knowledge of the living types by study of closely related genera and species. It will progress backwards to earlier geological horizons. Frequently the line of affinity may be found to be more or less seriously interrupted, and gaps may have to be bridged by hypothesis rather than filled in by demonstration. But in favourable instances, and probably the ferns are more favourable than any other phylum of plants, the lines can be traced back with reasonable assurance of affinity of the plants compared to the fossils of the Primary Rocks.

Comparative morphology as applied to the Filicales may be held to have amply justified itself, and to have presented in a coherent and natural phylum a convincing evolutionary picture. Much of the detail may be wanting, and it may be far from being worked out satisfactorily into all its modern ramifications. But the main outline is becoming clear, so that working back comparatively we can build up from the converging downward lines a picture of an archetypic fern. It comes out as a type of vegetation not very different from those plants that constituted the vegetation of the Rhynie Chert. We need not assume that these plants were actual fern-ancestors, but it is not difficult to imagine how from such a type of vegetation as they present a plant might have been derived which would rank as an early Cenopterid.

The Filicales are, however, an exceptionally favourable instance. From what has been said, it will be seen that even this phylum vanishes downwards into uncertainty, and other lines are still less clear. We arrive finally at that *terra incognita* of the early Palæozoic Period sketched by Seward. In this I see nothing that

is deplorable and little that need be held as depressing. Why should we pledge our sense of satisfaction in phyletic study to an evolutionary tree with a single trunk? Why should failure to find such a tree lead any one endowed with a spirit of adventure to sheer off from formal morphology? However many the starting-points of new phyla may have been, or the separate lines of origin of such parts as leaves, the general position of evolutionary theory remains as sound as before this wave of pessimistic negation struck it. Evolutionary history must depend as before primarily upon formal morphology: the study of the "process of development" cannot be held as satisfactory without the "record of development." I am glad to find a somewhat similar opinion expressed from the chair of the Zoological Section at Liverpool in the words that "Morphology must be the forerunner of Physiology."

These two aspects of the study of organic nature should be held to be more than ever inseparable and co-ordinate in the modern developments of biological science. Though specialism may threaten divorce, this should be resisted by all who entertain broad views. A school based primarily on the study of "process of development," and with the "record of development" relegated to the background, might turn out good statisticians, but it would probably fail in converting them into historians. This is what we have been threatened with in recent years. But the president of the Botanical Section of the British Association gives his adhesion to the only sound line when he advocates the co-ordination of physiology and morphology—that is, of the studies respectively of "process" and of "record."

Oysters and their Nutritive Value.

By J. R. NICHOLLS.

THE natural oyster beds of England are a valuable part of British fisheries, and English oysters have been held in high repute from time immemorial. It is interesting, therefore, to find that scientific attention has been directed towards the oyster and its problems. Dr. E. S. Russell has produced an interesting paper based on an elaborate series of analyses carried out by the Government Chemist's Department, whose report is included in the publication.¹

As a rule, monthly samples were examined from Burnham, Ipswich, Mersea and Whitstable during a period of a year. In all, 49 complete analyses are recorded. The average weight of meat per oyster was found to be greatest in the autumn or early winter, and the heaviest meats came from Whitstable, the order of the other districts being Ipswich, Mersea, Burnham. The proportion of water was practically constant. No clearly marked seasonal variation was observed in the percentage of fat, although it appeared to fall off in the autumn and winter. Proteins showed a well-marked change, being highest in the spring months and lowest in the second half of the year, but the total quantity of protein per oyster showed an increase during the growth period and remained nearly constant thereafter.

¹ Report on Seasonal Variation in the Chemical Composition of Oysters. By Dr. E. S. Russell (Ministry of Agriculture and Fisheries, Fishery Investigations, series 2, vol. 6, 1923, No. 1). H.M.S.O. 3s. net.

The most prominent feature was the change in glycogen, which showed a fall in the spring and a rise in the autumn. A general correspondence was observed between the variations in dry weight and variations in glycogen, indicating that the fattening of oysters in the autumn was due to accumulation of this carbohydrate. Glycogen occurs mainly and perhaps exclusively in the large vesicular cells of the connective tissue, and is the main, if not the sole, carbohydrate. As emphasised in the Government Chemist's report, it was found necessary to analyse a special portion of each sample for glycogen immediately after opening the oysters, as glycogen rapidly alters during the preparation of samples for analysis. It seems clear that surplus food material is stored mainly in the form of glycogen, and that this reserve is utilised certainly for the development of the sexual products, and probably also to maintain metabolism during periods of scarcity of food. The part played by glycogen in oysters is therefore similar to that played by fat in vertebrates.

The nutritive value is greatest in the autumn and early winter, hence oysters are then best as an energy-producing food. This period roughly corresponds with "the months with an τ " in accordance with the popular idea.

Dr. J. H. Orton investigated the mortality among English oysters during 1920-21, and he has issued a summary² compiled from chemical, bacteriological and biological reports, part of which are to be published in *Fishery Investigations*, series 2, vol. 6, No. 3, and part later. During the winter of 1919-20 unusual mortality was reported in the oyster beds of Italy, and in the summer of 1920 similar conditions had spread to the beds of Western France and the Thames estuary. The epidemic died down during the winter of 1920-21, but reappeared in the summer of 1921 in the beds of the Thames estuary, English Channel, and North and Western France. The abnormalities of 1920-21 in the Thames estuary were investigated, particular attention being paid to (a) physical conditions, (b) oyster pests, (c) parasites, (d) observations on sound and weak oysters, and (e) possible direct poisoning from dumped munitions.

There is a lack of trustworthy information regarding the normal mortality of oysters, but English oyster planters estimate it at 10 per cent. in locally grown and at a higher proportion in relaid oysters. The loss occurs mainly in the summer months, and there is no one assigned cause. Variations in the temperature and salinity of the sea affect oysters, especially at the spawning period, and the effects of predatory enemies are of course evident, but parasites are normally absent. None of these factors accounted for the abnormalities under review.

Little has been recorded of the pathology, physiology, or even the histology of oysters. Various hitherto undescribed symptoms observed in weak or dying oysters were found to be probably normal. The most constant abnormal symptom, now observed for the first time, was the occurrence throughout the tissues of microscopic muscle spindles, which appear to be due to muscular degeneration. They can be produced if the tissues are bruised or if the oyster is starved, but poisons appear to have little effect. The phenomenon may be normal, but the condition of excessive myolysis is pathological, and requires further study.

It is known that munitions were dumped in the Thames estuary and elsewhere prior to 1920, and this might have caused local poisoning. A saturated solution of T.N.T. (1 in 10,000) kills oysters in a few days, but no appreciable or significant amount was

present in the water of the Thames estuary after November 1920, either in solution or as floating particles. The conclusion is reached that the unusual mortality was not due to T.N.T., although a negligible amount of death may have occurred by ingestion of grains of T.N.T. by the oyster. Nitrites, oil and sodium picrate are not regarded as even probable causes of mortality.

From a large number of analyses of both healthy and sick oysters made at the Government Laboratory, it appears that oysters normally accumulate traces of metals such as copper, zinc, tin, iron, arsenic, etc. There is no uniformity in the proportions of metals present, nor do the quantities seem to be harmful to the oyster. It is suggested that the medicinal properties of oysters may depend upon these traces of metals. The metals are concentrated in the blood cells, and particular oysters may contain a far greater proportion of metals than the soil upon which the oysters rest. Mercury, barium and lead were not found either in oysters, soils or tow-nettings. Traces of arsenic are present in both sound and sick oysters, with, apparently, an accumulation in weak ones up to about five parts per million on the fresh meat. Of sound oysters yielding the maximum amount found it would be necessary, however, to eat more than two dozen to take the minimum medicinal dose of the British Pharmacopœia, and to eat about three thousand to take the minimum recorded fatal dose.

Varying quantities of arsenic from small to suspiciously large were found in soils, silts and tow-nettings; but some interesting experiments are recorded in which oysters have been kept in sea water containing white arsenic for many months without suffering harm. Under such conditions they easily absorb arsenic and easily lose it again, giving off continuously an arsenicated gas, probably arsine. The gas produced daily is minute in quantity, but can be easily recognised by the strong characteristic odour. The mode of absorption and retention of arsenic is not known, but it appears to be held differently from copper, zinc, etc. Arsenic, as well as most of the other metals, is present in sea water in very minute quantities.

No single cause or group of causes was found singly or collectively to account for the heavy and unusual mortality of 1920, but the investigation would appear to be of great interest and value to an industry to which very little scientific attention has been paid in the past.

² Summary of an Account of Investigations into the Cause or Causes of the Unusual Mortality among Oysters in English Oyster Beds during 1920 and 1921. By Dr. J. H. Orton (Journal of the Marine Biological Association, vol. 13, 1923, No. 1).

Obituary.

PROF. ROBERT TIGERSTEDT.

ROBERT TIGERSTEDT, professor of physiology at Helsingfors, died on December 2, 1923. Born in that city on February 28, 1853, he was the son of the well-known historian Prof. K. K. Tigerstedt and Evelina Degerman. Educated in Helsingfors, he took his degree in 1869, and at the age of twenty-three was appointed assistant in the Physiological Institute of the University. Ten years later he became professor of physiology at Stockholm, which post he resigned to return to Finland in 1900, at the time when that country was almost crushed out of existence by Russia. Appointed

professor of physiology in the University of Helsingfors he remained there until his death.

Tigerstedt devoted a long life to physiology, and this science has lost a most distinguished teacher, as well as one whose personality and wide knowledge rendered it easy for his contemporaries in other countries to give him a foremost place among those who have contributed to the establishment of physiology as an experimental science.

Though the names of famous physiologists from Harvey onwards are familiar to many, it should be recognised that physiology as it exists to-day has