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THE MATAMEK CONFERENCE ON BIOLOGICAL CYCLES, 1931[1]

By Dr. ELLSWORTH HUNTINGTON
YALE UNIVERSITY

DURING the last week of July, 1931, a biological conference of exceptional interest was held at the mouth of the Matamek River. This place is on the north side of the Gulf of St. Lawrence, 300 miles east of Quebec. The conference was called by Mr. Copley Amory, of Boston, and all its members were his guests. For years Mr. Amory has been interested in the fact that sometimes the fish, birds and mammals of that part of Canada are very abundant, and sometimes, for no apparent reason, very scarce. He has seen years when the cod were extremely abundant, and other years when practically no fish were caught. Salmon and all the animal population vary in the same inexplicable way. Therefore, at his summer home on the Matamek, Mr. Amory brought together about thirty scientists and Canadian officials to consider the problem of fluctuations among wild life.

The conference began in Quebec where its members were tendered an official luncheon at the beautiful Falls of Montmorency. Honorable Hector LaFerté, Provincial Minister of Colonization, Game and Fisheries, presided, and twenty or thirty other officials were present. The Canadian government as well as that of the Province of Quebec was much interested in the conference. Not only did Dr. Charles Camsell, Administrator of the Department of Mines, act as chairman, but the Forestry Branch, National Parks Branch, Department of Fisheries, National Museum, and Dominion Observatory were all officially represented. The interest of the Canadians was also evident in the fact that the Lower St. Lawrence Trans-

[1] Report by Ellsworth Huntington, Yale University, in collaboration with an editorial committee and approved by the conference.

portation Company sent its ship, the *North Shore,* on two special trips of 160 miles each in order to carry the conferees free of charge between Rimouski and Matamek.

Fluctuations of all sizes and sorts were discussed. They included not only irregular fluctuations, but cycles with lengths of anywhere from 30 months up to 260 years or more. Such fluctuations occur in trees, insects, fish of the sea, fish of the rivers, game birds, birds of prey, mice, rabbits and a dozen different fur-bearing animals that prey upon their smaller neighbors. They also occur in the bacteria and other parasites which cause epidemics among animals and sweep them away by the millions. Reproduction, diseases and deaths among human beings also came in for discussion. Agricultural fluctuations and even financial panics were not neglected. A number of solar, lunar and meteorological cycles were suggested as causes of the cycles in plants, animals and man.

Somewhat to the surprise of the conference the main discussion did not center around the well-known sunspot cycle of eleven years, but around shorter cycles of four years and especially nine or ten. The four-year cycle was described by Dr. A. O. Gross, of Bowdoin College, as being well shown by the migrations of the snowy owl into New England. Mr. Charles Elton, of Oxford, England, described the same cycle in far northern mice, lemmings and Arctic ptarmigan, and also in the Arctic fox and snowy owl which feed upon these lesser types of animals. He stated that similar cycles occur in Britain, and also in Norway where lemming migrations have been known for hundreds of years. In still another region, Alberta, Prof. William Rowan, of the University of Alberta, has found a similar four-year cycle in mice and probably shrews.

The regular course of events seems to be that the mice, lemmings and ptarmigan increase enormously in numbers for a season or two. Foxes, owls and other creatures are thus provided with abundant food. They, too, increase so fast that the number of skins brought in to the Hudson's Bay Company may be many times as great at one phase of the cycle as at another. Then there comes a change so sudden that the members of the conference call it the "crash." The rodents and game birds begin to die by the thousand or million. Some of them, such as the lemming, also migrate long distances, only to meet death in some other region. The creatures that have been feeding on them soon become hungry. They, too, begin to die, or else migrate to even greater distances. Snowy owls, for example, are described by Dr. Blair, of the New York Zoological Society, and by Dr. Gross as moving from Canada to southern New England and New York by the thousand. They generally perish, for they do not appear to return north, and they can not breed so far south. A similar cycle of increase and sudden decrease was described by Mr. Aldo Leopold, of Wisconsin, as occurring among the red grouse of Scotland, but there the period is six years instead of four.

The most remarkable feature of the biological conference was the great amount of evidence as to a cycle of nine or ten years. Mr. Leopold described such a cycle among the grouse and rabbits of Wisconsin and neighboring lake states. In the United States as a whole his figures seem to show that the increase and sudden decrease of these same animals take more nearly ten years, but further work may show that the two periods are really the same. One most interesting feature of the grouse is that those which live in the central and most favorable habitats apparently do not suffer violent fluctuations in numbers. The sufferers are those on the edges, which happen also to be the parts less densely populated by man. The findings of Mr. Leopold are confirmed by those of Dr. Gross who has studied the grouse in its more eastern habitat. Among the rabbits of Canada, however, Mr. Elton finds no evidence that fluctuations are less marked in the central area than on the margins. In fact, the opposite may be true, but all Canada is marginal in the sense that it is subject to great extremes of climate.

From the other side of the continent Prof. Rowan, of the University of Alberta, presented evidence that in the plains around Edmonton a cycle of almost ten years is evident in grouse, some other non-migratory birds, and rabbits, and also in their enemies such as the coyote and other fur bearers. Farther north in Canada the voluminous records of the Hudson's Bay Company have given Mr. Elton abundant data which show a cycle of about ten years, or more exactly 9.7, in hares, muskrats, grouse, lynxes, red fox, marten, wolf, mink and goshawks. The extraordinary thing about all this is not merely that many different animals show the same periodicity, but that the same period occurs in the far northwest of Canada, and all the way south into the United States. The increase or decrease in the animal population appears to begin in the far north and to work its way southward and eastward, reaching southern Canada after about three years. In spite of this the period of ten years or a little less is constant in each region.

Still more astonishing are the results of Dr. A. G. Huntsman, of Toronto University, Prof. E. B. Phelps, of Columbia University, and Prof. D. L. Belding, of Boston University Medical School. Using the records of the commercial catch of salmon in the bays along the coast of New Brunswick, Dr. Huntsman found indications that the salmon come and go in periods of 9.6 years. Professors Phelps and Belding used the very careful records of the salmon caught by the members of the exclusive Ristigouche Club on the Ristigouche River in New Brunswick. Each fisherman there religiously records the weight and size of his fish and the number of days spent in fishing. Thus it is easy to calculate the daily number of fish per rod or angler for each of the last fifty years. There, too, the fish appear in great abundance every ten years, but sink to smaller numbers in the interim. Curiously enough it is not because large or small numbers are hatched in special years, although such may be the case. The greatest immediate cause of the change in numbers from year to year appears to be something which happens when the smolt, or young salmon, enter the sea.

From far away on the other side of the continent the measurement of the annual rings of growth in the giant sequoias of California, by Dr. Ellsworth Huntington, of Yale University, supplies still another type of evidence of this same cycle of about ten years. Thus once in ten years or less something seems to happen which causes an increase and then a decrease in the vital activities of both plants and animals. This occurs all over North America from the borders of Alaska to the Maritime Provinces and the northern United States, and also in the adjacent seas. Then, to complete the picture, Mr. Comsia, from Rumania, stated that he, too, has found some evidence of a ten-year cycle of disease in the rabbits not only of Canada, but possibly of Europe. The European disease is coccidiosis, which may turn out to be an important disease in Canada. Scraps of evidence, such as locust migrations, suggest that this same cycle prevails over still wider areas.

Most of the members of the conference expected that the sunspot cycle of 11.2 years would figure prominently at Matamek. Dr. H. Mayer-Wegelin, of the German Forestry School at Munden in Hanover, did indeed present evidence of an 11-year cycle in the growth of German trees. His colleague, Dr. H. S. Eidmann, showed that noxious insects which destroy the German trees have a cycle which is probably about 12 years. Mr. D. R. Cameron, of the Forestry Branch at Ottawa, pointed out that the increase of pests here and in Germany might be due to the influence of man in upsetting insect balance. Moreover, Mr. DeLury, of the Canadian Observatory at Ottawa, presented a large number of curves which seemed to show an 11-year cycle in tree-growth, agricultural production, the value of fish and the abundance of animals. Nevertheless, the more detailed studies presented by other members of the conference suggest that many of the 11- or 12-year cycles may fit equally closely into a cycle of between nine and ten years, averaging approximately 9.5.

One curious thing about this 9.5-year cycle is that while it can be detected in meteorological records, it has not been much studied there. Moreover, no basis for it, such as sunspots, has yet been found. Mr. DeLury pointed out that it is a little longer than the lunar cycle of 8.85 years and almost exactly half of another lunar cycle of 18.6 years. These two cycles of tidal activity may influence climate by stirring up the ocean waters, allowing cold water to come to the surface, and thus influencing atmospheric pressure and storms. This is not clear, however, and the conference felt that much more evidence was necessary before so seemingly minor a cause could logically be connected with such great events.

The magnitude of the action of these cycles is still more evidence from certain facts pointed out by Dr. Huntington. He showed that the most distinct cycle of droughts and of agricultural productivity in the United States has a period of 18.6 years if measured by the five cycles between 1837 and 1930. Moreover, during that same time there have been six financial panics separated by five average periods of 18.4 years. The panics, curiously enough, go with the agricultural depressions, but may precede or follow them. This suggests that the panics and the droughts may owe something to a common cause, even though the agricultural depression resulting from the droughts may not be the immediate cause of the panics. The conference made no attempt to solve such problems as this. It was, however, impressed by the fact that droughts, panics and agricultural depression not only show greater regularity than the sunspot cycles, but seem to have a periodicity twice that of the very regular cycles found in sequoia trees, rabbits, grouse, foxes, salmon and many other animals.

The evidence as to still larger cycles is scanty, but this may be due mainly to the absence of long records. Dr. Eidmann thinks that the noxious insects in the forests of Germany wax and wane in cycles of about thirty years. Professor Rowan finds a cycle of 34 years in the ducks, crows, magpies and lake levels of Alberta. The Brückner cycle of 30 or more years is also found by Mr. DeLury in several series of meteorological data and in the growth of trees. The salmon statistics studied by Professor Huntsman seem to show a cycle of 48 years. Still longer cycles are suggested by the rings of growth of trees, but these fall beyond the scope of the present conference. So far as the length of cycles is concerned the results may be summed up as follows: There is fairly abundant evidence as to a four-year cycle, the length of which seems to be almost exactly four years. A cycle of six years is suggested but not confirmed. A cycle of between nine and ten years, on the other hand, is very strongly indicated. It is often called a ten-year cycle, but the most accurate determinations suggest that the true length is nearer nine and one-half years. A cycle of perhaps 18.6 years appears to be at least as widespread and definite as the four-year cycle. As to the larger cycles no data for gauging their importance were forthcoming at the conference.

The causes of cycles in animals appeared to the conference to be divided into three groups: biological, meteorological and astronomical. The first includes food, reproduction, parasitic insects and diseases, especially those of bacterial origin; the second, or meteorological group, needs no definition; the third group may be briefly discussed before we turn to the others. It was dealt with chiefly by Mr. DeLury. He holds that the chief causes of climatic variation are partly solar and partly lunar. The conference seemed to feel that while terrestrial climatic fluctuations are probably due to solar variations, such fluctuations are probably due to other astronomical causes as well as to the variations which manifest themselves as sunspots. One of the strongest impressions of the whole conference was that all sorts of cyclic phenomena must be controlled, though not necessarily caused, by some outside forces which dominate all forms of life. If these are solar forces, they manifest themselves as sunspots, prominences, faculae, the solar constant, electro-magnetic activity and perhaps still other phenomena. These presumably lead to both meteorological and organic phenomena on the earth. If lunar forces have any effect in producing cycles, they presumably act through the tides, which in turn give rise to oceanic currents and upheavals of cold water from below. These are supposed to alter the atmospheric pressure and thus cause winds, storms, rain and changes of temperature.

No one at the conference seemed to entertain much doubt that migrations of animals and variations in their numbers are often due to the food supply. Some of the most clear-cut examples are the migrations of the snowy owls when the supply of mice runs short after a period of great abundance. It is almost equally clear that the extraordinary variations in the numbers of rabbits, muskrats and other rodents from one extreme of the ten-year cycle to the other are one of the main causes for variations in the numbers of foxes, lynxes, mink and other fur-bearing animals. Mr. Elton's curves showing the numbers of skins of such animals brought in to the Hudson's Bay Company posts give good indication that the ups and downs of the furbearers follow closely on those of their prey, although the maximum number of the furs of carnivores is brought into the market a year after the maximum of rabbits. It was also made clear by various members of the conference that sea animals wander about in huge numbers in response to variations in their food supply. One of the most interesting of such wanderings is the migration of the sperm whales described by Dr. Charles Townsend of the New York Aquarium. The small crustaceans and other minute forms of life upon which these huge animals feed are abundant only in summer. Therefore, in order to obtain the barrels and barrels of food which form their meals, the whales each year wander back and forth over routes six to eight thousand miles long. During our summer they are in the northern hemisphere, and during the southern summer in the southern hemisphere.

Such annual migrations, however, were only an incidental feature of the discussions. The main interest in the wanderings of animals centered around those which recur at longer intervals. These generally represent great changes in the total number of living animals. But the fish of the sea, as Dr. Harry M. Kyle, of Glasgow, pointed out, show different phenomena from the animals of the land in this respect. Their numbers may vary enormously, but the fact that the fishermen do not catch the normal quantity of fish in any given year does not necessarily mean that there are fewer fish than usual in the sea. The ocean is so huge that the best food supply, or the best spawning grounds, may lead the fish to concentrate in parts of the ocean where there is commonly little fishing. Consequently the various conditions under which the fishermen do their work must be taken into account as well as the variable causes affecting the number of fish that hatch and survive. In other words, the optimum years for the fisheries are by no means necessarily the optimum years for the fish.

In spite of the importance of the food supply there appeared to be a strong feeling that other causes of variations in the numbers of animals deserve more attention than is commonly given them. One such cause is the rate of reproduction. Mr. Elton stated that the number of young snowshoe rabbits and other animals born in the average litter apparently tends to increase in certain years and to decrease when scarcity of food and other causes lead to a reduction in the number of animals. Dr. Huntington showed that even in man the rate of reproduction is very closely correlated with climatic conditions. A rapidly increasing race like the Japanese would decline in numbers if the relative rates of deaths and of conceptions resulting in living births stayed steadily at the levels of September when health and vigor are at a minimum. Professor Rowan presented experimental evidence suggesting that the same thing is true among birds. By altering the conditions of light and temperature he has induced birds to breed in midwinter. Dr. Kyle and Prof. Huntsman made it clear that reproduction in fish and other sea animals responds with equal readiness to changes in temperature.

One of the facts which the layman is only beginning to realize is the enormous number of parasitic worms and insects which infest most forms of animals, as well as plants. The importance of this in plants was explained by Dr. Eidmann in respect to the forests of Germany. He believes that the growth of trees is influenced quite as much by insects as by the climatic factors of temperature and rainfall. The insects themselves, however, are very closely dependent upon these same climatic factors. Thus the rate of growth of the trees is the composite result of the effect of climate upon the tree itself plus its effect upon the insects. Dr. Gross illustrated the same thing in respect to animals by means of the parasitic insects and worms which infest the organs of the grouse. Professor Rowan showed how the reverse effect is obtained by removing ticks or other infestations and allowing an infested animal to regain its strength.

In the production of cycles among animals an even greater part seems to be played by bacterial parasites and the diseases to which they lead than by the larger parasites. This was especially well illustrated by Professor R. G. Green, of the University of Minnesota, in his discussion of tularaemia, a disease of rabbits and grouse. He demonstrated clearly that during the last rabbit cycle in Minnesota the "crash" when the animals suddenly died off was due to a very virulent form of this bacterial disease. The disease is carried by ticks, which also infest grouse. Professor Green's findings have resulted in the theory that when the rabbit population begins to decline the tularaemia bacteria are extremely virulent, while the proportion of old and immune rabbits is very small. Hence millions of rabbits die, for the mortality is almost one hundred per cent. The ticks which they carry fall to the ground, but soon find new hosts in other rabbits and grouse, thus spreading the disease. For some unknown reason, however, the virulence of the tularaemia bacteria decreases rapidly. After the epidemic it becomes so low that as young are born from the surviving rabbits they do not die from the disease, but have a non-fatal form of the disease which makes them immune. Thus there arises a group of immune rabbits, some of which survive the next epidemic and carry on the race.

Another epizootic disease which received considerable attention was encephalitis in dogs, foxes and other fur-bearing animals. This disease, as was shown by Messrs. Green, Elton and Anderson, behaves somewhat like rabies, except that the affected animals do not bite. Here, unlike the case of tularaemia, we have a disease in which the resistance of the animal has a great effect in determining the occurrence and virulence of the disease. In tularaemia the parasitic bacteria are so virulent at the time of their main onset that practically all affected animals die no matter how strong they may have been. Such facts as this precipitated a lively discussion as to the relative importance of changes in the virulence of the parasites compared with changes in the degree of resistance of the host. The conclusion seems to be that there is no general rule. Under certain conditions and with certain diseases the power of a disease varies in close harmony with the general health of the animals which it attacks. Under other circumstances a more virulent parasite may be so strong that no animal can resist it. But all organisms from bacterial parasites to whales appear to pass through cycles of strength and weakness arising from the combined effects of food, conditions of reproduction, parasites and the immediate climatic environment.

The features of the climatic environment most frequently discussed at Matamek were naturally temperature and rainfall. Throughout the conference it was universally recognized that all forms of life have certain limits of temperature, and that between these limits lies an optimum or most favorable condition. According to Dr. Huntington this optimum in man varies not only with the age of the individual, but also from one function to another. Thus physical and mental activity have different optima of temperature. The optimum for reproduction may be still different, as was shown by Dr. Kyle and others. Rainfall was not much discussed, although its importance was frequently recognized in discussing the food supply.

Three other atmospheric conditions were also brought to the attention of the conference. One of these was ultra-violet light which was discussed mainly by Mr. DeLury and Professor Rowan. The latter explained to the conference certain very interesting experiments now in progress which seem to show that the effect of ultra-violet light upon reproduction in birds is striking.

On the basis of an extensive study of deaths Dr. Huntington presented evidence concerning the effect of the relative humidity of the atmosphere upon human health and activity. He also pointed out that variability of temperature in itself has an important effect apart from that of the actual temperature. In New York City, for example, a moderate degree of variability from one day to the next is distinctly the best condition. Very high variability, to be sure, is not so conducive to health as is moderate variability, but very low variability is still worse. In other words a climate with frequent storms of moderate severity is more healthful than one with uniform weather all the time. The conference seemed to feel that both relative humidity and variability of temperature are factors whose weight has not been fully recognized by biologists. Dr. Eidmann sustained this view by showing that among insects the effects of relative humidity and variability are almost the same as among men. In fact one of the outstanding features of the conference was the frequency with which one member or another emphasized the fact that in spite of minor differences the general reactions of men, animals and even plants to physical environment are essentially the same. Certain great laws seem to run all the way through the whole realm of life, and one result of the working of these laws is that cycles are very wide-spread phenomena.

The phenomena discussed by the conference included not only cycles due to external causes, but those of a purely biological nature. Thus Dr. Belding called special attention to the variable life history of the salmon with its river stage, oceanic stage and final stage of return to the rivers for spawning. The chief problem here is why the salmon vary in size, in age and in the length of their life cycle from one region to another and even from one river to its neighbor only a few miles away. Similar local and inexplicable variations are found in wholly different types of life such as the ticks described by Dr. Green. On one side of the Bitter Root River, ticks carry a highly virulent disease, while on the other side their virulence is far lower. When ticks are carried from one side of the river to the other they soon acquire the virulence characteristic of that side, no matter what may have been their previous condition.

The abundance of the cod, a truly oceanic fish, was shown by Dr. Kyle to follow laws which at first sight seem quite different from those governing the cycles so common in other creatures. Since each female cod lays from one to five million eggs per year the danger of exterminating the species or even diminishing it by fishing seems to be negligible. One of the most important features of certain fisheries, *e.g.*, herring and plaice, is that the animals are most abundant in the waters which have been most fully fished. Thus herring have been taken from the North Sea abundantly for 1,200 years. Yet to-day they are as abundant as ever, and perhaps more so. Dr. Kyle's explanation is that the fishing removes the old fish which consume much food, but nevertheless grow slowly. Where the fish are young, a given supply of food produces a maximum amount of growth and thus a maximum supply of food for man. From this standpoint fishing is like agriculture; that is, human activity leads to an optimum condition for man by reason of the rapid growth of the fish. Prof. J. R. Dymond, of the University of Toronto, stated that the same rule applies in the case of several fresh water fishes.

A general review of the mammals of the world, by Mr. H. E. Anthony, of the American Museum of Natural History of New York, illustrates some of the main conclusions of the conference as to the distribution of cycles. In a broad way the land mammals of the earth are at a minimum in the great tropical forests. There, too, so far as our present information goes, such animals are least subject to cycles. This may be because of the general scarcity of mammals in those areas, and also because the environment is so uniform that there is apparently little reason for great changes in numbers. Outside of such forests lie tropical regions where there is more grass and smaller trees. There the mammals increase greatly in numbers and we have such areas as the famous game regions of Africa. In such areas the number of animals is often incredibly large. As yet we have no definite evidence as to whether the fluctuation in numbers is correspondingly great, even though the variations from wet seasons to dry are extreme. In higher latitudes, as has already been implied, there are likewise certain rather steady areas such as the eastern United States where many animals live under conditions which approach the optimum and where extremely harmful variations in climate are comparatively rare. Thus in such regions the cycles in animal numbers are mild. In the marginal regions, however, such as the drier and colder parts of the continents, it requires only a slight departure of the climate from its normal condition to produce great changes in the food supply and in the conditions of reproduction and bacterial infection. Thus in those regions animals increase enormously at certain times and then decline with a crash. The same contrast between areas of relative uniformity and variability is perhaps seen in the cod, plaice and salmon. The cod and plaice, even though the fishermen can not find them, appear to be numerous at all times and may suffer relatively little from cyclic variations in numbers. This may be because they inhabit a relatively uniform region where the temperature and food supply vary but little. The salmon, on the contrary, because of its habit of coming to the rivers to spawn, occupies a marginal area. Not only is it subject to great variations in most of the conditions which control its numbers, but when the smolt pass from fresh water to the salt sea, they are subject to an environmental change unknown to the purely marine fish.

The conference closed with a general session on conservation and allied topics. Mr. D. R. Cameron added new strength to what he had previously said as to the importance of forest fires. Dr. Harrison F. Lewis, of the National Parks Branch at Ottawa, told about the Canadian game sanctuaries. Dr. Anderson drew attention to the importance of museum collections as a factor in cooperative field studies upon wild animals. It is useless to make observations upon wild animals if the species that is studied is not properly identified. The conference as a whole was strongly in favor of intelligent conservation. It was pointed out, however, that in some cases our conservation measures go so far that they defeat their own ends, as when deer ruin gardens or die for lack of food, or big fish eat the food that ought to be left for rapidly growing young fish, an eventuality unlikely to arise in the case of land animals. In other words, conservation, like almost everything else, has an optimum. Until the optimum is reached it is highly desirable, but beyond that it goes too far.

OBITUARY

CALVIN HENRY KAUFFMAN

CALVIN HENRY KAUFFMAN died at Ann Arbor, Michigan, on June 14, 1931, following a stroke of paralysis that occurred in February, 1930. He was born on March 10, 1869, near Lebanon, Pennsylvania, and received his preparatory training in a country school near Lebanon and at Palatinate College, Myerstown, Pennsylvania. In 1896 he graduated from Harvard University with the A.B. degree, specializing in Greek and Latin. From 1896 to 1898 he was principal of a preparatory school at Lebanon, Pennsylvania. He taught in a high school at Decatur, Indiana, from 1898 to 1900 and at Bushnell College, Bushnell, Illinois, from 1900 to 1901.

In 1901 he decided to take advanced training in science at the University of Wisconsin, specializing in chemistry and botany. Here he came under the influence of Professor R. A. Harper, who was responsible for definitely directing his interest in the field of mycology. The following two years (1902 to 1904) were spent as an assistant and graduate student with Professor G. F. Atkinson at Cornell University. Under Atkinson's influence his interest in the agarics was stimulated and developed. In 1904 he was appointed an instructor in the botany department at the University of Michigan, where he continued his graduate studies, stressing the physiological phases, receiving his Ph.D. degree in 1907, with a doctorate dissertation entitled "A Contribution to the Physiology of the Saprolegniaceae with Special Reference to the Variations of the Sexual Organs."[1]

The rest of his life was spent at the University of Michigan, where he developed courses and directed research in algae, mosses and ferns, mycology and forest pathology. He was advanced to the rank of assistant professor in 1912 and associate professor in 1920. In 1921 he was made director of the University Herbarium and in 1923 became professor of botany. From 1917 to 1919 he was on leave from the University of Michigan for the purpose of serving as pathological inspector with the Federal Horticultural Board of the United States Department of Agriculture. He was a fellow of the American Association for the Advancement of Science and a member of the American Botanical Society, Torrey Botanical Club, Société Linnéenne de Lyon, Washington Botanical Society, Michigan Academy of Science, Arts and Letters, Sigma Xi and the American Forestry Association.

Dr. Kauffman was outstanding both as an investigator and teacher. His interest in the agarics resulted in numerous papers concerning the taxonomy of various genera, especially Cortinarius, Inocybe, Lepiota, Clitocybe, Gomphidius and Armillaria. His "Agaricaceae of Michigan"[2] serves not only as an exhaustive and critical treatment of the agarics of Michigan but as a standard reference for the species described. In addition he published papers concerning various species of Phycomycetes, Gasteromycetes, Thelephoraceae and Polyporaceae as well as numerous mycological floras of Michigan and other states. He had a broad knowledge of the fungi of the United States gained from many summers spent in the field collecting in Michigan, New York, Pennsylvania, Maryland, Virginia, Kentucky, Tennessee, Montana, Colorado, Wyoming, Idaho, Oregon and Washington. He also contributed publications in the field of plant pathology, especially concerning the rots and mycorrhizas of trees. His broad interests have been reflected in the choice of subjects for investigation by his students who have been guided by him in studies concerning algae, bryophytes, ferns and among fungi have studied problems in all the major groups. He never lost his early interest and enthusiasm in teaching. His students will always remember him for the example which he set by his untiring enthusiasm in research and for the inspiring criticism and encouragement which he always freely gave.

E. B. MAINS

UNIVERSITY OF MICHIGAN

[1] *Ann. Bot.* 22: 361–387, 1908.

[2] *Mich. Biol. Geol. Surv.* 26: Biol. Ser. 5, 1918.