic, biochemical and behavioral evidence that the colonizations and evolu-

tionary sequences have been complex and cannot be explained in terms of either simple north-south or south-north movements.

Dr. Mayr investigated the generic classification of the Estrildidae, a group of Australian finches that are very popular as cage birds. Students of behavior, who have made an intensive study of the social and courtship behavior of these birds, have found so many species-specific peculiarities that they are inclined to place nearly every species in a different genus. This negates the role of the genus as a collective category. The task of the discerning taxonomist is to find an appropriate compromise between a classification that expresses all he knows about the distinctness of species and a classification that serves as a convenient information-retrieval system.

Dr. Mayr, with Dr. Lester Short of the American Museum, began an analysis of the sharpness of delimitation of species in North American birds. The question the two co-authors are investigating is: What difficulties occur in species delimitation when species are investigated over their entire geographic range and when their relations to their closest relatives are carefully considered? It turns out that the frequency of the difficulties is lower than might be expected and is decisively lower than for plant species. Most species taxa in birds are well defined.

General Biology

Dr. Simpson completed several theoretical papers having to do with the philosophy of science in general and of biology in particular. As pointed out in last year's report, "philosophy of science" has meant too often in the past "philosophy of physics." It is necessary to examine how far such a philosophy also applies to biology, a vastly more complex field than physics and one including some quite different principles, and how, therefore, the philosophy of science must be modified to be valid for all of science, including biology. Fur-

thermore, within biology there are conceptual differences between reductionists (generally molecular biologists) and compositionists (generally evolutionary biologists). An effort must be made to achieve the increasingly necessary reconciliation and synthesis of these two schools. Dr. Simpson also collaborated in the preparation of a first abridged and second revised version of Simpson and Beck's *Life, An Introduction to the Study of Biology.*

Dr. Mayr continued his interest in the history of ideas. During the past year he began to analyze Humboldt's contributions to biogeography and, in particular, his ideas on the origin of the diversity of organic life. Humboldt was the most popular naturalist of his time, but his ideas have been largely ignored in recent years. Dr. Mayr also devoted much of his time to completing the revision of the Mayr, Linsley, Usinger textbook of systematic zoology. A renewed analysis was made of the various, sometimes contradictory, demands that are placed upon a classification, and on the best procedures by which to meet these demands.

PUBLICATIONS

During this year approximately 132 publications were authored by the Museum staff and students (totalling some 1640 pages, exclusive of books). Of this number, about 100 were reports of completed research; there were 17 reviews of books, and several articles of either a more general or a popular nature. The third, and very extensively revised, edition of Dr. Romer's *Vertebrate Paleontology* was published by the University of Chicago Press; Harvard University Press published Dr. Evans's new book, *The Comparative Ethology and Evolution of the Sand Wasps.*

Eleven numbers of the MCZ *Bulletin* were published, totalling 703 pages, and there were 28 numbers of *Breviora,* with 407 pages. There were three numbers of *Occasional Papers on Mollusks,* one of *Johnsonia,* and four MCZ-sponsored papers in *Psyche.*

Details of all publications are recorded in the Bibliography at the end of this report.

COLLECTIONS

The year saw a large expansion and improvement in the Insect Department's collection of parasitic Hymenoptera. This group presents a major frontier in biology: recent revisions indicate that fewer than half the temperate-zone species have been described, fewer than a fourth of the tropical species. Knowledge of the life histories and behavior of these insects is on a very rudimentary level, yet it is evident that they play an exceedingly important role in nature in controlling populations of leaf-feeding insects. More and more students are being attracted to this group; it is essential that there be still further expansion of the MCZ collection. The Ichneumonidae are being rearranged by Charles Porter, who has made large additions from his own collecting.

The Mollusk Department received a collection of more than 16,000 Florida tree snails of the genus *Liguus* through the generosity of Mrs. Henry G. Frampton. Most of these were obtained between 1930 and 1935, and more than half could not now be duplicated, since the localities from which they were collected have since been destroyed. The Department was also given, by Mr. Arthur Merrill of the Bureau of Commercial Fisheries Biological Laboratory at Oxford, Maryland, over 500 lots of material collected from buoys along the Middle Atlantic seaboard.

In the Department of Marine Invertebrates, work this year was concentrated on relabelling and rearranging the Asteroidea and Echinoidea, in accordance with the new classification employed in the Treatise on Invertebrate Paleontology; a start was made on rearranging the scleractinian corals, also in accordance with the Treatise classification. New collections include materials from Madagascar, Panama, and the Massachusetts Bay shelf.

The remainder of the fossil reptile collection made by Dr.

Romer in the Triassic Chañares Formation of Argentina arrived in Cambridge in December. The Preparation Department has been hard at work making a partial preparation of the entire suite of more than 200 skulls, as well as considerable skeletal material, in order to survey the extent of the fauna present.

Large collections were made on the final cruise of the R/V *Anton Bruun*, from the deep-sea Caribbean and the tropical shelf off the Tortugas; collections were also made from the Atlantic and Pacific coasts of Panama and the fresh waters of the Canal Zone; from York River, Virginia; and from fresh waters in Brasil. Eight hundred lots of fishes were added to the collection.

The skin collections in the Bird Department were increased by 1800 specimens from Ecuador, 55 specimens from Russia, and miscellaneous lots of about 100 birds. Nearly 200 skeletal specimens were prepared and catalogued.

Additions to the collections of the Department of Reptiles and Amphibians again came from all over the world. Most important were the contributions of Fred Parker from New Guinea, of C. M. Fugler from Ecuador, of A. Schwartz and R. Thomas from the West Indies, and of E. Nevo, who donated the *Acris* material from the entire eastern United States on which his study of that genus is based. Additional material came from Afghanistan, Brasil, Chile, Cuba, Florida, Kashmir, Kenya, Panama, Rhodesia, Trinidad, etc. Exchanges of material were completed with Brigham Young University, the University of Kansas, the California Academy, the Transvaal, British, Australian, Stockholm, and Berlin museums.

VISITORS

As always, the Museum has served as host to many visitors. Our research collections are among the oldest and largest in the country and are particularly rich in types. Several hundred specialists have worked in the Museum during the past

year, their stays extending from one day to several months. In order to accommodate our graduate students, post-doctoral fellows, and short- and long-term visitors, it has been necessary in several departments to make use of even the last square foot of working space. Without the proposed new building, it will be quite impossible to take care of the ever-increasing number of visiting scientists.

LIBRARY

The Library card catalogue is being printed in book form. There will be eight volumes, and an early publication date is scheduled. It will be an important bibliographic tool, and will also facilitate the coordination of activities in the several natural science libraries at Harvard.

Because of the pressing shortage of shelving space, books have been shifted on a large scale this year to gain space in the most essential areas. Two rooms, now used for shelving serials, have been renovated, with new flooring, new lights, etc. As a result, the most frequently used serials are now shelved in three adjacent, very pleasant rooms. This, perhaps, is part of the reason that there has been an increase in the number of readers in the Library and a decrease in the number of books taken out. If the trend continues, the seating capacity of the Library, barely adequate even after renovation, will have to be increased radically.

EXHIBITS AND MUSEUM SHOP

The work on the Holarctic Room is now 80 per cent complete. All the cases were repainted, new lighting was installed, and the specimens were cleaned this year; in addition, several hundred labels were written for specimens in this room and the African Room. The large coelacanth, given to the Museum last year by Dr. Bigelow, was placed on exhibit.

The Museum Shop again made a small gain in its gross income, and so has continued to support modest improve-

ments and expansion of the exhibits. In the interests of further expansion, we are anxious to know of anyone going on safari or on any other distant expedition who might be able to obtain for the Museum new specimens or replacements for some of our older ones. This method or replenishing and expanding exhibits has been notably successful in other museums, and can prove financially advantageous both to the MCZ and to the donors.

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ERNST MAYR, *Director*

PUBLICATIONS FOR THE YEAR

1966-1967

BULLETIN

Vol. 134

No. 10. The Lower Triassic formations of the Salt Range and Trans-Indus Ranges, West Pakistan. By Bernhard Kummel. Pp. 361-429. 22 figs. 4 pls. 19 August 1966.

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No.1. The postcranial skeleton of the giant Permian pelycosaur *Cotylorhynchus romeri*. By J. Willis Stovall, Llewellyn I. Price, and Alfred Sherwood Romer. Pp. 1-30. 17 figs. 22 September 1966.

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No. 4. A review of the Mesochrysinae and Nothochrysinae (Neuroptera: Chrysopidae). By Phillip A. Adams. Pp. 215-238. 42 figs. 24 February 1967.

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No. 45. The subfamily Tellininae in the Western Atlantic. The genus *Tellina* (Part I). By K. J. Boss. Pp. 217-272. 15 pls. 31 October 1966.

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No. 36. William Gaillard Mazÿck (1846-1942), with a bibliography and catalogue of his species. By W. J. Clench. Pp. 37-44. Pl. 14. February 1967.

No. 37. Notes on *Pleurobema collina* (Conrad) from the James River, Virginia. By K. J. Boss and W. J. Clench. Pp. 45-52. Pl. 15. February 1967.

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Appendix A

NATURAL HISTORY SEMINARS
ACADEMIC YEAR 1966-1967

September 28: Dr. Peter Weygoldt (First Zoological Institute, Free University of Berlin, and Duke University Marine Laboratory), *Reproductive Biology of Pseudoscorpions.*

October 5: Prof. Edward O. Wilson (Department of Biology, Harvard University), *Prospects for an Experimental Biogeography in the Florida Keys.*

October 19: Dr. Kenneth J. Boss (Museum of Comparative Zoology), *Studies in the Systematics of Marine Clams.*

October 26: Basil G. Nafpaktitis (Museum of Comparative Zoology), *Aspects of Oceanic Ichthyology.*

November 2: Prof. F. M. Carpenter (Biological Laboratories, Harvard University), *Paleoentomology in the Soviet Union, with Irrelevant Comments.*

November 9: Richard Vahan (New England Aquarium, Boston), *Manned Undersea Stations as a New Tool for Science.*

November 16: Vincent D. Roth (SW Research Station of the American Museum of Natural History, Portal, Arizona), *The Scientists' Shangrila, Chiricahua Mountains, Arizona.*

November 30: Prof. Charles Walcott (Department of Biology, Tufts University), *Airplane Tracking of Homing Pigeons.*

December 7: Dr. Howard E. Evans (Museum of Comparative Zoology), *Aspects of the Evolution of Behavior of Sand Wasps.*

December 14: Dr. Paul B. Kannowski (Biological Laboratories, Harvard University), *Flight Behavior of Ants.*

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