Letters

Adoption of the Metric System

Pursuant to the resolution adopted unanimously at the business session of the American Geophysical Union on 7 May 1958 [*Trans. Am. Geophys. Union* **39**, 558 (1958)], Maurice Ewing, president, appointed a Committee on Adoption of the Metric System in the United States.

Bills for the compulsory adoption of the metric system in the United States have been more than once presented to Congress, but they have not been enacted into law, the principal reason being that in each case the effective date proposed followed too soon after passage of the bill. An early effective date would undoubtedly work a severe hardship on the adult population not familiar with the metric system, and it would make obsolete a prohibitive number of everyday items pertaining to weights and measures.

A solution would appear to be a bill to make the metric system the only official system of weights and measures in the United States, effective in not less than one generation (33 years) after passage of the bill. Following this action by Congress, the grade schools and high schools would begin immediately to teach children the metric along with the English system and, during the transition period, would place more and more emphasis on the metric system. At the end of the transition period the English system would still be taught, but the emphasis would be just the reverse of what it is today. A long transition period would result in a smooth change. In a generation most items of equipment involving weights and measures normally become obsolete or are worn out and replaced. Also, persons engaged in professions and trades now using the English system exclusively would normally retire during this period and would be replaced by a new generation thoroughly educated and trained in the metric system.

The questionnaire given below has been prepared for readers for the purpose of gathering statistical information to indicate the degree of interest in this matter. The metric committee of the American Geophysical Union will welcome any comments. Those submitting replies are urged to suggest solutions to difficulties which may be foreseen in the adoption of the metric system.

Additional copies of the questionnaire are available upon request. A small effort on the part of readers to complete and mail this questionnaire will be of invaluable help to the committee. The completed questionnnaire should be mailed to the Executive Secretary, American Geophysical Union, 1515 Massachusetts Ave., NW, Washington 5, D.C.

FLOYD W. HOUGH
Arlington, Virginia

Metric System Questionnaire.

1. Indicate professional field of interest in the AGU _____
2. What approximate percentages of units used in your work are:
   Metric ____ British ____ Other ____
3. Would it be to your advantage if a complete conversion to the metric system could eventually be made? Yes ____ No ____
4. How long a period of time (in years) should be allowed for the conversion?
   10 ____ 20 ____ 30 ____ 40 ____ 50 ____ Longer ____
5. Should the centigrade system of temperature measurement be adopted?
   Yes ____ No ____
6. Do you believe that United States export trade is suffering as a result of the use of British units? Yes ____ No ____ No opinion ____
7. Do you believe that the eventual adoption of the metric system is inevitable?
   Yes ____ No ____
8. Do you believe that the cost of a long-time conversion to the metric system would be prohibitive? Yes ____ No ____
9. In the event a joint committee were established to study the problem, circulate questionnaires, accumulate statistics, and report, it should be sponsored by (check one):
   Professional societies ____ Educational institutions ____ Industry ____
   Government ____
   How should the study be financed? _____
   Would you be willing to assist such a study group? Yes ____ No ____
   In what way? Financially ____ As an adviser ____
10. Additional remarks are welcome. _____

_____

Signature (optional)

Vertebrate Metamorphosis

As a conclusion to his most interesting article, "The significance of vertebrate metamorphosis" [*Science* **128**, 1481 (1958)], Wald states: "Metamorphosis is a basic and general phenomenon, common to the whole vertebrate stock. It includes anatomical, physiological, and—perhaps prior to these—biochemical components, all designed to prepare the animal to leave its natal environment. Necessarily, in order to reproduce, the animal must eventually return, so completing its life cycle. . . ."

As far as the lower vertebrates are concerned, the examples which are listed by the author (species such as the sea lamprey, fresh-water eel, salmon, and certain amphibians) support such a conclusion very well. However, these examples alone do not make it valid for the whole vertebrate stock, mainly because these are illustrations of the *exceptional* rather than the *usual* kind of behavior among the vertebrates.

In the largest group of vertebrates, the fishes, the anadromous or catadromous life cycle that Wald speaks of is very rare indeed, being found in probably less than 1 percent of the known species. The vast majority of fishes remain in essentially the same environment into which they are born, having no need for, and showing no evidence of, metamorphic change to prepare the adult for entry into a special natal environment. In fishes there is often a profound change from a larval to adult stage, but this also is not one that necessarily prepares the animal for entry into a new environment in the sense referred to by Wald.

In regard to the higher vertebrates (mammals, birds, and reptiles), no one will deny that there are vast changes during embryological development, some of which are recapitulatory in nature, but the idea that there are changes at maturity which facilitate a return to the natal environment is indeed far-fetched. This is no more true of a spermatozoan than it is of the entire individual.

When one speaks of the natal (or more properly the prenatal) environment of a higher vertebrate embryo, the reference is almost always to the amnion and its contained fluid. Obviously, even a spermatozoan could not "return" to such an environment, since, in a given individual, such structures could not appear until long after the advent of fertilization.

The most momentous event in the course of evolution of the higher vertebrates is often considered to be the appearance of the amniote egg, primarily because *the adult was then freed of the necessity for a return to the natal environment* in order to reproduce.

Instead of the sweeping statement quoted at the beginning of this letter, I would like to take the opportunity to

offer a conclusion more in line with the evidence presented: Certain species of anadromous and catadromous fishes and probably many amphibians have a most interesting life cycle which includes two types of metamorphic change. The first is a preparation for the animal to leave its natal environment, and the second prepares the adult for re-entry into this environment for reproductive purposes. In some of its aspects, this second metamorphosis is the reverse of the first.

JOHN C. BRIGGS
Department of Anatomy,
University of British Columbia,
Vancouver

Briggs' letter is kind and generous, up to the peroration, in which it characterizes one of my statements as "sweeping." I hardly know what this means; but I suppose that all generalizations sound odd, until some of them, through reiteration, become familiar; and I have tried to keep my sweepings visible.

When I said that "metamorphosis is a basic and general phenomenon, common to the whole vertebrate stock," I meant in part that the relatively few observations of the kind discussed which have been made, already offer examples ranging from cyclostomes to mammals. In all justice, I meant to imply something more: that these phenomena already appear to be so widespread that whatever lines are eventually drawn to delimit them will have to be rather arbitrary.

Briggs stresses the point that anadromous and catadromous fishes include "probably less than 1 percent of the known species." This percentage is irrelevant; also, the phenomenon is not so limited. Beyond such extreme examples as cited in my paper, one encounters in fishes all degrees of the anadromous and catadromous condition. A. Meek says in his valuable book [*The Migrations of Fish* (Arnold, London, 1916), p. 18]: "Fish which leave the sea to spawn in estuaries only differ in degree from those which spawn just beyond brackish water, and there are fish which may spawn on the coast or in brackish water. So that it may be said all degrees of anadromous migration from mid-ocean to the upper limits of streams may take place and corresponding catadromous migrations. . . ."

Apart, however, from this range of life histories, it is generally agreed that the vast majority of contemporary fishes have migrated, perhaps repeatedly, between fresh waters and the sea during their evolution. A. S. Romer [*Man and the Vertebrates* (Penguin Books, Harmondsworth, Middlesex, 1954), vol. 1, pp. 39–40], for example, thinks that though the fishes as a class arose in fresh water, virtually all teleosts now found in fresh water have probably re-entered that environment from the sea: "The primitive teleosts, as we have suggested, evolved in the sea, and the vast majority of the group still live in salt water. They have, however, returned in considerable numbers to the fresh waters *which were the homes of their ancestors* . . ." (italics mine). It is probably true, therefore, that the great majority of what are now stenohaline fishes have had euryhaline forms in their ancestry, and so might exhibit metamorphic changes associated not only with their own migrations, but recapitulating those of their ancestors.

As for traces of biochemical metamorphosis in stenohaline fishes, Clyde Manwell has recently reported finding distinct embryonic hemoglobins in the spiny dogfish *Squalus suckleyi*, the skate *Raja binoculata*, and the marine teleosts, the sculpin *Scorpaenichthys marmoratus*, and the live-bearing surf-perch *Embiotoca lateralis* [*Physiol. Zoöl.* **31**, 93 (1958); *Science* **128**, 419 (1958); *ibid.* **126**, 1175 (1957)].

Altogether, therefore, Briggs comes perilously close to a sweeping statement in saying that "The vast majority of fishes remain in essentially the same environment into which they are born, having no need for, and showing no evidence of, metamorphic change to prepare the adult for entry into a special natal environment."

Finally, Briggs takes issue with my suggestion that the land vertebrates have not left either metamorphosis or problems of migration wholly behind. I speak of "*residues* of metamorphosis" and "*vestiges* of a second metamorphosis," and say with regard to the latter: "I suppose that puberty is so to be regarded. To be sure, this does not prepare a land vertebrate to migrate, for the natal environment is now segregated, and puberty prepares the animal only to mate." I had said earlier that land vertebrates "have developed two special devices" for pursuing ashore their embryogeny in water: "the boxed-in or cleidoic egg, and viviparity." Are these thoughts different from Briggs' remarks about the development of the amniote egg? And though it may be true that the natal environment of a land vertebrate "almost always" refers to the amniotic fluid, I hope the context of my discussion made it clear that I had included (see Fig. 18 of my article) the environment also of the egg, before and after fertilization.

I think that if Briggs will pursue the phenomena themselves, apart from conventional ways of talking about them, he will find, as I have, that it is difficult indeed to know where to stop.

GEORGE WALD
Biological Laboratories of
Harvard University, Cambridge, Mass.