protons are dislodged from the atoms of the element struck and that therefore transmutation has been actually carried out.

The quantity of matter so transmitted is indeed almost inconceivably small, but it is the first step towards what may well be the greatest achievement of the human race, the release and control of the so-called "atomic energy." We now know with certainty that four neutral hydrogen atoms weigh appreciably more than one neutral helium atom, though they contain identically the same units, 4 protons and 4 electrons. The change of weight is probably due to the closer "packing" in the helium nucleus, but whatever the explanation may be transmutation of hydrogen into helium must inevitably destroy matter and therefore liberate energy. The quantity of energy can be calculated and is prodigious beyond the dreams of scientific fiction. If we could transmute the hydrogen contained in one pint of water the energy so liberated would be sufficient to propel the *Mauretania* across the Atlantic and back at full speed. With such vast stores of energy at our disposal there would be literally no limit to the material achievements of the human race.

The possibility that the process of transmutation might be beyond control and result in the detonation of all the water on the earth at once is an interesting one, since, in that case, the earth and its inhabitants would be dissipated into space as a new star, but the probability of such a catastrophe is too remote to be considered seriously. A recent newspaper article pointed out the danger of scientific discovery, and actually suggested that any results of research which might lead to the liberation of atomic energy should be suppressed. So, doubtless, the more elderly and apelike of our prehistoric ancestors grumbled at the innovation of cooked food, and gravely pointed out the terrible dangers of the newly-invented agency, fire, but it can scarcely be maintained to-day that subsequent history has justified their caution.

The Herring Fishery and its Fluctuations.

By B. STORROW, Dove Marine Laboratory, Cullercoats, Northumberland.

HERRINGS are fished in every month of the year, and the catches show considerable variation in the size of the fish, the state of the reproductive organs, and the age composition of the shoals. It is necessary, therefore, before arriving at any conclusion with regard to the fishery, to take into consideration the kinds of herrings which are caught on the different grounds throughout the year.

In the beginning of the year, January, February, and March, shoals are fished about the north-west of Ireland, off the north of Scotland, including the Shetlands and Orkneys, and in the Firth of Forth. These herrings are all fish with the gonads well developed, and they spawn towards the end of February or in March. They are known as spring spawners and, except for the shoals of the Firth of Forth, they, so far as the western part of the North Sea is concerned, are caught in northern waters. In April the spent fish from the spring spawning shoals are caught all over the North Sea, from the Shetlands to Bergen Bank, from North Shields to the Naze, and off Yarmouth and Lowestoft. The catches are used chiefly for bait by the drift-net fishermen, who at this time are fishing with lines for cod, ling, halibut, etc. Among some of the bait catches are found numbers of small fish with the gonads not developed, and without doubt these can be classified as virgin fish.

During May the number of drifter-liners decreases and catches of herrings are made from ten to thirty miles off our coast. These catches consist of young fish with the gonads at practically the same stage of development as those found in catches made in April, 100 miles from the nearest port, and when, for the offshore and inshore fish, the growth as calculated from the scales is compared, the agreement warrants the conclusion that the young fish have moved shoreward from the deeper waters. In good seasons this movement towards the shore coincides with increased landings of herrings.

Throughout June waves of migrating herrings come on to the grounds, and in the beginning of July the migrations are large enough to bring about a considerable increase in the fishery. These June and early July migrants have been found, off the Northumberland coast, to be marked with a comparatively small first-year growth, as determined from the scales, which, for the most part, show three winter rings. Recovering spents from spring spawning shoals are found among catches of young developing herrings, but after the beginning of July they disappear, or the numbers found are insignificant.

Herrings with three winter rings and with a comparatively larger first-year growth than the June fish invade the grounds during July and August and give the high catches which are taken in these months in a successful fishery. Towards the end of August and the beginning of September shoals of larger and older herrings appear. They are full fish with their reproductive organs developed, and they, together with the young herrings sufficiently developed, form autumn spawning shoals. After spawning they disappear quickly and only young fish are to be caught.

The summer fishery of the east coast, the Shetlands excluded, is one which depends chiefly on young fish, and samples examined from Wick to Scarborough have been found to contain from 50 to 70 per cent. of fish with three winter rings on their scales. Fish of this age, therefore, determine the productivity of the fishery.

In September herrings are caught in the vicinity of the Dogger Bank by Dutch luggers and by trawlers, off Scarborough and Grimsby by drift-nets. Some of these fish are autumn spawners, but some, especially those caught by trawlers, are spring spawners, which now make their reappearance in great numbers. An examination of catches made on these grounds points to the herrings coming from the north-east to the south-western end of the Dogger Bank and then moving in a south-westerly direction to the Grimsby grounds.

The East Anglian harvest begins in September and continues to the beginning of December. In the early part of the fishery many of the catches are landed from the grounds off Grimsby and it is not until October that the large fleets concentrate off Yarmouth and Lowestoft. This fishery is essentially one for full

herrings and, although small numbers of spawning fish and spents are caught, the bulk of the catches consists of fish which will become spring spawners. The herrings are of all ages, from fish with three winter rings to those with as many as nine or ten, and the samples obtained from these shoals point to the older fish being the latest migrants.

The herring fishery of the southern part of the North Sea differs from that of the east coast in that it depends for its success upon the presence of older and adult fish. In this respect it is like the fishery in northern waters about the Shetlands. But both these fisheries must receive additions from the summer shoals of developing fish if they are to continue in existence, and the question of their productivity cannot be considered without reference to the younger shoals.

For other waters we have not the same quantity of data as we have for the North Sea. In the Minch and off the north-west of Ireland there are spring and autumn spawners and summer shoals of developing fish. In the Irish Sea the summer feeding shoals are followed by autumn spawners, but for these waters, owing to the large numbers of herrings with two winter rings found in the catches of 1921, further investigations are required before a definite statement can be made as to the age when the young fish join commercial shoals in greatest numbers.

The poor summer fishery of 1920 and its failure in 1921 can be accounted for by a shortage of fish with three winter rings and belonging to the year-classes of 1917 and 1918. For an explanation of the poor catches from shoals of adult herrings a consideration of their age composition is necessary. Samples examined in 1919, 1920, 1921, and the spring of 1922, and obtained not only from the East Anglian shoals but from the north-west of Ireland and the north of Scotland, have contained large numbers of fish of the 1913 and 1914 year-classes. In all samples the year-class of 1915 has been poorly represented. The year-class of 1916, which gave the fairly successful summer fishery of 1919 when the young fish had then three winter rings, can be considered a good but not a rich year-class. The older herrings have naturally decreased in numbers and the samples and catches obtained from shoals of adult fish give no indication that a rich year-class of young herrings has joined these shoals.

While a consideration of the age composition of the shoals leads to the conclusion that the failure of the fishery is due to the relative value of the different year-classes it indicates also that the migrations have had some effect. Although we know little about the migrations of the herring, there appears to be no doubt that the migrations of the fish which have become adult and joined spawning shoals differ from those of the young which have not yet spawned. In the spring of 1921 comparatively large numbers of young herrings with three growth areas on the scales were found as full fish among the samples from the north of Scotland and the Firth of Forth. Further sampling in 1922 has confirmed the finding of the previous year. Now, fish of this age in the spring of the year are those which, in June, July, and August, determine the yield from the summer fishery. Since large numbers of them had spawned in the spring of 1921, and afterwards would migrate as adult fish, the summer fishery of that year was poorer by reason of their absence. The high catches made this year from the waters about the Shetlands came, in part, from grounds which have been unproductive for a number of years, and they point to migrations which we know have followed the activity of Atlantic waters and herrings reaching maturity at an early age.

The age composition of the adult shoals fished off the north-west of Ireland, the north of Scotland, and in the southern North Sea, does not permit of the idea that the conditions which govern the fishery occur in small areas only. A consideration of the 1904 year-class from data accumulated by Hjort and Lea gives some idea of the widespread nature of the factors which produce good year-classes. In the southern waters of the Gulf of St. Lawrence the year-class of 1903 was found to predominate, and that of 1904 in the northern waters of the Gulf. The same year-class was the mainstay of the Norwegian fishery for a number of years and was rich in Icelandic waters. The large catches on the east coast of Scotland in 1907 can be referred to the 1904 year-class, and so can the good fisheries of the English Channel in 1909 and 1910. The conditions producing good year-classes extend over the greater part of the North Atlantic area. The difference between the north-west of Ireland fishery and that of the North Sea in 1909 and 1910 suggests that in some years, *e.g.* 1905, the factors which govern year-classes may move along the west coast of Ireland towards the North Sea. The age composition of the shoals in 1919–1921 indicates the coincidence of conditions over the area north-west of Ireland north into the North Sea. That variations in oceanic circulation may bring about local changes in the fishery would appear from the failure of the Firth of Clyde fishery, 1904–1920, and that of the west of the Shetlands, 1905–1922. The disappearance of young herrings from the Wash points to the same conclusion.

To say that fluctuations in the herring fishery have been observed since the beginning of the fishery is to make a statement incapable of proof but one which is extremely probable. The history of the fishery, so far as we know it, consists of a series of fluctuations, and the attempts to account for these have given rise to explanations which have varied from the conditions of the year of capture to the wickedness of the people.

However ridiculous some of these old opinions may appear, it is only since Norwegian investigators, Hjort, Dahl, and Lea, directed attention to the scales of the herring that we have had any definite knowledge of the age composition of some of the herring shoals. Few people think of herrings in their fourth year as being of greatest importance in our summer shoals; a still smaller number think of the conditions of the year of hatching as being the factor which determines good and poor year-classes. Evidence recently examined points to this view requiring some modification and to the possibility that the conditions of the year preceding hatching are the dominant factor in the production of good year-classes. Whatever modification may be needed for this latest idea will depend on the knowledge we hope will be obtained of the life of the herring before it enters the commercial shoals.

That the conditions preceding hatching are of greatest importance is indicated by some of the results obtained when this has been taken as a working hypothesis and

a period of four years allowed between hydrographic phenomena and herring catches. For a period of fifty years it has been possible to show a relation between the range of tide at Aberdeen and the productivity of the herring fishery of the east coast of Scotland. The curves representing tidal data and herring catches show periods in which they tend to parallelism and to convergency, but until this periodicity is understood and can be foreseen the result will be of little use commercially. Good year-classes can be referred to the activities of Atlantic water, which have been shown by Pettersson to depend upon the periodic variation of lunar influence, but more definite knowledge is required as to the time, intensity, and direction of invasions of Atlantic water into the North Sea. This is particularly illustrated by the conditions which are held to have produced the 1907 year-class, which gave the rich fishery on the east coast of Scotland in 1910. The wide-spread occurrence of the rich year-class of 1904 which was found in the Gulf of St. Lawrence and in practically all waters of north-west Europe suggests that a study of the hydrographic conditions of the North Sea alone is insufficient for a full understanding of the factors which determine the wealth of the different year-classes.

Although the production of good year-classes has the greatest influence on the fishery in that these year-classes give a herring population sufficiently large to yield a succession of large catches throughout the season, or a number of seasons, the migrations of the herrings have an effect which is considerable and they may in some cases bring about the formation of new fisheries or the non-existence of others. Pettersson has shown how the great Baltic herring fishery of the Middle Ages coincided with a maximum activity of Atlantic waters, due to the greatest possible tidal influence of the moon and sun, and, also how the present Baltic fishery fluctuates in a period of eighteen to nineteen years. These fluctuations are noticeable chiefly in shoals of adult fish, and, in our waters, for the shoals off East Anglia and the winter herrings of the east coast of Scotland, they have been found to alternate with those of the Baltic fishery. The composition and nature of the shoals about the Shetlands this year point to migrations which have followed the most recent invasion of Atlantic waters, with which has coincided the lateness of the appearance of the Northumberland July shoals in 1920 and 1921 and of the shoals fished from Yarmouth in September 1921. Before we can hope to understand this periodicity in migrations and the difference from year to year in the arrival of our shoals a much more comprehensive knowledge of the hydrography of the North Sea and of the factors controlling the movements of the waters of the North Atlantic is required. Further, the publication of the statistics relating to the fishery in a form which will allow of their examination as to where and when the catches were made is desirable.

That the poor quality of the herrings and the early maturity of the younger year-classes have coincided with one another and with the presence of large quantities of Atlantic water cannot be taken as solving the problem of their occurrence. Neither does the poor liver yield from Norwegian cod, which, in some years at least, coincided with large numbers of young fish among adult cod and with Atlantic water activity, throw any further light on what must be regarded as a physiological problem awaiting investigation, and one which cannot be considered as explained by a reference to a possible scarcity of copepods.

The problem of the fluctuations in our herring fishery is not one which can be solved by a consideration of one or two isolated set of phenomena. That the activity of Atlantic water has a connexion with periodicity in the fishery and with the production of good year-classes suggests a possible way of approach. It is a problem which demands the attention not only of the zoologist and the hydrographer, but also of the physiologist and probably that of the astronomer. Further, it must not be forgotten that the men engaged in the fishery and the industries connected therewith are concerned more about the fluctuations from year to year than those which are spread over much longer periods.

The Nebraska Tooth.

By W. P. PYCRAFT.

AT the meeting of the Zoological Society on November 7, Prof. Elliot Smith exhibited a cast of the now famous Nebraska tooth, which is regarded by American palæontologists as representing a new genus and species of the human race—*Hesperopithecus haroldcooki*. This tooth—a "second upper molar"—differs, we are assured, on one hand from that of any known anthropoid apes, and on the other from any of the primitive types of man yet discovered.

Prof. Elliot Smith is in agreement with this interpretation; and presented fresh evidence in its support, furnished him by Prof. Osborn. This evidence included the results of radiographing the tooth, together with the teeth of a chimpanzee and Piltdown man. But these, it must be admitted, were unconvincing pictures, since they failed to demonstrate the features they were designed to show.

The teeth of the Piltdown man, it will be remembered, showed a large pulp-cavity placed above the level of the alveolar border of the jaw, as in modern man; wherein, however, the cavity is smaller. But the Piltdown teeth, in this regard, differ as much from the teeth of Neanderthal man, wherein the pulp-cavity was of great size, and evidently developed at the expense of the roots. Sir Arthur Keith has called such teeth "taurodont." They are peculiar to men of the Neanderthal type. The Piltdown teeth, like those of the modern man, are of the "cynodont" type. This fact, it may be predicted, will come to have an additional significance in the near future.

Dr. A. Smith Woodward, in the discussion which followed Prof. Elliot Smith's remarks, reaffirmed his original belief—expressed at the time when the discovery of the Nebraska tooth was first announced, and set forth in NATURE of June 10 (vol. 109, p. 750)—that this tooth was more probably that of one of the primitive, extinct bears (Hyænarctos), than of some primitive member of the primates. Prof. Osborn