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THE DRY-ROT OF OUR ACADEMIC BIOLOGY[1]

OUR society requires its retiring president to close the annual meeting with a discourse or sermon—a task which has become increasingly difficult, for every year the program of the morning and afternoon sessions becomes more abstruse and therefore makes greater demands on our attention and the lingering memories of past presidential rhetoric invite to more odious comparisons. To me the task was the more arduous, because I had been busy for many years in remote fields of entomology in which few of you are interested, and because it fell to me at an inopportune moment, while I was in the very act of laying—if you will pardon a French expression—a volume of some 1,100 pages on ants. This racking oviposition leaves me reduced to a mere blob of corpora lutea and so feeble that I can only crawl, in search of a text for my sermon, to the next Encyclopedia Britannica article, which is not "ant-eater," but "Antæus." You will recall Antæus, that mythical F_1 generation hybrid between Poseidon, the Sea, and Gaia, the Earth. His hybrid vigor was so great, we are told, that he not only grew to gigantic stature, but insisted on wrestling with every stranger that happened to pass through his Libyan domain. He was always invincible in these encounters because his strength waxed with each successive contact with his mother Earth. When not engaged in wrestling he was building a monument to his father with the skulls of the vanquished. One day Hercules came along and, knowing the secret of the giant's strength, raised him aloft and strangled him in the air.

We may, perhaps, interpret this exploit of the sun-god Hercules as a mythical expression of the fact that no terrestrial substance can permanently resist evaporation or volatilization by heat, but the accepted and, I believe, more

[1] Address of the president of the American Society of Naturalists, Boston, December 29, 1922.

manifest meaning of the myth is that even an agile and vigorous mortal had best keep his feet on the concrete if he wishes to avoid death at the hands of the Hercules of abstraction. That the myth is of rather late origin would seem to be indicated both by this somewhat sophisticated interpretation and by the fact that the slaying of Antæus was not one of the twelve great labors of Hercules, but one of his Parerga, or deeds done by the way. The athletic demigod, while sprinting across the Sahara to get the golden apples of the Hesperides, merely stopped for a few minutes to finish Antæus. One might conjecture that the myth had been invented by some malicious Athenian potter or weaver, who, happening to live next door to the Academy, had often been annoyed by the "hot air" emanating from that institution, were it not that an Antæus-Hercules wrestling bout is known to have been a brilliant scene in one of the lost dramas of Phrynichus, written about 500 B. C.[2] Nevertheless, the myth remains to this day as one of the most beautiful expressions of the practical man's attitude toward those who place too much confidence in their more abstract intellectual operations.

After securing this text there was difficulty with the title of my sermon. I could not decide whether to call it the "tommy-rot" or the "dry-rot" of our academic biology. I finally chose the latter, because some of our activities so closely resemble the inroads of the fungus *Merulius lacrymans* in old timber, and because it might be amusing to find that the conscientious cataloguers of the Widener Library had included my effusion under cryptogamic botany or phytopathology. Imagine the hilarity of some young foot-ball player in the year of our Lord 1952, condemned to bone up for a final exam, and happening on a reprint of this paper reposing unashamed between such monuments of cryptogamic erudition as the 74 folio volumes of Professor Farlow's "Toadstools of God's Footstool" and the 27 quarto volumes of Professor Thaxter's "Laboulbeniales of the Universe"—like a naughty tick pressed between the hide of some royal Siamese she-elephant and that of her suckling daughter!

Text and title having been selected, auto-psychoanalysis, which, like prayer, is now one of my favorite diversions, revealed the fact that I was suffering from an acute, repressed desire to commit sabotage on our academic biology hy hurling a monkey-wrench into its smug machinery. Since, according to the Freudians, such desires simply must be satisfied, and since I may never have another opportunity to hit so many of the wheels with one shot, I can see no reason why I should not obtain all the catharsis to which psychopathology entitles me. My mental condition is, no doubt, partly due to the disappointing spectacle of our accomplishments as more or less decayed campus biologists in increasing the number, enthusiasm and enterprise of our young naturalists. I estimate that at least 25 per cent. of all students graduating from our colleges have had the equivalent of an elementary course in zoology or botany.[3] There must be many thousands of these young men and women in the country and yet, in a prosperous population of 110,000,000, the number with a vital and abiding interest in biological inquiry, even as an avocation, is extremely small. And in our universities, apart from the students preparing to enter medicine, the number indulging in advanced and graduate courses in the science would probably shrink to zero if we failed to provide fellowships or to hold out to them at the end of a long pole that enhaloed bundle of hay, the doctor's degree.

Is this situation due to the moronic ignorance or the satanic machinations of our trustees, presidents and deans? I take down Professor Cattell's illuminating monographs on the taxonomy and behavior of this fauna, but can not find that it is to blame. Is it the fault of the students? Obviously not, for no coun-

[2] One may also conjecture that the story of Antæus is a very ancient but much distorted vegetation myth. It certainly resembles the myths of the Phrygian Lityerses and the Lydian Syleus. Both of these vegetation gods compelled strangers to compete with them, the one in the corn-field, the other in the vineyard, and both habitually slew their competitors and were in turn slain by the passing Hercules. See Frazer, "The Golden Bough," abridged ed., 1922, pp. 425, 442.

[3] *Cf.* the very temperate article by Professor H. H. Nininger, "Zoology and the College Curriculum," *Scient. Month.*, 16, 1923, pp. 66-72, an article which I did not see till after the delivery of my address.

try produces a greater and more sweetly docile mass of pedagogical cannon-fodder. It would seem, therefore, that the teaching of biology should not be entrusted to those whom Bismarck called the damned professors, or that there is something wrong with us who try to teach the science, or with the environment in which we carry on the business. I can not avoid the impression that the problem involves, in varying degrees, all three of these factors. Of course, their adequate discussion would be extremely wearisome. I can only pull out little mycelial tufts of *Merulius lacrymans* here and there and submit them to your inspection as evidence of the dry-rot which seems steadily to be invading the underpinning of biology, at least in some of our eastern universities. If you can bear with me, after a day of strenuous attention to far worthier utterances, I shall first consider very briefly some of the disabilities, both material and personal, under which we seem to be laboring, and in conclusion suggest what I believe might be an ameliorative if not a remedial plan of action.

The hampering effects of the material and environmental conditions under which we strive to inspire the young to become life-long naturalists deserve more attention than they have received. Any one of us who endeavors to grasp with his poor intellect, enfeebled by years of gyration in the academic mill, the stupendous and confusing accumulation of facts, not to mention the assumptions, fictions, hypotheses, theories and dogmas that make up present-day biology, must be staggered by the difficulty of selecting the most appetizing, concentrated and nourishing food for the student just entering the academic cafeteria. Perhaps no other collegiate department is expected to deal with such a vast and heterogeneous wealth of potential pedagogical pabulum. And the difficulty is greatly increased by the fact that one and all of us are highly specialized cooks, who delight in feeding the young on the dishes we ourselves like or that mother used to make and incidentally in showing our fellow cooks what delicious messes we can prepare. The student's metabolism may require plain gruel and toast, but we often insist on filling him up with so many elaborate pastries and salads that we ruin his digestion and, what is a thousand time worse, his appetite. Please bear in mind that I am trying to discuss the very practical business of teaching, not research. I am, of course, a ritualistic, high-church, port-and-sherry-loving Episcopalian in research, but only a poor, Peruna-soaked Methodist when it comes to teaching. I would go to such absurd lengths in helping research that I would even provide a room in the very modest institution to which I belong for any young man who might wish to spend the next ten years of his life investigating, say, the nucleololus of the fourth cell from the end of the last caudal cartilage of the embryo chipmunk, and if his work became very absorbing and his digestion impaired, I should be willing to feed him through a tube in the wall till his head swelled to the size of the room and he believed that he had become the nucleololus of Betelguese, but I should not permit him to see, much less converse, with freshmen. Such a pearl should not be cast before swine.

We might regard it as a great handicap that we academic biologists, unlike our native woodchucks and muskrats, are compelled to be most active pedagogically during the annual glacial period, but our superior intelligence enables us to cope with that situation. Every autumn we lay in a few cans of soused dog-fish and pickled sea-cucumbers, coop up some guinea-pigs, earth-worms, cockroaches and fruit-flies, throw in a bag of beans and several bales of hay for the botanists—and we are prepared for the worst. We can now proceed to disentangle and unreel the infinite and ineffable complexity of organic reality. We have more than enough for the purpose, for were we not all taught in our childhood by some old maid with ringlets that any little flower, or any little bug, for that matter, plucked from the crannied wall and held in the hand, is sufficient? When the neophyte becomes nauseated with the mess we have provided we can encourage him and incidentally heighten our own prestige by telling him that he is learning to forecast and control the behavior of organic nature, that he may shortly be able to make real live homunculi and regulate their mating habits, and all the pishpash with which, since the Neolithic Age, other priests and other wizards have heartened their constituencies.

More important than the drawbacks I have hinted at are certain types of personality en-

gaged in the business of teaching biology. Since the inquiring scientist insists on poking his nose into every fold of reality, and since biology professors constitute a part, and, in their own estimation at least, an important part of reality, we might expect them not only joyfully to investigate the behavior of their colleagues—they do this already—but also to submit themselves to investigation, with at least a show of good grace. What startling results we might hope to obtain from a thoroughgoing application of the Freudian and Adlerian analyses and the intelligence tests! But even if we concede that the damned professor is an extraordinary being because he has sufficient inertia to specialize for a life-time in a particular department of learning, we must admit that he will grow old like the most ordinary individual of his species. He will gradually take on most or all of the stigmata of gerontic involution, which Dr. G. Stanley Hall has enumerated. At forty, if not sooner, his sense-organs, musculature, endocrines, emotions and memory will begin to atrophy and his intellectual processes will become more and more stereotyped, dogmatic and abstract. From a young Antæus continually gaining fresh strength from each successive contact with concrete reality he will become a creature increasingly infatuated with generalizations, relationships and hypothetical explanations, especially if they are of his own confection, and he will eventually drift into a stage in which words, formulæ and imaginary entities become the very breath of his nostrils. He has been borne aloft to be slowly asphyxiated in the tenuous atmosphere of the unreal. There are, of course, all degrees of the process and it is so gradual that it may completely escape even a professor. One rather mature student, who had spent four years in a divinity school, recently told me that, having outgrown theology, he had entered the course of one of our eminent geneticists, a man capable of twisting one's head off, were one to insinuate that he had ever released his feet from the concrete. A few weeks later the student quietly dropped the course and when asked the reason replied that the professor's mental processes were so similar to those of his decrepit divinity teachers when they held forth on predestination, salvation through grace, infant damnation, and the like, that he had decided not to add a fifth year to his theological training.

Unfortunately we have no intelligence tests for individuals with a mentality of more than 18 years, and biologists are supposed to be older, though some of them somehow manage to harmonize a physical age of 40 to 60 with a mentality of 8 to 14. These, however, if really human and endowed with a decorative personality, seem to make the best teachers, probably because they enter most readily into mental rapport with the freshmen and sophomores. It is not from such professors that the Merulius spores proliferate most profusely, but from those who have a physical age of 40 to 60 and a mental age of 80 to 105.

I do not wish to be misunderstood on this matter of aging. Those of us whom the gods have not sufficiently loved to remove early in life all develop what might be called the normal inferiority complex of senescence, but we rationalize and compensate or even overcompensate for it. This is apparent in all the discussions of the subject from the remarks of the aged Cephalus in the prologue of Plato's "Republic" and Cicero's "De Senectute" to the very recent essay of the still delightfully youthful Professor Jennings "On the Advantages of Growing Old." La Rochefoucauld put the matter concisely when he said that "old men are fond of giving good advice in order to console themselves for being no longer able to serve as bad examples." As youngsters we are all filled with a spirit of adventure and long to dominate reality; later, after we have worn down our eye-teeth on its resistant carapace, we try to compromise with it by cajolery, and when this, too, fails, we forsake it and create a reality of our own, a realm of ideas, Platonic, esoteric, inviolable, eternal, in which we can still exercise the meager remnants of our will to power. This type of senescent compensation is most beautifully displayed in the sheltered environment of our universities, and I would not underestimate its enormous value to science and therefore to the race. It is clearly exhibited by old or prematurely old taxonomists, morphologists and geneticists, who derive from static fictions like species, unit characters, genes, etc., a certain feeling of potency, of having their fingers on the very vitals of organic reality. Many of

our most revered biological hypotheses are the work of senescents who have been sufficiently industrious and ingenious to make their subconscious compensatory strivings tally with very considerable bodies of facts. It would be interesting to ascertain the precise age, conditions of the sense-organs, endocrines, etc., of men like Darwin, Spencer, Galton, Weismann, Bruecke, Naegeli, Haeckel, Jaeger, Altmann, Wiesner, Haacke, Brooks, Verworn, DeVries, Hatschek and Johannsen, when they first began to operate with pangens, biophors and similar ultra-microscopic flora. We might also need the cephalic index, since certain racial tendencies may be involved. This is suggested by the fact that the French and Italian biologists have rarely shown the slightest interest in the construction of such entities. Are these biologists deficient in imagination or analytical power? Hardly. Or must we assume that the French and Italians, after having produced so many of the great scholastics, have lost confidence in their methods of dealing with the phenomenal world?

Undoubtedly the best culture medium for the academic dry-rot fungus consists of about equal parts of narrow, unsympathetic specialization and normal or precocious senile abstraction; and as this medium is always present in many personalities that find their optimum environment in our universities, the outlook is depressing. A friend who has long been studying our institutions of learning maintains that our only salvation lies in discharging all our faculties and burning or thoroughly disinfecting all the buildings every 25 years. I am somewhat less pessimistic, for although I have seen very little improvement in pedagogical method in our biological departments during the past 35 years, the stress they have laid on research has preserved them from the hopeless mummification that has overtaken some of the other departments.

It seems to me that there are two periods when the young biologist is most susceptible to lethal infection by the Merulius spores that are continually being thrown off by his professors. One is his freshman year, when he should be stimulated to develop an enthusiastic, receptive attitude, the other his graduate year or years, when he may be expected to adopt an independent, adventurous and creative attitude toward his science. Of course, the treatment of advanced students is easy for any professor who will follow the excellent example of the late Professor Roland of Johns Hopkins. The story is told that he was once presented with a list of rules for teaching graduate students and that he crossed out all the items and wrote beneath: "Neglect them!" Despite this very convenient precept, many of us coddle our graduate students till the more impressionable of them develop the most sodden types of the father-complex. Some of us even wear out a layer of cortical neurones annually, correcting their spelling and syntax. One fussy old guru of my acquaintance has destroyed both of his hemispheres, his corpus callosum and a large part of his basal ganglia hunting stray commas, semicolons, dashes, parentheses and other vermin in doctor's dissertations.

Not only do many of us wear out our most valuable tissues converting the graduate students into mere vehicles of our own interests, prepossessions and specialties but nearly all of us fail to excite in them that spirit of adventure which has in the past yielded such remarkable results in the development of our science. The finest example of this lack of vision is seen in the stolid indifference, especially in our eastern universities, to exploration and research in the remoter portions of our own country, in foreign lands and especially in the tropics. We have in the Philippines and at our very doors in the West Indies, Mexico, Central and South America the most marvelous faunas and floras in the world, but we still persuade our traveling fellows to cut more sections in the laboratories of Professor Rindskopf of Berlin or Professor Himmelschwanz of Leipzig, because thirty or forty years ago we were sent to the same *bemooste Häupter*. There was then a certain justification for this procedure because we at least picked up much valuable information from our fellow students in the *Bierstube*. But what shall we say to such dry-rot exhibitions as the following? A few years ago I was asked to secure a young botanist to accompany a biological expedition to the little-known Solomon Islands and therefore begged one of our eminent *exsiccati* to aid me in the quest. To my amazement he actually asked me whether I

did not know that New England was covered with a luxuriant and almost unknown flora and did not regard it as a crime to dissuade a young botanist from devoting his life to pressing the plants of Cape Cod! And yet the theory which has revolutionized all our thinking was brought to us from the tropics by two naturalist explorers, and for a century those who have presided over higher education in Great Britain, France, Germany and the Scandinavian countries have seized every opportunity to send their young biologists to the tropics. I refrain from wearying you with the long list of gifted European naturalists who, just before the war and throughout the tropics of both hemispheres, were increasing our biological knowledge by leaps and bounds. The neglect of our splendid opportunities has, in fact, become such a scandal that it is known even to our august band of Delphic hierodules[4] in crinolines, the National Research Council.

When we leave the advanced student and turn to the beginner, the picture is even more depressing. To us gerontic schoolmarms in trousers, who have flown from reality and have slowly succumbed to autistic thinking, with defective eye-sight, doughy musculature, brittle ossifications, demoralized intestines, decayed autonomic nervous systems and atrophied interstitials, there comes every year a small army of freshmen—very properly so called—in the late teens and early twenties, burning for impact with reality, with exquisite sense-organs, superb bones, muscles and alimentary tracts, mirific endocrine and autonomic apparatus and a mentality of nine to fourteen years, or thereabouts—and what do we give them? Perhaps we give them what they deserve for coming to us, but it might be more charitable to discuss what we do not give them. What portion of the science of life, that most concrete and most entrancing of all the sciences, ought we to administer to this suckling host of postadolescents? I answer: they should be fed during the first year on the simple oat-meal pap of ecology, but I hasten to declare that I do not mean the "ecology" of the zoologists, and especially of the botanists, of what Mencken calls the silo and saleratus belt of our great republic. For the sake of defining my meaning I shall have to make another tedious digression.

If, as some one has said, mathematics is the science that gives a single name to a great many different things, biology is certainly the science that gives a great many names to the same thing. This is an old story to the taxonomist, who, if he be worth his salt, will not only confer as many names as possible on every animal and plant, and change those of the commonest species every six months, in order to apprise other biologists that he is on the job, but he will also consign as many as possible of the other fellow's names—especially if he dislikes the other fellow—to the synonymy. I admire Haeckel, but I dislike his term "ecology" and have repeatedly pointed out that it belongs in the synonymy with a number of other terms, ranging in order of priority as follows: "natural history" (eighteenth and nineteenth centuries), "ethology" (Isidore Geoffroy St. Hilaire, 1859), "ecology" as "Relationsphysiologie" (Haeckel, 1866, 1869), "Biologie" in the restricted German sense (later nineteenth century to present), "bionomics" (E. Ray Lankester, 1889), "behavior," "comportement," "Gebaren" (past three decades). In this country the inept Haeckelian term, largely as a result of the afore-mentioned silo and saleratus botanists and their zoological camp-followers, has won the day and my adrenals are now too weak to offer further resistance.

Huxley, writing in 1879, apparently distinguished three ontogenetic and phylogenetic stages in the development of biology. He says: "Every country boy possesses more or less information respecting the plants and animals which come under his notice, in the stage of common knowledge; a good many persons have acquired more or less of that accurate, but necessarily incomplete and unmethodized knowledge, which is understood by Natural History; while a few have reached the purely scientific stage, and as Zoologists and Botanists, strive towards the perfection of Biology as a branch of Physical Science. Historically, common knowledge is represented by the allusions

[4] The definition of "hierodule" in the Century Dictionary is followed by the remark: "Large numbers of such slaves were attached to some foundations, and were either employed about the sanctuary or let out for hire for the profit of the god."

to animals and plants in ancient literature; while Natural History, more or less grading into Biology, meets us in the works of Aristotle, and his continuators in the Middle Ages, Rondeletius, Aldrovandus and their contemporaries and successors. But the conscious attempt to construct a complete science of Biology hardly dates further back than Treviranus and Lamarck, at the beginning of this century, while it has received its strongest impulse, in our own day, from Darwin."

This view of the matter is no longer adequate, quite apart from the fact that we are now entering on a fourth stage, a kind of metabiology, embracing biochemistry. The first of Huxley's stages, that of "common knowledge," should have been differently presented, in order to emphasize the practical, or economic source of the science in the activities and lore of the hunter, trapper, woodsman, herdsman, fisherman, husbandman, gardener, herbist, midwife, medicineman, etc. His second stage, that of "natural history," seems also to be presented in an adequate, if not misleading manner, probably because he was primarily a morphologist and somewhat dazzled by the fresh effulgence of the Darwinian theory of evolution, so that he seems to treat natural history not only as a transitional but also as a transitory phase in the development of biological science. History shows that throughout the centuries, from Aristotle and Pliny to the present day, natural history constitutes the perennial root-stock or stolon of biological science and that it retains this character because it satisfies some of our most fundamental and vital interests in organisms as living individuals more or less like ourselves. From time to time the stolon has produced special disciplines which have grown into great, flourishing complexes, and it has itself changed its name from time to time as the investigators of different periods have been impressed by different aspects of its fundamental tendencies. Aristotle wrote of the "histories" of animals, the naturalists of more recent centuries spoke of their "habits"; we have become more articulate and speak of their "behavior." Even a superficial acquaintance with the voluminous writings on natural history from those of the Stagirite to those of Gessner, Réaumur and Buffon and the naturalists of the first half of the nineteenth century, shows that for obvious psychological reasons human interest in organisms has always centered in their activities or what we now call their reactions to stimuli, their adjustment or adaptations to their environment and to one another. By the latter part of that pedantic century, the eighteenth, such great reserves of observation and experimentation had accumulated in the stolon that it began to bud. Taxonomy, morphology, paleontology, physiology began to shoot up, branch and differentiate, becoming independent specialties, developing their own methods, fictions and hypotheses. In the middle of the nineteenth century, after the great voyages of exploration, the bud chorology, or geographical distribution appeared, and about the same time I. G. St. Hilaire and Haeckel, wishing to emphasize the fundamental importance of adaptation, but mistaking the stolon for a bud, named it "ethology" or "ecology." More recently another dear little bud, genetics, has come off, so promising, so self-conscious, but, alas, so constricted at the base. And future centuries will no doubt witness a further gemmation of biological disciplines from the same old natural history stolon.

This is, of course, an extremely imperfect and summary sketch of the development of biological sciences, but it emphasizes the primitive, central and dynamic source of our interest in organisms. Obviously we can offer no criticism of those who prefer to call natural history or ecology "general" or "external physiology." Burdon Sanderson in 1894 presented the matter very concisely from this point of view in the following passage: "Now the first thing that strikes us in beginning to think about the activities of an organism is that they are naturally distinguishable into two kinds, according as we consider the action of the whole organism in its relation to the external world or to other organisms, or the action of the parts or organs in their relation to each other. The distinction to which we are thus led between the *internal* and *external* relations of plants and animals has of course always existed, but has only lately come into such prominence that it divides biologists more or less completely into two camps—on the one hand those who make it their aim to investigate the actions of the organism and its parts

by the accepted methods of physics and chemistry, carrying this investigation as far as the conditions under which each process manifests itself will permit; on the other, those who interest themselves rather in considering the place which each organism occupies, and the part which it plays in the economy of nature. It is apparent that the two lines of inquiry, although they equally relate to what the organism *does,* rather than to what it *is,* and therefore both have equal right to be included in the one great science of life, or biology, yet lead in directions which are scarcely even parallel. So marked, indeed, is the distinction, that Professor Haeckel some twenty years ago proposed to separate the study of organisms with reference to their place in nature under the designation of 'œcology,' defining it as comprising the relation of the animal to its organic as well as to its inorganic environment, particularly its friendly or hostile relations to those animals or plants with which it comes into direct contact. Whether with the œcologist we regard the organism in relation to the world, or with the physiologist as a wonderful complex of vital energies, the two branches have this in common, that both fix their attention, not on stuffed animals, butterflies in cases, or even microscopical sections of the animal or plant body—all of which relate to the framework of life—but on life itself."

The stolonic relationship of natural history, or ecology to the other biological disciplines is of great theoretical and practical significance. Nearly all the important biological problems, especially of a physiological or morphological character, have arisen in the course of simple investigation in natural history and many of the more difficult of them have been turned over to the special disciplines for solution. On the other hand, the ecologist is continually drawing on the methods and resources of physiology, morphology, taxonomy, distribution, etc., in solving his own particular problems of adaptation and behavior. The most interesting and important of them relate, not to the reactions of organisms to their inorganic environment, but to their reactions to one another. As this matter, though very simple, is often misunderstood, you will pardon me for dwelling on it for a few moments. Since all organisms, either of the same or of different species, invariably live in relationships of dependence on or of cooperation with others, the ecologist is justified in regarding the whole living world as an intricate congeries of biocoenoses, or consociations, ranging in complexity from at least two to a great many organisms. Even genetics may be regarded as a department of ecology, which is striving to formulate the precise symbiotic relationships of the gametes to each other in the constitution of the zygote, and their reactions with the environment. Hence the problem of adaptation is not foreign to this discipline though it is at present either ignored, as Bateson implies, or expressed in terms that are unfamiliar to the ecologist and physiologist. Moreover, since human societies are very intimate and elaborate biocoenoses of individuals of the same species, psychology, sociology, economics, anthropology, ethnology, history, ethics, jurisprudence, government, hygiene, medicine, etc., are essentially ecological, for their central problems are behavioristic.

It follows from these considerations also that applied, or economic biology is merely applied ecology, as Forbes, Needham and others have repeatedly stated.[5] Whenever and wherever one

[5] *Cf.* the following passage by Professor J. G. Needham, *Science,* N. S., 49, 1919, p. 457: "Dr. Howard suggests that we give more time to taxonomy and ecology and less to physiology and genetics. This is a good suggestion. We are all out of balance. Some of our laboratories resemble up-to-date shops for quantity production of fabricated genetic hypotheses. Some of our publications make a prodigious effort to translate everything biological into terms of physiology and mechanism—an effort as labored as it is unnecessary and unprofitable. Why not let the facts speak for themselves? Our laboratories are full of fashions. They go from one extreme to another. In my high school days we learned systems of classification; in my college days we did nothing but dissecting; later came morphology and embryology, then experimental zoology, then genetics, and the devotees of each new subject have looked back upon the old with something like that disdain with which a debutante regards a last year's gown. Natural history and classification are perhaps long enough out of date, so that interest in them may again be revived. I hope so; for these are the phases of biology by means of which a youth is best oriented for more special work. Then, too, they are immensely practical.

of the organisms of a biocoenose happens to be man, we have an economic situation, and it is in the precise determination of the relationships thus developed that ecology celebrates many of its greatest triumphs. I need only refer to the great field of parasitology—the work on cestodes, trematodes, trichinæ, hookworm, malaria, yellow fever and all the other insect-borne pathogenic organisms, in bacteriology, phytopathology, economic entomology, etc., all work which does not transcend the concrete natural history or ecological level. And everything indicates that we are only at the beginning of the revelations and benefits which similar studies have in store for us. Surely the ecologist need not veil his face in modesty even in the presence of a Mendelian formula or a new Drosophila mutation.

Although I have left our lusty young freshmen out in the cold during this long harangue, I have not forgotten them. I repeat: what ought we to give them? I do not believe that we should inform them with the first crack out of the box that they are animals and descended from ape-like ancestors. This must come as a severe shock to any young *Boobus americanus* who has never had an opportunity to make the acquaintance of really high-class apes, like the chimpanzees recently studied by Wolfgang Koehler at the German Anthropoid Station on the Island of Teneriffe. The freshman should be gradually led through a sympathetic study of the lower organisms as marvelous centers of beautiful and dignified processes to a knowledge of his own animal respectability, descent and responsibilities. This, I am convinced, is not to be achieved by taking dead and more or less smelly crayfish, earthworms, starfish and cockroaches to pieces, because Huxley in 1879 intimated that it might be a meritorious occupation for the young, nor by a too immediate study of living forms so remote in the scale of being as the Protozoa, Coelenterates and plants. It would seem to be preferable to start with living animals somewhere in the middle or higher reaches of organic development—small vertebrates, mollusks, insects, arachnids—and to make them the objects of direct, simple, comprehensive observation and experiment, severely suppressing or subordinating all morphological details which have no immediate bearing on the study of their activities. Necropsies, autopsies and postmortems might be introduced with discretion, but only after the student has acquired an acquaintance with the life-histories and more obvious methods of growth of his organisms—with the aid of moving pictures, whenever necessary—their methods of locomotion, feeding, respiration, excretion, defense and concealment, their reactions to light, temperature, humidity, etc., and especially to one another, *i. e.*, their mating, oviposition, parturition, nidification, parental care, predatory, parasitic, symbiotic, gregarious and social behavior, etc. Simple experiments in genetics, regeneration of lost parts, etc., could be introduced, but without cytological lace and ruffles. The successful teacher of elementary mathematics does not overwhelm and confuse the student with all the known recondite properties of the triangle and circle. The freshman laboratory should be neither an animal morgue nor a herbarium, but a vivarium. Its teaching staff should be numerous, competent, enthusiastic and young and, in order that Merulius infection may be avoided, no old professor or weary research student should be permitted to enter it without a complete change of mental underwear and, I might add, without a few moments of silent prayer or meditation at the door. To the present depauperate glacial fauna of the laboratory, the perpetual rat-guinea-pig-frog-Drosophila *repertoire,* we should add many of the thousands of even more interesting organisms that will live and multiply in confinement, and—although I realize the great difficulties involved—some means must be devised for taking the students into the field more frequently, since it is impossible to reproduce and study the more complex biocoenoses under artificial conditions.

You will probably agree that such a program of freshman work as I have very hastily sketched could in adroit hands yield at least a vital part of the needed preparation, first, for men who will devote the remainder of their collegiate and postcollegiate lives to occupations foreign to biology, and such men, of course, constitute the majority of any freshman class; second, for men who are primarily interested in the "Geisteswissenschaften"—psy-

One has to deal with species, and must be able to recognize them; and all economic procedure is applied ecology."

chology, philosophy, history, economics, law, etc.; third, for men who will enter medicine and may therefore be expected to specialize mainly in morphology and physiology during the remainder of their college course; fourth, for men who may wish to specialize in other departments of applied biology, such as agriculture, forestry, economic zoology and botany, fish and game conservation, etc., subjects to which our present freshman biology is a hopelessly inadequate introduction; fifth, for the biological investigator and teacher, who can not be too quickly persuaded to assume the modern dynamic and experimental attitude toward his science. It is, of course, this new attitude, that many of us older men, trained during the late Victorian morphological boom, have difficulty in assuming, and that makes us so conscious of our inability to participate very effectively in the biological education of the present generation.

There is another suggestion I should like to make, in order that the freshman course may be preserved from the dry-rot, which may invade even the most dynamic type of instruction, and that is the utilization by the instructor of competent amateur naturalists as occasional assistants. This seems never to have been tried, except in some of our summer camps and marine laboratories, and the reason is obvious. The typical professor has about the same liking for the amateur that the devil has for holy water, and the amateur habitually thinks of the professor in terms which I should not care to repeat. You will find a choice collection of them in Mencken's writings. The truth is that the amateur naturalist radiates interest and enthusiasm as easily and copiously as the professor radiates dry-rot. For years I have taken a malicious delight in introducing amateurs to professors, because the behavior of the latter on such occasions yields a precise quantitative test of the amount of Merulius in their timber. Dear, old, mellow, disinfected professors of the type of Louis Agassiz, Asa Gray, Shaler, Hyatt and Ryder enter at once into sympathetic rapport with the humblest amateur, but the young or those of middle age are almost invariably more or less priggish, condescending or worse. Now there is an opportunity to develop a mutual understanding and respect in both of these parties, so essential to the development of biological science, if the young instructors will only welcome and encourage the cooperation of the amateur in interesting his freshmen. We have all known amateurs who could make an enthusiastic naturalist out of an indifferent lad in the course of an afternoon's ramble and, alas, professors who could destroy a dozen budding naturalists in the course of an hour's lecture. The instructor who would from time to time call in some of our talented ornithologists, herpetologists, entomologists, arachnologists and malacologists to assist him, both in the laboratory and the field, would himself profit greatly, the significant human contacts of the students would be multiplied and the amateur be given just the right environment in which to spread the divine fire of his enthusiasm.

And this brings me in conclusion to what is perhaps the main source of our failure in incubating naturalists, and that is our too highly specialized, or esoteric attitude toward organic nature. Whether we contemplate the whole or only some particular portion of the realm of living things, it eventually tends to become for us merely so much material to be used in the solution of the many tantalizing problems which it suggests. We are, indeed, obsessed by problems. No doubt this is the correct attitude for the seasoned investigator, and no doubt a certain spirit of skeptical inquiry should be cultivated even in freshmen, but surely we should realize, like the amateur, that the organic world is also an inexhaustible source of spiritual and esthetic delight. And especially in the college we are unfaithful to our trust, if we allow biology to become a colorless, aridly scientific discipline, devoid of living contact with the humanities. Our intellects will never be equal to exhausting biological reality. Why animals and plants are as they are, we shall never know, of how they have come to be what they are, our knowledge will always be extremely fragmentary, because we are dealing only with the recent phases of an immense and complicated history, most of the records of which are lost beyond all chance of recovery, but that organisms are as they are, that apart from the members of our own species, they are our only companions in an infinite and unsympathetic waste of electrons, planets,

nebulæ and suns, is a perennial joy and consolation. We should all be happier if we were less completely obsessed by problems and somewhat more accessible to the esthetic and emotional appeal of our materials, and it is doubtful whether, in the end, the growth of biological science would be appreciably retarded. It quite saddens me to think that when I cross the Styx, I may find myself among so many professional biologists, condemned to keep on trying to solve problems, and that Pluto, or whoever is in charge down there now, may condemn me to sit forever trying to identify specimens from my own specific and generic diagnoses, while the amateur entomologists, who have not been damned professors, are permitted to roam at will among the fragrant asphodels of the Elysian meadows, netting gorgeous, ghostly butterflies until the end of time.

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TENDENCIES IN AGRICULTURAL RESEARCH[1]

LAND rather than soil problems engaged the attention of our pioneer farmers. To them the passing of the public domain into private ownership meant much. It meant the conquest of the wilderness, the leveling of dense forest growth, the turning of prairie sods. It was the era of agricultural exploitation without the thought of climbing yields and of better races of plants and animals. The rugged faith and courage of the pioneer were pitted against a not over-friendly environment in the persistent building of an agricultural empire. But, while in the retrospect of the present day the outcome was predestined, the path of progress was beset with many difficulties and uncertainties. Despite these, an unending procession of home-seekers braved the perils and solitude of forest and plain, the human stream flowing on to the west to build, to sow and to harvest.

Scarcely more than one hundred million acres of our land surface had been transformed into improved land by the middle of the last century. In the following decade each year brought an addition of five million acres of improved land, a rate of progress temporarily halted by the tragedy of the Civil War. But the beckoning furrows lengthened and multiplied, and it was a poor year between 1870 and 1890 when the addition to our improved land area was less than ten million acres. In the thirty years following 1890 this area grew from about 360 to more than 500 million acres. The conquest is still to be completed, but the era of land exploitation as such has been well passed. Coincident with the development of our land resources the acreage of our staple crops grew by leaps and bounds. The area under hay and forage crops increased from about thirty millions in 1879 to about ninety-six millions in 1919. There was a corresponding increase from about sixty-two million to eighty-seven million acres in the case of corn, from thirty-five to seventy-three millions in the case of wheat, from sixteen to about thirty-eight millions in the case of oats and from fourteen to nearly thirty-four millions of acres in the case of cotton. The relative increase in the acreage of rye, potatoes, tobacco and rice was even greater. Increasing numbers of farm animals followed the expansion in the acreage of improved land. They brought, as did the expanding acreage, a great array of problems that insistently called for solution.

The pioneer farmer was chiefly interested in methods that promised the most effective utilization of the vast resources of our soils and forests. He reached out for more efficient tools as well as for more efficient plants and animals. The invention of agricultural machinery was stimulated by the apparently unlimited acreage and ready accessibility of agricultural land. Implements of tillage, as well as harvesting machinery, multiplied the labor resources of our farms. Improved transportation came with the reaching out of our railroad systems. Mechanical power was later added to our agricultural labor resources and land utilization soon assumed vast proportions. In response to the demand for more efficient plants and animals better varieties of plants were made available by importation and se-

[1] Address of the vice-president and chairman of Section O—Agriculture, American Association for the Advancement of Science, Boston, December, 1922.