REMARKS ON BIOLOGICAL PROBLEMS IN RELATION TO MARINE RADIOACTIVITY

by Walter CHIPMAN

The presence of radioisotopes in the marine environment has brought to the fore the urgent need for more complete information on problems of biological oceanography, particularly the knowledge of the elemental composition of marine plants and animals and the passage of chemical elements from one form of organism to another. Phases of oceanography dealing with water movement and transport, sedimentation, and the chemical composition of sea water, particularly for many little-known and certain trace elements, have likewise become of increasing interest because of the addition of radionuclides to sea water in this period of the development of nuclear energy and the use of nuclear power.

Although much attention has been given to immediate and local problems of dispersion of radioactive materials and the accumulation of radionuclides by marine fish, animals, and plants used for human food, and some attention has been given to the appearance of fall-out radioactive substances in the marine environment, the presence of radionuclides in the sea has brought the opportunity to study and obtain answers to many fundamental problems in different fields of oceanography by making use of these substances as radioactive tracer materials.

In marine radiobiological investigations, little emphasis has been placed on the ecological relationships of various species of plants and animals and the uptake and movement of radioisotopes by populations. A more complete knowledge of the distribution and growth of populations, their seasonal and geographic changes in size, will make possible a better understanding of many problems in biological phases of radioactivity in the sea. Of particular importance is the knowledge of the rate of accumulation and turnover time within populations. Mention might be made in this regard to the processes of biological transport of radionuclides through the horizontal migrations of many species of fish and the possible transfer of materials vertically through the diurnal migrations of some species of zooplankton. The latter may allow a more rapid movement of radionuclides through different density layers in the sea than by physical processes of mixing. Much of the required information cannot be obtained from studies of turnover times of elements by individuals of the different species alone and must be derived from studies of natural populations.

Valuable information can be gained in regard to accumulation of radioactivity by marine organisms from a knowledge of their elemental composition. The maximum possible accumulation of radionuclides can be estimated for a given specific activity of the nuclide in the environment. Improvement of chemical methods of analysis has been made possible by the use of radioactive tracers to follow the efficiency of various steps in the chemical proceedures. Also of great importance is the use of methods of activation analysis employing neutron sources, particularly for those elements present in minute quantities. Valuable as it may be, the knowledge of the elemental composition of various marine plants and animals does not tell us of

the steps taken in accumulation, the rate of accumulation, nor the accumulation of certain radionuclides present in the sea in various physical and chemical form. Carefully executed investigations in the laboratory and in the field in marine radiobiology and radiochemistry are necessary.

A fundamental law of tracer methodology, one with which we are all familiar, is that a radioactive tracer must be in the exact chemical form of the material to be followed in its chemical and biological processes. Unfortunately, in many laboratory investigations of the uptake and accumulation of radionuclides by plants and animals, little attention has been given to the chemical form of the radioactive material employed. This may have been due in part to the lack of information as to the various chemical states of the element being added to the sea in nature and the chemical forms of the elements present in sea water.

Certain radionuclides may enter the sea in one chemical or physical form and, after entering, may remain unchanged or be changed into another form. A fall-out radionuclide, for instance, may enter in the form of a minute particle or in a dissolved state and then may be present in the sea in ionic solution, as a particle, or associated with particles. We are all well aware of the importance of particle filtration in the uptake of certain elements in the food chains of marine animals. However, uptake of many elements by these animals does not follow the uptake pattern of many of the nutrient chemicals of sea water and may not proceed along the same path as taken in the transfer of energy through the different trophic levels.

It is well established that the fall-out radionuclide, strontium-90, is present in the sea water in ionic solution and its uptake by marine life is related to its presence in this form. Many studies have been made of the passage of a number of elements in ionic solution, such as sodium, potassium, and caesium, across the various absorbing membranes of different marine animals and fishes. In the case of radionuclides of cerium, a great part of the radioactivity when in sea water is associated with particles. The question of biological uptake of particulate radiocerium and the possible uptake of dissolved cerium has recently been raised by Dr CHESSELET and his co-workers at the *Centre des faibles Radioactivités* from their studies on the behavior of fall-out cerium in sea water and on some benthonic invertebrates taken in this area of the Mediterranean which have accumulated radiocerium (CHESSELET and LALOU, 1964*a*; 1964*b*).

In the case of iron and manganese, elements which are important in the physiology of marine organisms, both are found predominantly in the particulate state in sea water since the cations are readily adsorbed on organic surfaces. HARVEY (1937) demonstrated that marine phytoplankton can directly utilize ferric hydroxide adsorbed on the cell walls. GOLDBERG (1952) obtained experimental data which he interprets to indicate that the diatom, *Astrionella*, could utilize only particulate or colloidal ferric hydroxide, whereas iron complexed by organic matter was not available to them for growth. The question arises as to the use of adsorbed hydrated oxides of manganese and the possible role of manganese in some other form. The addition of divalent manganese to sea water does not result in its rapid precipitation, and it seems possible to think that fall-out manganese-54 enters the sea in some form which may allow its uptake from solution. Manganese-54 from fall-out it is accumulated to much higher concentration levels by fresh water molluscs than by marine molluscs. It has been demonstrated that the specific activity of the manganese-54 in fresh water mussels is the same as that in the lake water in which they live (MERLINI, personal communication), which would indicate that here the radionuclide is available in the same chemical form as the stable manganese. It would be difficult to interpret experiments on marine organisms of the accumulation of manganese-54 employing the divalent form unless considerations were given to changes on its addition to sea water and the association of the radionuclide with particles present in sea water.

Many of the trace metals form chelates and complex with organic materials. It is possible that such complexes are important in affecting the uptake and accumulation of many of the radionuclides of trace metals by marine organisms. In some experiments carried out in my laboratory here, it has been observed that chelation and organic complex formation can change the uptake of chromium-51 by different marine invertebrates.

Aggregates formed by mechanical processes acting on soluble organics in the sea may be important in supplying particulate organic matter to the higher forms of marine animals, as evidenced in the growth of laboratory cultures of filter-feeding crustaceans supplied only with this material as food. The question now arises as to the role of these aggregates, which are abundant in the sea, in carrying radionuclides to the marine animals and fishes.

Problems concerning the chemical and physical forms of the elements in the sea and the uptake of particular chemical forms and their radionuclides by various types of marine life give intriguing research problems in marine radiobiology.

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