view. With the species of the sea-urchin *Micraster* the changes undergone in the course of ages were apparently gradual in all the different characters, and many other instances of continuous evolution might be given. After brief references to the concepts of seriation or the direction of change, Dr. Bather proceeds to discuss the question of pre-determination, which many palæontologists seem to have accepted. The principle is thus expressed: "A race once started on a certain course will persist in that course; no matter how conditions may change, no matter how hurtful to the individual its own changes may be, progressive or retrogressive, up hill and down hill, straight as a Roman road, it will go on to that appointed end." The principle is allied to Driesch's concept of entelechy in ontogenetic development, and the question of its validity seems to be part of the wider problem as to whether teleological categories have any place in biological thought, a question which is answered in the negative by all men of science, excepting the small minority who adopt the attitude of Dr. J. S. Haldane. Dr. Bather next discusses adaptive evolutional "convergence" and passes on to consider Dollo's so-called law of irreversible evolution. He does well to insist that this law is a statement of observed fact, and, understood rightly, need not imply any inherent principle affirming the impossibility of reversal. The next sections deal with the "study of habitat" and "the tempo of evolution", which, it is shown, is variable, depending on changes in the outer conditions. This is illustrated by the comparative study of the development of whales, sirenians, and horses during the Tertiary period, the rate of evolution of these three groups varying with that of changes in the nature of the food. Thus the sirenians underwent a slow change because they retained the habit of feeding on soft water-plants, the horses developed more rapidly in correlation with their taking to the plains and becoming eaters of grain, while the whales, though at first their development was slow, from the Oligocene onwards changed with extraordinary celerity as they adopted and diversified new habits of feeding and living. In referring to the "rhythm of life", Dr. Bather concludes that the phenomenon must reflect the great rhythmic waves that have uplifted the mountains and lowered the deeps, as well as the smaller waves and ripples that have from time to time diversified the face of the earth. The address is throughout both suggestive and stimulating. It concludes on a note of sanguine anticipation for the future.

F. H. A. M.

CORRESPONDENCE.

FLINT PROBLEMS.

Sir,—All efforts to solve the problems of flint formation are likely to be unsuccessful unless we marshal all known facts and deal with them seriatim. At present I doubt if it is possible to give even a satisfactory definition of flint!

Many years ago I found flint at Margate and Studland Bay, which is clearly silicified chalk. In places silicification has not been completed, and these softer parts have been removed, leaving cavities. Near Corfe I came across nodules in the chalk which, with the exception of a thin external crust of flint, are entirely composed of soft, white cryptocrystalline silica. There are flint pebbles at Boscombe and Southbourne-on-Sea that are composed partly of the same cryptocrystalline silica[1] and partly of chalcedonic

[1] *Nature*, May 1, 1890.

and opaline silica. On Chesil Beach there are pebbles which appear to be nothing more or less than indurated colloid silica.

Again, we have at Rottingdean, Walmer, and other places, examples of flint filling up cracks and fissures in chalk that was evidently ex-marine at the time. In some places fractured flints have been repaired by such secondary precipitations of silica, in others (Freshwater) there has been no such reparation in the crushed flints, but at Alum Bay silicate of iron has acted as a cementing medium. At Corfe, though the conditions appear to be the same, I have found the cracks of crushed flints filled with calcite.

Near Faversham there are compound flint nodules, flints within flints—as many as four or five, formed one around the other, with evidence of a periodic cessation of the process of aggregation between each.[1] It is difficult to understand how such processes could operate either in ex-marine chalk or submarine ooze. Again, why are so many flint nodules hollow when they contain fossils? Did the gases of decomposition cause expansion before the silica became completely "set"? Why are cavities so often lined with crystalline quartz when fossils, or parts, are present, and with chalcedony when they are absent? I have frequently noticed this.

Our ignorance of the chemical and physical conditions prevailing at the bottom of the old chalk sea renders the work of the flintist very difficult. What do we know in reference to the pressure, temperature, and composition of the water at that time? Supposing flint existed originally in a colloid state on the sea-bed, then the sponges and other organisms, so often associated with flint, must have existed there too. But this postulates a hard bottom upon which such things would rest, not a soft one into which they would all sink and become buried in ooze. A friend of mine has a flint nodule from the chalk which has been formed around a piece of teredo-bored wood, and another example of a nodule with a nucleus of silicified wood may be seen in the Museum at Dover. Now, did these pieces of wood sink some 2,000 fathoms to the chalk ooze, and then become surrounded with colloid silica, which subsequently became flint? If not, did they, then, sink some depth into the ooze and become enveloped by it? If the latter, was the ooze surrounding the wood replaced by colloid silica, molecule for molecule, or was the ooze mechanically displaced by the colloid during its accrescence on the wood? If we cannot admit either of the foregoing we are driven to the conclusion that the silica was formed around the wood while suspended in the water. If objects suspended in water sink more slowly as the pressure increases, there might be time for the deposition of colloid silica around organisms before they reached their final resting-place in or on the ooze.

C. Carus-Wilson.

Strawberry Hill.
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[1] *Nature*, June 28, 1917.