nished the only basis for the continuation of research by the esoteric botanists who looked askance at them not so many years ago. How large an audience and what kind of equipment would these academic botanists have to-day were it not for the cooperation of the botanists in the public service and the enthusiasm they have transmitted to young men looking for a career?

Another consequence of the activities of the "lesser minds" has been the securing of funds for experimentation and research on a scale never dreamed of by the older botanists. They have become the principal source of information about the growth of plants out-of-doors. They have transformed the old indoor botany, with its "bean, pea and popcorn" demonstrations in Wardian cases, into a science of plants as they grow in fields and orchards, as well as in forests, grasslands and deserts. At the same time, they have probably contributed as much to botanical theory as have the occupants of the ivory tower.

I have briefly sketched some of the changes in point of view that have occurred during the past four decades, and I have pointed to some of the dangers that attend the impending overproduction of doctors in the field of botany. The present year-to-year increase must sooner or later lead to many personal catastrophes.

We the members of the Botanical Society constitute the only group that can anticipate and ameliorate this situation. By mutual cooperation we can suggest more intelligent preparation for graduate study of botany, and we can insist on a higher and a broader foundation for admission to candidacy for the Ph.D. degree. By this method alone we can also gradually adjust the number of graduate assistants and fellows to the number that can secure permanent appointments upon graduation.

If, in the near future, an outlet for our doctors develops in the secondary schools we should be prepared to certify that every doctor can not only meet the State Board requirements, but that he has a background in the allied sciences that will enable him to visualize the field of plant science as a whole and that his perspective is not limited to the narrow confines of his research interest.

All that I have said up to this point was written a month ago before we became active participants in the life-and-death struggle between Hitlerism and Democracy. The future is even more complicated than it was a month ago. The implications of an all-out war further emphasize the need for a new qualitative and quantitative appraisal of our procedures both in the field of graduate studies and in the enlistment of continued public support through the education of undergraduate students.

In the face of the sacrifices of our young men, the dissipation of our natural resources and the threat to all our ideals of "life, liberty, and the pursuit of happiness," the future of our profession may seem trivial and irrelevant. Nevertheless, there will be an end to this war just as surely as there was a beginning, and now is the time to plan for the aftermath.

EVOLUTION AND KNOWLEDGE

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I AM incited to the following remarks by the difference, concerning the evolution theory, between R. Goldschmidt and F. B. Sumner as manifest by Sumner's recent article "Is Evolution Inscrutable."[1] These zoologists are fellow colleagues of mine (or would be if I were not a mere emeritus) in the University of California, and both have my high esteem, personal and scientific. And I make the remarks with less hesitation in that I do not pretend to mediate the seeming difference between them.

If we biologists—especially the zoologists among us—look at ourselves closely, it strikes me that most, if not all of us, would see that we have steered a rather queer intellectual course relative to the evolution problem since Darwin gained, for the general theory of it, acceptance by almost every student well grounded in the fields of research in which it chiefly lies.

And perhaps the queerest, if not the most unfortunate, thing about it is that so much of our procedure has reversed the order, so far as knowledge is concerned, followed by Darwin in working out the theory.

It would seem quite uncalled for to remind any educated person to-day of the origin of the theory from Darwin's experiences as the naturalist of the famous *Beagle* voyage. But there are aspects of his experiences, as an observer of the vast and varied phenomena he came upon, that call for a sort of attention that they get all too little of, even by many of the most highly educated persons.

For instance, I was rather shocked lately by being called down quite emphatically in a group of natural scientists, for quoting Darwin's well-known statement that he worked on true Baconian principles and "without any theory collected facts on a whole scale."[2]

[1] SCIENCE, May 30, 1941.

[2] "Life and Letters," I, p. 68.

Although the subject was touched only incidentally, the essence of the group's view seemed to be that no real scientist ever begins a real research without a theory of some sort as a starter.

Yes, I am now convinced by my later, more thorough reexamination of Darwin's attitude toward nature and his methods of research that he was entirely right in what he said about his procedure that led him not only to his general theory, but to all his special hypotheses in connection with it.

A secondary but yet important thing here is the naiveté, the literally child-like confidence the man (like nearly all persons eagerly devoted to the study of nature) had in thoroughly verified sense perceptual knowledge of the phenomena under investigation.

Could anybody be so egregiously foolish as to contend that Darwin did not see, that is, observe by the sense of sight, the various fossils he came upon in South America *before* he guessed, that is, made hypotheses, that they were once parts of creatures that lived long ago; and that those creatures might be the ancestors of creatures he had observed as present-day inhabitants of the region?

And recall the extent of observational study he had to make on the birds, especially of the Galapagos Islands, before he could theorize about their kinship with birds of the rather distant South American continent.

A particularly crucial factor comes into the situation with the endlessly debatable idea of "cause." For the evolution problem, the fact of "variation" was a poser for Darwin as it has been for every one else who has observed widely and thought earnestly on the nature and origin of the kinds or species of plants and animals. And the great figure the facts cut in Darwin's theory is too familiar to need dwelling on. The cardinal point for us here is that Darwin just took the facts of variation as observed by him and innumerable other trustworthy naturalists. Regardless of the cause or causes that produced variations, *there they are,* he said in substance over and over again, *amply verified and readily verifiable by observation.*

Not by any means was he disregardful of the problem of their causes. But so innately certain was he of the necessity of their being established as observed facts before the question of their cause or causes could even be asked, that he justifiably saw no reason why they should not enter as factors into a general theory of the origin of species while yet the causal question of the variations was still under investigation.

For one thing, the very idea of such a thing in living nature as "species" Darwin knew, as do all other persons thoroughly devoted to the study of this portion of nature who are usually classed as "naturalists," rests at bottom on sense perceptually acquired facts about the make-up of this portion of nature.

So the problem of the cause or causes of variation would be only a part of the larger problem of the cause or causes not only of species, but also of the existence of living nature.

I find nothing in Darwin's writings that seems to me more convincing of his faith (I do not think this word is too strong) in the reality of nature generally, and in the basic role of sense perception for gaining knowledge and understanding of that reality, than in one of his letters to Asa Gray. The sentence that appears to me crucial, but to have received too little attention, is this: "Personally, of course, I care much about Natural Selection; but that seems to me utterly unimportant, compared to the question of Creation or Modification."[3]

Read in the light of all his work this is only another, and a bit more the crucial, way of saying that as opposed to the doctrine or theory of a *supernatural* cause of living nature with its maze of different kinds of individuals, Natural Selection as a causal theory of it is "utterly unimportant" as compared with a theory that *natural* causes of some sort have produced the modifications, and changes of kinds into other kinds as they are presented for sensory observation in endless profusion.

But it was only when Darwin came to deal specifically with the nature of man in the light of the general theory of evolution, that his faith in, and reliance on, such observation becomes manifest in all its concreteness and depth. Here it is most fully displayed in "The Expression of the Emotions in Man and Animals." For here he undertook his most systematic and thorough-going comparison of man with his closest subhuman mammals on the basis of one attribute (the "emotions") common to both. One thing about this research is particularly significant for these remarks. That is its example of one aspect of what research in "natural history" included for Darwin, when applied to man. This is indicated, for one thing, by his making the problem of "causes" strictly subordinate to, and dependent on, facts of observation. Thus, after speaking about various difficulties encountered in such a research as he was here entering upon; and mentioning "the observation of infants" as one means of overcoming the difficulties, he writes: "But there remains the much greater difficulty of understanding the cause or origin of the several expressions and of judging whether any theoretical explanation is trustworthy" (p. 20).

Considerably more of the paragraph in which this

[3] "Life and Letters," II, p. 163.

occurs is much to our point—but we pass it. A particularly significant thing in connection with the causal question is the little reference to natural selection in the whole book. The term has no place in the index.

Another sharp indication of the place evolution, as compared with natural selection, had in Darwin's thought is given us on the same page as the above quotation. "With respect to my own observations," he says, "I may state that they were commenced in the year 1838. . . . At the above date, I was already inclined to believe in the principle of evolution, or of the derivation of species from other and lower forms."

No one should need to be told that the "above date" was many years before the hypothesis of natural selection had entered his mind.

But Darwin's faithfulness to sensory observation as an essential preliminary to all theory about evolution, finds its most crucial illustration at a specially recondite point in "The Descent of Man." This we shall notice presently. But it seems desirable to glance at one or two simpler illustrations, prefacing the glance, by noting that the procedure in the entire book is really illustrative of the principle. Having reached the general theory as to living nature, his purpose here is to consider whether the observational facts of the particular species, man, are such as to justify the theory that he too originated as species in general almost certainly have originated—and are still originating.

The whole of Part I is devoted to evidence available from observational studies of man as he exists now or has existed in the recorded past, that which agrees with the observational evidence basic to the general theory of evolution, especially as applied to the higher portions of the animal world. That is to say, it is not a theory of man's origin at some remote time in the past that Darwin starts with, but an extensive presentation of observed facts of what he is at present.

Thus notice some of the items listed in the first chapter of the first part: "Nature of the evidence bearing on the origin of man; Homologous structures in man and the lower animals . . . muscles, sense-organs, hair, bones, reproductive organs, etc." These are such commonplace matters that to one absorbed in the great philosophic problems of man's nature and origin they may seem too trivial to deserve serious attention.

Accordingly we pass to the "specially recondite point" referred to above—with the reminder that it occurs in the same Part I of the book. That is to say, for Darwin it belonged to the same category of sensory observational knowledge as the trivial stuff quoted above. The point is in Chapter IV, which starts off with the discussion of "The moral sense." "'This sense,' as Mackintosh remarks, 'has a rightful supremacy over every other principle of human action.'" Then follows immediately the "recondite point" referred to. It contains Darwin's own statement of what the supreme "principle of human action" is: "It is summed up in that short but imperious word ought, so full of high significance. It is the most noble of all the attributes of man, leading him without a moment's hesitation to risk his life for that of a fellow creature; or after due deliberation, impelled simply by the deep feeling of right or duty, to sacrifice it in some great cause."[4]

It would have been well had Darwin cited a few well-known observed and recorded examples of the applications of the "imperious word"; and of the sacrifice of one's life in "some great cause." But it probably did not occur to him that any of his readers would question either the recognition of the imperiousness of the *"ought"* or the "deep feeling of right or duty"; or of the knowledge of these having been reached in part through sense-perceptual experiences.

However, had he gone into the matter more specifically, more analytically, he might have clarified his conception that the "most noble of all the attributes of man" belong to him as a product of natural evolution and hence are subjects to be studied and understood by the method of "Natural History"—by the methods, that is to say, the initial steps in which are sensory observations.

In the very same paragraph with these statements we read:

> Immanuel Kant exclaims, "Duty! Wondrous thought, that workest neither by fond insinuation, flattery, nor by any threat, but merely by holding up thy naked law in the soul, and so extorting for thyself always reverence, if not obedience; before whom all appetites are dumb, however secretly they rebel; whence thy original?"

It is noteworthy that Darwin quotes this from the "Metaphysics of Ethics" (translated by J. W. Semple, Edinburgh, 1836, p. 136.)

A comprehensive study of "The Descent" and the "Expression of the Emotions" leaves not a scintilla of doubt—with me at least—that as Darwin wrote this his own answer ("Evolution" as he conceived it) to Kant's "whence thy original?" was in the back of his mind.

But momentous as this is in its implications it is not what specially concerns us here. Our main concern is the knowledge problem involved. This leads us to words in the next paragraph of the same chapter. After speaking almost apologetically of why he felt he could not avoid touching the great problem of

[4] "Descent," 2nd ed., p. 148.

morals, he tells us: "As far as I know, no one has approached it exclusively from the side of natural history."

Here we have a striking example of what may well be called Darwin's naiveté. In pitting his natural history method against the *a priori* method employed by Kant in his doctrine of the categorical imperative as an interpretation of the "imperious word ought," and of "Duty! wondrous thought," Darwin seems to have realized very dimly if at all that he was running head-on into one of the worst tangles of logic as a subject for general treatment. The tangle referred to is that of the relation between the two portions of logic known as inductive and deductive. More specifically stated, it is the relation between sense perception and observation on the one hand, and reason and thought in all their vast scope and power on the other hand. Darwin seemingly felt perfectly certain of the essentiality of both—of their inseparableness at bottom—for getting knowledge by the methods of natural history as he conceived and practiced those methods in all his work. Hence it apparently did not occur to him that anybody would be confused by his approach to the moral problem including the idea of "Duty! wondrous thought," as he was now approaching it.

But the more acquainted I become with the flood of discussion, by friends and enemies of the Darwinian theory of evolution, the more I am impressed by the extent of the confusion, even contemptuous hostility, on this very matter.

I am now convinced that in probably no other connection, in all Darwin said about evolution, is there more to justify the recent conclusion reached by a few students and pungently expressed by Sir Arthur Keith, that even the best of biologists and historians have not yet accepted evolution "beyond their lips."

It may possibly add something to this view if I say that my own efforts during the last decade or more to understand the human species in the entire scope, physical, mental and spiritual, of its nature, had led me to essentially the same conclusion before I came upon Sir Arthur's statement.

It now seems to me impossible for anybody whose technical training and general experience enables him to grasp what Darwin meant by, and included in, natural history, to fail, after a thoroughgoing study of Part I of "The Descent" and the whole of "Expression of the Emotions," to recognize the full justification of Darwin's confidence in both the inductive and deductive sides of logic as defined above.

As something of an indication of his fidelity to reason, thought and the rest of what the deductive side of logic chiefly depends upon, notice the list of topics treated in Chapter III of Part I: "The difference in mental powers between the highest apes and the lowest savage, immense—Certain instincts in common—The emotions—Curiosity—Imitation—Attention—Memory—Imagination—Reason—Progressive improvement—Tools and weapons used by animals—Abstraction, Self-consciousness—Language—Sense of Beauty—Belief in God, spiritual agencies, superstitions."

This list of topics and the fifty-page discussion of them should, of course, be read not as though written by a full-fledged psychologist or philosopher of to-day, but by a full-fledged naturalist of more than three quarters of a century ago.

This list shall serve to bring these "remarks" of mine—already run far beyond what I expected—close to an end. The crux of the remarks that I've been trying to reach all the while is this: Although Darwin says nothing of the sort expressly, the implications of much that he says are unmistakable (to me at least) that the problem of knowledge itself would be for him part-and-parcel of the problem of evolution. The much-used phrase "natural knowledge" would not for him have the usual limited meaning of knowledge of external, sense-perceptual nature, but would include knowledge of knowledge itself as one aspect of the grand sweep of nature in its unified wholeness. Then since the theory of evolution is a product of, and is embedded in, natural knowledge; and this as a whole is produced by men and is constantly being reproduced, revised, and improved by the observations and reasonings of men actually living at any given time, this very year for instance, no causal or other factors of the evolutionary process can rightfully be conceived as lying outside the scope of nature. That this is true Darwinism, not only as to Evolution but as to nature in general, I trust my sketchy remarks have made to appear highly probable at least, to my readers.

Finally as to the relevancy of such a view to the issue between Goldschmidt and Sumner: Sumner's solicitude expressed in the last sentence of his article lest Goldschmidt is leaving "naturalistic biology in a most embarrassing position" does not disturb me nor, I think, any adequately understanding Darwinian. This is so because nothing in the framework of a naturalistically conceived biology can rightly be conceived otherwise than as naturalistic. The Darwinian theory of evolution is only one aspect or phase of the Darwinian theory of the all-inclusiveness and all-adequacy of nature.

Goldschmidt's causal theory of evolution must, of course, according to the standpoint of these remarks, be brought to the bar of natural knowledge as defined above—just as is the case with any other such theory.