

are, in the last resort, of biological origin. The phosphoric acid in sea-water is derived chiefly from the skeletons and tissues of the marine fauna. At certain spots great masses of these skeletons are heaped up at the bottom, and here or hereabouts phosphatic nodules are presently formed. In order to explain why the phosphate of decaying bones goes into solution it is not necessary to postulate exceptional conditions in the surrounding sea-water. The solubility of tricalcium orthophosphate in water is a matter which bristles with complications, and experimental difficulties have hitherto proved too great for its exact measurement; but it seems to be of the order of decigrammes per litre. The solubility is much enhanced by the presence of H⁺ ions, *i.e.* of acids. The solvent action of carbonic acid which has been suggested seems, however, to be merely hypothetical. Carbonic acid is so weak that at best it can produce only a negligible concentration of H⁺ ions; moreover, there is experimental evidence that so long as excess of lime (as bicarbonate) is present, calcium phosphate is no more soluble in carbonated than in pure water. In all probability the rapid dissolution of the calcium phosphate and carbonate in fish-bones is simply due to the fine state of division. This effect has already been discussed with reference to sea-shells. The extreme fineness of the inorganic particles disseminated in the gelatinous matter of fish-bones is attested by the translucency of the mass. Or it may even be that the carbonate and phosphate are present in a colloidal form. In either case they will readily yield supersaturated solutions when the enclosing ossein rots away, and as soon as a nucleus presents itself the formation of concretions is ready to begin. Since phosphatic concretions usually occur, as already indicated, in positions where organic remains accumulate on the bottom at a rapid rate, as in areas having a great range of surface temperature, the transference of matter from bones to nodules must have taken place without much delay. Consequently there has been little opportunity for differential diffusion of carbonate and phosphate, so that these calcium salts are invariably found to have been deposited simultaneously. The "Challenger" analyses show 1½ to 3 parts of tricalcium orthophosphate to one of calcium carbonate. Magnesium phosphates being considerably more soluble than those of calcium, the phosphate of bones is re-deposited unchanged after its passage through sea-water; only a trifling percentage of magnesium is shown by the analyses, and this is probably present as carbonate.

Phosphatic
concretions.