With the smaller Berkeley cyclotron, which gives particles of about half this energy, a considerable amount of biological work has already been done. The effect of neutrons in killing mice, Drosophila eggs, bacteria and fern spores, in producing chromosome abnormalities and in inhibiting growth in wheat seedlings has been compared with similar effects produced by X-rays and gamma-rays. The effects are in general qualitatively similar, but suggest that in most of these cases the biological effect per ionization in the tissue is greater for neutrons than for X-rays. That this is not a general phenomenon is shown, however, by the experiments of Timoféeff-Ressovsky and Zimmer, who find that neutrons are somewhat less effective per ionization than X-rays in the production of gene mutations in Drosophila. The investigation of the dependence of the biological efficiency per ionization upon the specific ionization of the ionizing particle is one of the most promising methods of investigating the mechanism of the biological action of radiations.

Following the experiments on animal and plant material, the treatment of cancer patients with neutrons has now begun at Berkeley. A satisfactory degree of collimation of the neutron beam, which is essential for cancer treatment, has been obtained by the use of a lead-lined channel in a water tank. It is not yet known how successful the use of neutrons will be in the treatment of cancer, compared with X-rays. Encouraging therapeutic results have, however, already been obtained in another direction, namely, in the treatment of leucæmia by the oral administration of radiophosphorus. A marked fall in the white cell count and improvement in the condition of the patient follows the dose, which is repeated at intervals when called for by a rise in the white cell count.

Numerous uses for the artificial radio-elements in experimental biology have already been found, particularly in investigating metabolic problems. The admixture of a small quantity of a radioactive isotope with a larger mass of inactive atoms serves as a tracer for these atoms, and enables one, for example, to find out what proportion of a particular element administered orally is excreted immediately, and what proportion is taken up by each organ. If sodium chloride containing some radioactive sodium is swallowed, sufficient will find its way into the hand in ten minutes to affect a Geiger counter shielded from the rest of the body. Injected intravenously in one arm, its presence can be detected in the other arm some twenty seconds later, an experiment having possible applications in the investigation of circulatory disorders.

THE HABITS OF SALMON

IN recent years, intensive investigation of the life-history and habits of salmon and trout has been carried out in all the countries where the species are of importance. The results of the investigations were recognized by a symposium on salmon at the summer meeting of the American Association for the Advancement of Science in Ottawa in 1938, and by a morning devoted to the subject at the recent meeting of the British Association at Dundee.

Salmon spend from one to five, and normally two or three, years as parr in fresh water. Here recent investigations have shown that growth is not entirely seasonal but that, contrary to expectation, a marked slowing down, if not cessation, of growth occurs in August when conditions might normally be expected to be favourable. This coincides with the experience of trout anglers, to whom August is often anathema, and of fish farm operators who, however, recognize a close connexion between water temperature and food intake and digestive activity. Mr. K. R. Allen has already noticed this fact and, at the Dundee meeting, Dr. K. Carpenter argued that the diminution of growth and, concomitantly, of the intake of food organisms, was directly associated with a marked decrease in the number of organisms available in the streams.

It has long been recognized that in their second year, or for those that remain so long, in their third autumn, certain male salmon parr may become sexually mature and may spawn with adult females. That the spermatozoa of these precocious fishes functioned successfully was shown at least fifty years ago. Prof. J. H. Orton and Mr. J. W. Jones have recently pointed out that a quite considerable proportion of the male parr may be ripe, and Mr. Jones stated at Dundee that by dissection it is possible to trace during the smolt stage in the following year those which had spawned some six months earlier. The significance of this precocity is not yet understood. It is unlikely that it forms an important contribution to the continuance of the stock, but it is quite possible that it may affect the length of life spent in the sea. The fish concerned may return after a

shorter, or longer, period of sea feeding than those which did not spawn in the parr stage, among which are included all the females. The present writer, however, recently examined a female salmon which had apparently become voluntarily landlocked in a long and deep Scottish loch, and in the course of its seven years of life had spawned at least twice.

Once the parr become smolts and descend to the sea they are lost in the widths of the ocean, but something may be learnt of their routes of travel when, their feeding finished, they touch the coast and continue onwards to fresh water. From Ardnamurchan Point on the west coast of Scotland, the salmon either stay in the locality or travel south, it may be as far as the Liffey in Eire or the Conway in Wales. But, from only thirty miles farther north at the island of Soay off the south coast of Skye, and then up through the Minch to Cape Wrath, the majority of fish which strike the coast do not belong to the neighbouring rivers and do not travel south. They go north to Cape Wrath, along the north coast and, in many cases, down the east coast. From the middle area (near Bergen) of the outer island belt on the Norwegian coast, the fish spread both north and south, some to very considerable distances: one fish travelled some 1,600 miles from the place of marking before it was recaptured on the inner shore of the White Sea. From another marking station near the North Cape, on the other hand, Prof. Knut Dahl and Dr. Sven Somme have found that the fish made no long migrations southwards, but many were re-taken, like the salmon marked in the north-west of Scotland, to the eastwards. They travelled along the north coast of Sweden, Finland and Russia as far as the eastern limit of *Salmo salar* in the River Petchora. On the other hand, the movements of the salmon captured, marked and released at the east end of the north coast of Scotland, on the Scottish east coast and close to the mouths of the Norwegian fjords, are limited close to their original locality or the immediately neighbouring rivers.

The inference to be drawn from a consideration of all the marking experiments and other relative data is that the feeding ground for the European salmon is not in the North Sea. The movements revealed are not inconsistent with the probable journeys of fish from an area some distance to the west or north-west of the British Isles. It would, further, seem probable that the majority of the fish going to the rivers flowing into the North Sea enter that area by the open channel between Shetland and Norway, and some possibly by the Fair Island Channel, but relatively few through the Pentland Firth.

In spite of the distances which many of the marked fish travel, it would appear that they do so not in random wanderings but in the course of a definite journey to their native river. Every angler and net fisher of experience knows that different rivers contain salmon of different character. Some rivers, for example, have salmon early in the season, and some only later in the spring and summer; some rivers contain essentially grilse, others chiefly older and larger salmon. Such differences might be ascribed to selection by the fish on account of physical characteristics of the river itself. But Mr. P. R. C. Macfarlane stated that other evidence such as the lengths of the fish at the end of each year of life, as shown by measurements of the scales, the condition factor (the relationship of weight to length), and the type of scale growth, points to the existence of separate biological communities in each individual river. As cases in point, a salmon marked in Scotland and recaptured in Norway had scales with parr growth of a very characteristic Norwegian type, while others marked on the Norwegian coast similarly showed parr growth exactly comparable with the known type of the Scottish rivers in which they were recaptured.

W. J. M. M.

OBITUARIES

Dr. G. J. Robertson

DR. GEORGE JAMES ROBERTSON, senior lecturer in chemistry in the United College, University of St. Andrews, died suddenly on September 5 at the age of forty-one years. A son of the late Mr. James Robertson, head master of Colinsburgh School, Fife, he entered the University of St. Andrews from the Madras College, St. Andrews, in October 1916. He undertook military duties soon afterwards, and held a commission in the Gordon Highlanders, 51st Highland Division. He was on active service in France from September 1917, and in March 1918 he was taken prisoner at Cambrai and interned in Germany until the end of the war.

Robertson returned to the University of St. Andrews in 1919, and graduated M.A. (1921) and B.Sc. with first-class honours in chemistry (1922). He held in succession a Carnegie Research scholarship, fellowship, and teaching fellowship in the Chemistry Department at St. Andrews. In 1924 he was awarded