heated metal undergoing compression and elongation is such as to insure good practical results.

It also follows that if the heat between these points can be ascertained, it may *only* be necessary to ascertain the fusion-point of any given steel, from which the working temperature can be determined, for the welding heat will obviously be a constant of temperature below the fusion-point of the steel sample, and it is probable that the discrepancies so often observable are simply due to deviations from the critical temperature required for welding and rolling purposes.

The welding or rolling heat should correspond to the fusion-point of steel, which is governed mainly by the amount of carbon it may contain, and possibly other elements may play a part in affecting the final result.

Finally, as the results of purely practical experience, the writer has been led to think that the term impurity, as applied to the mixed foreign elements present in iron, "is simply a conventional one, applicable only under certain rigid conditions of temperature combined with manipulation"; and these must be present in fixed quantities, bearing uniformly the same ratio to each other. It follows that under other conditions of temperature and manipulation a product possessing the same physical properties might be produced from a material sensibly differing in composition from that quoted above.

It is well known that those solely engaged in the manufacture of iron and steel have, "independent of the teachings of science," long ago come to the conclusion that iron undergoes unaccountable changes. It is asserted that ordinary chemical analyses afford no explanation of the observed phenomena; further research is insisted upon. To use their own words, they ask "What is iron? In our practice something often happens to iron of which your analyses afford no explanation." It is to be hoped that recent research has partly solved the problem; and that, by a further study of the metal itself, some clue may be found indicating more clearly than at present that iron is either a true chemical compound, or, if not, subject to allotropic modifications.

Practically, it does not seem to matter which, as, to quote the words of Dr. Gore, "every substance becomes a more or less different substance at every different temperature" (*Phil. Mag.*, May 1890).

JOHN PARRY.

THE GROWTH OF THE PILCHARD OR SARDINE.

IT was long since proved that the pilchard of the south-west coasts of England and the south coast of Ireland is the same species of fish as the sardine of the Atlantic coasts of France and Portugal, and of the Mediterranean. But there are apparent differences in the sizes and habits of these fish in different regions, of which the explanation has only recently been sought. The life-history of the species has been studied during the past few years with great care by several naturalists at various points of the coasts along which its habitat extends; and as a result of these researches, the extent to which its local peculiarities are real or only apparent is gradually being ascertained. Thus Marion at Marseilles has established the facts that the Mediterranean sardine in that neighbourhood spawns chiefly in February and March, but that the spawning period extends from December to May, that the adult fish does not exceed 18 cm. in length, and that the smallest sexually mature individuals are 15 cm. long. The majority of the pilchards caught by drift-nets on the south coasts of Devon and Cornwall are from 20 to 25 cm. in length, while those which I have seen in the ripe condition were 23 to 25 cm. Thus it is clear that the Mediterranean sardine, at any rate in the Gulf of Lions, is in its adult state a much smaller fish than the Cornish pilchard, although no structural differences have yet been described which would separate the two as local races or varieties.

The well-known French sardine, such as we see it preserved in oil in tins, is also a small fish. The sardine fishery and the sardine-preserving industry in France are carried on along the south coast of Brittany from La Rochelle to Brest. The great majority of the sardines caught there are fish from 13 to 16 cm. in length. Considering the short distance between Cornwall and Brittany, it might be suspected that these fish are not full grown; and Prof. Pouchet, Director of the Zoological Laboratory at Concarneau, tells us in his Reports that these sardines are young fish which have not yet reached sexual maturity. In fact, full-grown sardines of the same size as typical Cornish pilchards are also caught on the Breton coast, and are locally distinguished as "*sardines de dérive*," the small fish used for tinning being called "*sardines de rogue*." The adult sardines are captured principally in winter, the *sardines de rogue* in summer. The question therefore arises whether small pilchards of the same size as the *sardines de rogue* of the French coast occur on the coasts of Cornwall, and if not, why not. During the four years I have been at the Plymouth Laboratory I have never heard of any such fish being caught by the fishermen. Not long ago I asked Mr. Dunn, who has been engaged in the Cornish pilchard trade the greater part of his life, if he had ever seen any pilchards of the same size as French sardines, and he said he never had. He is connected with the factory at Mevagissey, where adult pilchards are prepared in oil in tins in the same way as French sardines, and he told me that some years ago the owners of the factory took steps to ascertain whether pilchards of small size could be captured near Mevagissey. A seine of the kind used by the French fishermen was procured from France, and several trials were made with it; but instead of half-grown pilchards of the required size, it captured only very young specimens 2 or 3 inches long. The recent capture, therefore, in nets belonging to the Marine Biological Association, of young pilchards similar in size to the French *sardines de rogue* is a matter of some interest and importance. The discovery also adds considerably to our knowledge of the growth and history of the pilchard.

Some months ago the Director of the Plymouth Laboratory was instructed to procure a fleet of small-meshed drift-nets for the purpose of catching anchovies, in order to ascertain at what seasons and positions and in what abundance these fish appeared off Plymouth. These nets are five in number, each being 60 fathoms in length; the mesh is about $\frac{1}{2}$ inch square, or 70 meshes to the yard. They were shot a few miles outside Plymouth Breakwater on November 3, 4, 5, and 6, and on each occasion the chief part of the catch consisted of pilchards measuring 13 to 16·5 cm. in length. The rest of the catch consisted of a few full-grown pilchards, a few young mackerel, a few sprats, and sometimes a few anchovies. On each occasion there was a considerable difference in size between the smallest of the large pilchards and the largest of the small. The spawning period of the pilchard off Plymouth extends from the beginning of June to the beginning of November—five months—and may possibly be prolonged a little beyond these limits. Now all the available evidence tends to show that even the smallest of the young pilchards above mentioned, 13 cm. in length, could not have reached that size if hatched the same year, even if they were derived from eggs shed in May. For in the latter case they would be only a little more than five months old. Meyer found that herrings at five months were only 6 to 7 cm. long, and Marion states that the sardine at Marseilles is 7 cm. long at the same age. It might be argued that the Atlantic pilchard grows faster than the Mediterranean sardine, but it can scarcely grow so much faster as to reach 13 cm. in five months. It is pretty

certain, therefore, that these young sardines were derived from the previous year's spawning, and were between twelve and seventeen months old, probably thirteen to fifteen months. This being the case, the young pilchards hatched the same year ought to have been discoverable. Day states, doubtless on Mr. Dunn's authority, that young pilchards are first seen in September, 3 or 4 inches long—that is, 7·5 to 10 cm. Mr. Dunn himself tells me that the young pilchards about this size regularly occur off this coast in autumn, and that he has seen them taken in seines and in the stomachs of whiting. I found young pilchards myself in the stomachs of the young mackerel taken in the anchovy nets at the dates above mentioned, and in full-grown mackerel examined at the same time. These young pilchards measured 6 to 9 cm., and were doubtless derived from spawn shed the previous summer. It is, of course, possible that the pilchards measuring 13 to 16·5 cm. in length at the beginning of November were derived from spawn shed rather late in the spawning season of the previous year, and that their age was nearer twelve than seventeen months. But the above facts indicate clearly that the pilchard does not reach adult size in one year, and is not capable of spawning until it is two years old, while the larger spawners are probably three years old.

If we compare the data and inferences just given with the facts concerning the sardine of the French coast recorded by Pouchet, we find that the data agree and the inferences are confirmed. Pouchet, it is true, denies that the eggs of the sardine are pelagic, and has not defined the spawning period. But he tells us that he has only seen eggs approaching maturity in fish taken in April and May, when the fishing for *sardines de dérive* ceases, and that for *sardines de rogue* commences. There can therefore be no doubt that near Concarneau the sardine spawns in the months following May. Pouchet's records of the fish captured are somewhat difficult to interpret. He publishes in his Reports the records kept by the manufacturers, in which the size of the fish is registered according to the number required to fill a tin of a certain size. Two processes of calculation have to be carried out in order to get approximately the length of these fish. Having made these calculations, we find that at Concarneau in 1888, in June, the *sardines de rogue* were 12·5 to 14 cm. long; in July, 13 to 14·3 cm.; in August and September about the same; in October, for the most part 15 or 16 cm., though some were still taken of 13 to 14 cm. In some of his reports Pouchet gives the dimensions according to actual measurement of two or three sardines taken nearly every day throughout the season, but nowhere does he give the range of sizes of the total number of fish taken on one day. Thus in the year 1888 he obtained sardines of 10 to 11·5 cm. in March, 11 to 14 cm. in April, 15 cm. in May, 13 to 15 cm. in June, 13 to 16 cm. in July, 13 to 14 cm. in September, 14 to 18 cm. in October. On the whole, the *sardine de rogue* gets larger towards the end of the season, though it is obvious that the shoals in a given place replace one another, so that fish taken in September at Concarneau may be of the same age and size as others taken in June. This phenomenon is a necessary consequence of the extended spawning period of the species. But I think there can be no doubt that the *sardines de rogue* caught in such numbers along the coast of Finisterre in summer are yearling fish, which in the following summer reach maturity at a length of 20 to 22 cm. There is one consideration which may give rise to a doubt as to the general validity of this conclusion. According to Pouchet, sardines 15·7 cm. long are taken at the end of May: would not these reach a length of 19 or 20 cm., and be capable of spawning, by the end of October, when the spawning period for the year is not yet terminated? This question cannot be definitely answered in the negative at present. I will merely point out that the increment of length corresponding to the same increment of weight becomes smaller as the fish grows larger. Thus at 13 cm. a sardine weighs about 15 grammes; at 16 cm. about 30 gms., an increase of 15 gms.; at 19 cm. it weighs about 60 gms., an increase of 30 gms.

If, as the above considerations indicate, the sardine of the Cornish and French coasts reaches a length of 13 to 16 cm. at one year of age, it is surprising that the Mediterranean sardine should reach the same length at the same age, since its maximum length is so much less than that of the more northern fish. But Marion finds that the sardine at Marseilles grows at the rate of 1 cm. per month, starting from a length of 3 cm. at one month old. Thus, according to his table of growth, the sardines hatched in December are 14 cm. long in the following December. I cannot help thinking that Marion has over-estimated the rate of growth, but it may prove that the fish reaches maturity more quickly in the Mediterranean, although it does not grow so large. Marion has conclusively shown that the spawning period at Marseilles extends from December to May, instead of from May to October. J. T. CUNNINGHAM.

SCIENCE IN JAPAN.[1]

THE growth of modern science in Japan is one of the most interesting phenomena connected with the history of civilization. The Japanese, and the Magyars of Hungary, are the only peoples of other than Aryan stock who have founded Universities and taken part in the development of the historical and physical sciences. The University of Buda-Pesth dates from the fifteenth century, and at the present moment its large staff of eminent Professors contains but few names which are not distinctively those of Magyar nationality. The University of Tokyo was founded in the year 1868 by the union of the Tokyo Daigaku and the Kobu Daigakko. It has more than seven hundred students, and comprises a College of Law, with eleven Professors, of whom one only is a European; a College of Medicine, with sixteen Professors, all native Japanese; a College of Engineering, with eighteen Professors, three of whom bear English names; a College of Literature, with ten Professors, of whom two are Englishmen and two Germans; a College of Science, with fifteen Professors, amongst whom one—a chemist—is English, the rest being Japanese.

The present volume bears testimony to the high qualifications and serious work which distinguish the Japanese Professors and their assistants in the College of Science of Tokyo. It contains seven memoirs on biological subjects—a branch of study for which the Japanese have proved themselves during the last fifteen years to have a special and indeed a remarkable aptitude. The names of Mitsukuri, Ishikawa, Iijima, and Watase, not to mention others, are known and esteemed in every laboratory in Europe and America where the study of embryology and comparative anatomy is cultivated.

The list of papers in the present volume is as follows:—(1) The fœtal membranes of the Chelonia, by K. Mitsukuri, with ten plates; (2) The development of Araneina, by K. Kishinouye, with six plates; (3) Observations on fresh-water Polyzoa, by A. Oka, with four plates; (4) On *Diplozoon nipponicum*, n.sp., by Seitaro Goto, with three plates; (5) A new species of Hymenomycetous Fungus injurious to the mulberry-tree, by Nobujiro Tanaka, with four plates; (6) Notes on the irritability of the stigma, by M. Mujoshi, with two plates; (7) Notes on the development of the suprarenal bodies in the mouse, by Masamaro Inaba, with two plates.

Some of the authors of these admirable papers bear the title "Rigakushi," whilst Prof. Mitsukuri alone is styled

[1] "The Journal of the College of Science, Imperial University, Japan," vol. iv., Part 1. (Tokyo, Japan, 1891.)