

regard the phosphate of lime of these nodules as being a direct deposit from the waters of the ocean without the previous intervention of organisms; the small quantities of this substance found in analyses of sea-water prevents us in the actual state of our knowledge from having recourse to this interpretation. But if phosphates are not deposited directly from the waters of the ocean, it is incontestable that by the action in the first instance of vegetable organisms phosphates are without cessation removed from these waters during vital processes, and a notable proportion is fixed in the hard parts of certain groups of organisms.

Organic remains must sometimes accumulate in vast numbers on the sea-bed, and sometimes be buried in the sediments; it seems to us that the decomposition of such organic remains is the immediate source of the phosphates in the concretions here described. We know that *Lingulæ* have secreted this substance since the Cambrian Period, and indeed this process has been going on from geological periods of the most ancient date, ever since the conditions had become favourable to the existence of organisms in the bosom of the ocean. It is evident that the phosphates thus elaborated by organisms ought, when life abandons the organic structures, to accumulate along with sedimentary matters upon the bed of the ocean. The deposits there forming are the seat of many chemical reactions under the joint influence of decomposing organic matter and sea-water. All the mineral substances here described under the name of chemical deposits are the very best proof of these reactions, and although not energetic, they are not the less considerable as to their effect, granted the duration of the action and the mass of substances present. In that pulp formed by the calcareous and siliceous organic envelopes, by the fragments of rocks and minerals reduced to the state of muddy matter, and albuminoid and other matters derived from higher organisms, the phosphates are re-arranged, with the result that phosphate of lime in a nodular form is in some places found in considerable abundance. It may be supposed that this phosphatic matter dissolved in the sea-water impregnating the mud is endowed with the properties of colloidal bodies, for we know that phosphate of lime presents incontestable analogies with certain colloids, for example, with hydrated silica. By admitting that phosphate of lime can effect this colloidal state, it is sufficient that a centre of concretion should arise to initiate precipitation, and the nucleus once formed would subsequently enlarge by successive additions.¹

Many substances may have played, with respect to the phosphate, the role of centre of attraction. It may have originated in the first instance, as we have shown, in the filling up of the hollow spaces of a *Globigerina* shell; afterwards it may be deposited around this shell and agglutinate the surrounding portions of the deposit into a more or less com-

¹ The phosphate of lime may be held to be directly derived from the products of decaying bones of dead animals, upon which carbonic acid exerts a powerful solvent action. At the same time the organic nitrogenous matter of the bones is decomposed into ammoniacal salts, which would readily dissolve in water containing free carbonic acid, and form a solution exceedingly prone to re-deposit the phosphate of lime held in solution on any nucleus or in any cavities or shells.