example, with the Federal Polytechnic at Zurich or the Technical High School of Charlottenburg did not exist in Great Britain. The scale on whch they were designed, their large staffs of distinguished teachers, the number of full-time students, students who had remarkably good secondary school training and had passed a rigorous entrance examination, astonished all English visitors. The English organic chemist with industrial experience was equally astonished at, for example, the Leverkusen or the Badische factories. These factories differed from the corresponding English factories in scale, in the size of the buildings, their staffs, their financial results, just as the British schools differed from the corresponding German institutions.

The number of students taking a degree in pure science at 17 English and Welsh Universities in 1913–1914 was 1867. In 1921–22 the number was 4575, *i.e.* about two and a half times the 1913–14 number. At the University of Cambridge the figures were as follows:

	1913–14.	1921–22.
Number of chemical students working	498	804
Research workers	10 (about)	29
Staff, including professors	25	43

The growth of the dyestuffs industry within this period is well known, and there has been a similar growth in the fine chemical industry. In 1913 some 100 fine chemicals were made in England, whereas 4000 are now being made; for every ton of fine chemicals made here in 1913 exactly 2½ tons are made to-day. This ratio is identical with that of the increase in science students taking a degree course.

Is it possible that this parallel growth in our teaching institutions and newer industries is accidental? The figures are symptomatic, but they indicate that the strength of our higher teaching bodies is a measure of our strength in the industries depending on invention.

It may be said that there has been in Germany, too, and no doubt in other countries, a great increase in the number of students at their High Schools. In part this is one of the social changes brought about by the new industrial revolution.

The increase in the number of chemical students is partly due to the publicity given in 1914 to the renascent dyestuffs industry, and to the support given by public opinion and by the Press for the first time in our history to those engaged in these industries. These industries open out to a young man who has a love of research the opportunity of earning a livelihood in a most interesting way, with the added possibility, if his inventions prove commercially successful, of earning considerable profits. Before the War it was difficult to live by research.

It is probable that the grants made by the Department of Scientific and Industrial Research have tended to increase the number of chemists undertaking training, "for the underlying object of the Scheme of Grants is the output of an increased number of trained scientific investigators." At the same time, the Department has done much to increase the possibility of finding employment for chemists. The Department, including its headquarters staff, boards and committees, Fuel Research Station and the Research Associations, already employs 78 chemists, none of whom were employed in 1913, at salaries ranging from about 250*l.* to 2000*l.*, the majority between 350*l.* and 700*l.* In other Government Departments, too, there has been a great increase in the number of chemists employed. In 1913–14 the staff of the Government Chemist consisted of 48, with a salary range of 120*l.* rising to 1500*l.* The majority of the posts ranged from 120*l.* to 500*l.* In 1921–22 there were 75 posts, ranging in salary from 300*l.* to 700*l.* At the War Office in 1913–14 there were 22 posts and 2 teaching posts at the Ordnance College. The salary range was about 150*l.* to 550*l.* In 1921–22 there were 93 posts, with salaries ranging from 300*l.* up to 1200*l.*, but with the majority falling within a range of 300*l.* to 700*l.* At the Admiralty in 1913–14 there was one inspector of cordite, in addition to the teaching staff at the Royal Naval College at Greenwich and the schools at Dartmouth and Osborne. In 1921–22, in addition to these teaching staffs, there were 20 posts with salaries of from about 150*l.* to 600*l.* The total number of chemists who can to-day find employment in the service of the above Government Department is thus 193 more than in 1913.

In the 1921 report of the Department it is stated that of the 132 students receiving grants 24 found employment under the State or under State-aided research institutions, 22 went into the teaching profession, and none went into industry, no doubt owing to the slump in trade.

If our fine chemical industries begin to increase their staffs regularly, as in prosperous years they will, the situation will be improved, but it is to the general trade of the country and not to the specifically chemical industries that we must look to give employment to all those who have taken a chemical degree.

Large Telescopes and their Work.

SIR FRANK DYSON'S presidential address to the Optical Society on February 8 on the subject of "Large Telescopes" dealt with the progressive advance of astronomy so far as it was brought about by the increased optical powers of telescopes. The Copernican system was established before the discovery of the telescope, but Galileo's telescope removed many difficulties and commanded its acceptance. The great telescopes of Herschel revealed the vast extent and variety of the stellar system. At the beginning of the nineteenth century, excellent achromatic telescopes of 6 inches were made by Fraunhofer and Merz, and in 1824 an object glass of 9·6 inches was made for Struve at Dorpat with which he carried out his great work on double stars.

When the Russian National Observatory at Polkovo was founded a 15-inch glass was obtained from the Munich firm, and this was the largest refractor in the middle of the nineteenth century. The large telescopes of this time were the reflectors of Lord Rosse and Lassell, and with them the heat from the moon was measured and new satellites of Uranus and Neptune discovered. A new development in reflecting telescopes came with the process of silvering on glass, and gradually these superseded speculum. In England in the early 'eighties photography of nebulæ began with Common's photograph of the Orion nebula, and was pursued by Isaac Roberts. The manufacture and mounting of reflectors was brought to a high degree of perfection by Ritchey at the Yerkes Observatory, but it was with the Crossley reflector, made by Calver and presented to the Lick Observatory by Sir Edward Crossley, and remounted by Keeler, that most systematic work was done.

Meanwhile, larger refractors were being made. In 1868 one of 26 inches aperture was made by Cooke for H. S. Newall of Newcastle. This was soon followed by large telescopes in America by Alvan Clark, by Grubb in England, and the brothers Henry in France. In 1892 a 36-inch glass was made for the Lick Observatory by Alvan Clark, and a 40-inch for the Yerkes Observatory in 1897. These large telescopes led to the discovery of new satellites, the accurate determination of the sizes of planets and satellites, but their main work—used visually—was the discovery and measurement of large numbers of double stars, leading to a very satisfactory knowledge of the masses of stars. Used with the spectroscope, they gave the velocities of stars to and from the earth, and enabled the velocity of the sun among the stars to be determined as 19 kilometres per second. This result, in combination with measurements of angular motions of stars, served to give the mean distances of stars. Large photographic refractors have made possible the measurement of the actual distances of thousands of stars, leading to a much more complete view of the stellar system.

The discoveries made by the large 60-inch and 100-inch reflectors of Mt. Wilson and the 72-inch of British Columbia were also detailed, culminating with the measurement of the size of the disc of Betelgeuse and of several other stars by the interferometer as applied by Michelson.

Irish Sea Plankton.[1]

SIR WILLIAM HERDMAN, in an interesting paper recently issued, gives a summary of plankton researches in a single area extending over a period of fifteen years, and compares the results in each year in such a way that certain general facts are at once apparent.

The object of the investigations was twofold: "(1) To study the distribution of the plankton as a whole, and of its various constituents during the year; and (2) to arrive at some estimate of the representative value of the samples collected in the plankton nets."

The results show very clearly that the distribution of life in the sea is not uniform, but that the organisms appear in patches. Although this applies to a certain extent to all the plankton, it is especially the case with the copepods, which are frequently present in large swarms in one place, while possibly only a short distance away few or none occur. This naturally affects the distribution of other organisms feeding on the copepods, especially fishes, and is of fundamental importance. The diatoms were found to be more evenly distributed both vertically and horizontally during their maximum in the spring than at any other time. Comparing the records for the fifteen years (1907–21), there is always this spring maximum of phytoplankton (chiefly diatoms), which may range from March to June and reach to hundreds of millions in one haul, a dinoflagellate maximum, in much smaller numbers, coming on about a month later; and later still, a copepod maximum ranges from June to October. In late summer or autumn each group may have a second smaller maximum in the same order.

That the bulk of the plankton consists of a small number of genera, chiefly diatoms and copepods (and only a few species of copepods), is well established, and these few form the chief food of most of the marine animals. So far as fishes are concerned, copepods are by far the most important food of the young stages, and also of the plankton-eating adults; but as most copepods are predominantly diatom feeders the presence of diatoms is quite as important to the fish as to the copepod. With regard to the phytoplankton, however, Sir William Herdman apparently regards it as the direct food of many larval fishes, at any rate of the plaice in its infancy, which he has seen with its stomach full of diatoms.

The diatom maximum occurs usually just before the time when most of the fish larvæ begin to be abundant, and the copepods follow. These plankton investigations are thus of great importance relative to the food of fishes.

Dr. Johan Hjort suggests that large mortality among the fish larvæ may occur because of the lack of suitable food at the time when they begin to feed. In the present plankton investigations, together with data gathered from experiments in the plaice hatching at the Port Erin Biological Station, it is shown that diatoms are abundant usually a short time before the very young plaice are set free; but in four out of thirteen years the diatoms were late, and in these years it is possible that the young fishes may not have found enough to eat. "The evidence so far seems to show that larvæ set free as late as March 20 are fairly sure of finding suitable food: but if they are hatched as early as February they run some chance of being starved."

While discussing fully the phytoplankton in relation to fish larvæ very little is said of the zooplankton other than copepods, and one would infer from the conclusions that it is only the diatoms which are of importance as young fish food in the spring. It is, however, probable that in spite of the fact that more diatoms than anything else are present, yet the zooplankton is really of more direct value as food for the larval and post-larval fishes: for example, cirripede nauplii and mollusc larvæ besides copepods, the latter, although not at their height in the spring, yet occurring in large numbers.

Sunlight is shown to play a very important part in the growth of the plankton. In the daytime, however, the largest hauls are usually not at the surface but at about five or ten fathoms, the depth varying with the meteorological conditions. It is regarded as probable that the spring phytoplankton maximum is due chiefly to the great increase of sunlight aided by the winter increase of carbon dioxide and other food matters. The rapid disappearance of the diatoms after the spring maximum is accompanied by a greater alkalinity of the water, and it is suggested that it may be due to the injurious effect of their own metabolism. May not the explanation lie partly in the fact that the diatoms are eaten by an enormous number of pelagic animals coming on just after the diatom maximum?

As to the representative value of the samples collected in the plankton nets, it is shown that variation in the composition of similar hauls is great. These differences show clearly that the life in the sea is not spread evenly either horizontally or vertically, but everywhere occurs irregularly. Simultaneous hauls of similar nets were usually different in quality even if alike in quantity, and the same applied to successive vertical hauls in which the amount of organisms was much the same in each haul but different in kind.

In plankton investigations in which tow-nets are used, however carefully the experiments may be carried out, there is necessarily a great deal of inaccuracy, which is freely admitted and discussed. None of the numerical results can be absolutely exact, but when, by examining and recording these, certain phenomena are seen to repeat themselves year after year, we can at least feel sure that by making these careful quantitative experiments in connexion with numbers of hauls all carried out in an exactly similar way, we are approaching the solution of the general problems relative to the distribution of life in the sea.

M. V. L.

[1] "Spolia Runiana. V. Some Results of Plankton Investigations in the Irish Sea," by Sir William Herdman. Extracted from the Linnean Society's Journal—Botany, vol. xlvi., July 1922.