by MM. Le Royer and Blondel. It has recently been completed (April 1922). Among the conclusions which emerge, it is now clear that the inhabitants of the lake-dwellings in the polished stone age had constructed stockades facing the open water, for protection against the waves raised by the prevailing northerly wind. These breakwaters must have afforded the dwellings relatively smooth water. From these investigations it may also be concluded that the lake-dwelling sites of Geneva were of considerable size. Unfortunately of these there remain to-day only some thousands of piles implanted in the bed of the lake.

Geneva is thus one of the most ancient cities of the world, since man has lived on this site continuously ever since the neolithic period.

The stratigraphical investigations undertaken by M. Vouga enable us to establish with certainty the succession of the types of industrial objects throughout the neolithic period of the lake-dwellings. Several of our *a priori* conceptions based on typology must be abandoned. Thus the pottery of the earliest period is more refined, more beautiful, more highly burnished than that of later periods. In technique it approaches more nearly the pottery of the bronze age than that of the middle and upper neolithic.

Thanks to a careful study of the stratification of objects found at Auvernier, M. Vouga has been able to plot out the progressive modification of several objects in daily use, such as the axe-hafting sockets of stag horn, flint arrow-heads, and the like.[1]

In many cases, however, stratigraphical study has only slightly modified classifications, such as those of Ischer, based upon the typology of lake-dwelling sites which have been investigated with minute care.

Other observations of importance for the history of culture have also been made by M. Vouga :—

The lowest stratum (IV.) has not yet yielded any of the spindle whorls which are necessary for weaving. The art of drilling stone would appear to begin in Stratum III., but only in the triangular axe hammer-head. The true perforated axe hammer-head appears much later—in Stratum I.

In Stratum I.—the latest—appear flint flakes of Grand-Pressigny type. Relations between Switzerland and western France are thus clearly established.

For the first time *all* bones found in the excavation of a lake-dwelling site have been preserved. My assistant, Dr. Reverdin, and myself have examined more than 4000 mammalian bones from the station of St. Aubin. Our conclusions, which are valid only in respect of the material obtained and for this site, may be summarised as follows :—In the neolithic period corresponding with the earliest lacustrine sites, the horse was not domesticated. It was not even hunted, or, if it was an object of the chase, its flesh was not brought back to the lake-dwelling. If this were the case, would it not be permissible to suggest a taboo as the reason? The five domesticated animals of the neolithic period were represented in the lake-dwellings from the earliest times. Accordingly, the suggestion that domestic animals appear at different stages cannot be accepted. It is true that these five animals are not represented in equal abundance. At the beginning of the period of domestication, the goat and the sheep are much more rare than the ox, the dog, and the pig.

For a considerable time man continued to rely for his food-supply on wild animals, especially the stag; but the proportion of domestic animals rapidly becomes preponderant.

As regards their culinary tastes, the neolithic lake-dwellers seem to show a preference for certain of the domestic animals. The species of which they ate most abundantly were the ox and the pig; next come the dog (though it is not certain that the dog was eaten), the sheep, and the goat. What is the reason for this order of preference? Does it depend upon a special taste for any particular meat? Would they not in that case rear in large numbers only those species which they appreciated most?

The lake-dwellers in the stone age ate the domestic animals when they were full grown, except in the case of the pig. This animal was frequently eaten while it was young, and even when it was still a sucking pig. The ox and the goat were never eaten when quite young. The distinction was dictated, without doubt, by the desire to use the milk-giving qualities of the cow and the goat, and also, perhaps, the sheep, as long as possible, but this explanation does not affect the males of these species.

It thus appears that the exceptionally low water in the Swiss lakes in 1921 has not been without interest to science. Thanks to this phenomenon, some new and important facts have been recorded in the history of the culture of the neolithic lake-dwellers and, at the same time, of all the neolithic peoples.

[1] I would refer the reader to the reports published by M. Vouga in "Indications d'Antiquités suisses" in the *Arch. suisses d'Anthrop. Gén.*, Geneva, 1921 and 1922.

## Vitamin Problems.[1]

By Prof. A. HARDEN, F.R.S.

THE existence of three vitamins, termed A, B, and C, has now been firmly established and a general idea has been obtained of their distribution among animal and vegetable organisms. Hitherto, comparatively little quantitative work has been done in this direction, and further progress must depend on a more general adoption of quantitative methods. These are at present tedious and not very accurate. In the case of each of the vitamins the requirements of the special animal employed serve as the unit of comparison and these vary considerably from individual to individual, so that many observations are necessary if any, even moderate, degree of accuracy is to be attained. Thus in the estimation of the antiscorbutic potency of food materials, by the method worked out by Miss Chick and her colleagues at the Lister Institute, it has seldom been possible to achieve a greater accuracy than about 25-50 per cent. This obviously imposes a very serious limitation on any attempts to study variations in potency unless these are of a very gross order. Another great difficulty inherent in this kind of observation is that when the

[1] Abridged from a Discourse delivered at the Royal Institution on Friday, April 28.

potency is low, the necessary dose of the material to be tested is correspondingly high, and soon transcends what is permissible without interference with other necessary conditions of the diet, such as protein content, etc. Very much the same conditions hold with regard to Vitamin B, especially when this is estimated by the effect of the material on the growth of rats; and, as a matter of fact, the great bulk of the work carried out in America by this method is not strictly quantitative, but simply leads to the result that a certain ration does, or does not, suffice for the growth of a young rat.

As regards Vitamin A the method of Zilva and Miura promises to yield moderately accurate and consistent results. This is attained by keeping the experimental animals (young rats) on a diet totally deficient in Vitamin A until they have ceased to grow, and then ascertaining the minimum dose of the material to be tested which will induce definite and steady growth for four weeks. Animals which do not cease to grow in three weeks are rejected, greater uniformity in the results being thus attained. The test material is, whenever possible, administered quantitatively to the animal and not, as was formerly the practice, mixed with the ration in a known proportion. One of the immediate results of the application of this method has been the discovery that cod-liver oil, formerly classed with butter as a good source of Vitamin A, is in reality 200-250 times as potent as butter and is, along with similar fish-liver oils, by far the richest in this material of all the substances which have so far been examined.

A further piece of information, which is essential for the detailed study of these substances, is their behaviour towards heat, oxidation, etc. In this respect some progress has been made, and it may be stated with some confidence that both Vitamins A and C are moderately stable towards rise of temperature, provided that air be excluded, whereas in the presence of air they are rapidly inactivated. Whether the effect of air is reversible or not has not yet been ascertained. Vitamin B, on the other hand, appears not to be affected by air and is also moderately stable towards rise of temperature. None of the three vitamins is easily inactivated by hydrolysis under anaerobic conditions, and this fact has led to the interesting observation that Vitamin A, although usually associated, in the animal organism, with fat, is not itself a fat but remains in the unsaponifiable residue with almost unabated potency. This indicates how small a weight of the vitamin itself is necessary for the daily ration of a young rat. In some cases as little as 1·2 milligram of the oil is sufficient to permit of definite growth, and of this only 1-2 per cent. is unsaponifiable, while, as is well known, the chief constituent of the unsaponifiable matter is cholesterol, which has itself no vitaminic potency. The actual requirement of the vitamin itself must therefore be of the order of 1/500 milligram per diem. The other two vitamins have not been obtained in so concentrated a form, but it appears highly probable that they too are present in foodstuffs only in infinitesimal amounts.

The origin of all three vitamins is to be sought in the vegetable kingdom. The production of Vitamin A has been followed (Coward and Drummond) from the seed, and it has been found that it does not appear until the photosynthetic processes begin. Thus sunflower seeds are almost devoid of it, and so are the etiolated seedlings formed when these seeds germinate in the dark. In the light, on the other hand, the green seedlings, grown in a medium free from the vitamin, produce it freely. This vitamin is often closely associated with the carotene and xanthophyll of plants; so intimately, indeed, that it was at one time thought that it might be closely related to, if not identical with, one of them. The association, however, although very frequent, is not essential, and no definite relation can be shown to exist between the two. Vitamin C is either absent from seeds or only present in them in very minute amount, but appears when the seed germinates and before any green parts are formed. Nothing is, however, known of the inactive pro-vitamin or of the process by which it is rendered active.

Concerning the origin of Vitamin B a considerable amount of discussion has taken place. Its presence in a large proportion in yeast points to the probability that it can be produced without the intervention of light, and both in America and in this country it has been found that yeast can actually produce the vitamin when grown in a "synthetic medium" comprising only substances of known composition and free from the vitamin in question. Recently, however, Eijkman, in Holland, has obtained a contrary result, so that this question remains at the moment open.

The animal organism appears to be unable, in normal circumstances, to produce any of these principles for itself, and hence the amounts found in animal products depend ultimately on the diet of the animal. This opens up, among many other problems, the important question of the vitaminic properties of milk, and there seems to be no doubt, from experimental work, both here and in America, that these properties are profoundly affected by the diet of the cow. Milk obtained in winter when the animals are stall-fed has been shown to be markedly deficient in Vitamin A, and there is also great danger of a deficiency of Vitamin C. One of the pressing requirements of the moment is the careful quantitative examination of foodstuffs available for the feeding of cattle, so that a rational system of winter feeding can be adopted which will produce milk as good as that given in summer. Such an examination would seem naturally to fall within the purview of the Board of Agriculture.

The evil results of a deficiency of Vitamins B and C, especially in the diet of children, are well known—beri-beri and scurvy, latent or patent—but the effect of a lack of Vitamin A is not so well recognised or so universally acknowledged. One school considers that a deficiency of this vitamin is at least a prominent factor in the causation, if not, as they formerly held, the sole cause of rickets. Others consider rickets to be a disease brought on by non-hygienic surroundings, lack of fresh air and exercise, etc. The latest experimental results show that rickets (in rats) can infallibly be produced by dietetic changes, but that the lack of Vitamin A does not of itself lead to the disease unless at the same time the diet is faulty as regards the supply of calcium or phosphorus. This faulty mineral supply

does not usually lead to true rickets if sufficient Vitamin A be present, although the bone formation under these circumstances is not quite normal. This explains the well-known curative effect of cod-liver oil in rickets. So marked is the effect of this remedy, that McCollum, not appreciating the relatively enormous concentration of Vitamin A present in it compared with that in butter, as proved by Zilva, has suggested that cod-liver oil contains some other specific substance absent from butter, to which its great superiority is due. The difference, however, seems to be merely quantitative, and the further complication suggested by McCollum appears to be unnecessary.

These experiments on rickets have led to what promises to be a discovery of far-reaching importance. Rats on a diet, which in the laboratory will infallibly produce rickets, do not acquire the disease if they are exposed to sunlight in the open air or to ultra-violet radiation, and rats which have acquired the disease can be cured by either of these treatments, just as they can be cured by the administration of cod-liver oil. Sunlight and ultra-violet radiation have also been found to be effective cures or preventives of rickets in children. The cures by light and by cod-liver oil seem to proceed in precisely the same way, and the idea naturally suggests itself, especially to the mind of a chemist, that the light actually brings about the synthesis of the Vitamin in the animal body just as it does in the plant. This idea still awaits experimental verification or disproof; but there is no doubt that the discovery of this function of light will lead to profoundly important developments in our knowledge.

## Obituary.

### PROF. W. GOWLAND, F.R.S.

PROF. WILLIAM GOWLAND died on June 10 in his eightieth year. He had originally intended to enter the medical profession and actually worked with a medical man in Sheffield for two or three years. Afterwards he became a student at the Royal College of Chemistry, from which he passed in 1868 to the Royal School of Mines. Two years later he obtained the associateship both in mining and metallurgy. He was awarded the Murchison medal in geology and the De la Beche medal in mining.

His first post was that of chemist and metallurgist to the Broughton Copper Company, Manchester. Two years later he went out to the Imperial Mint at Osaka, Japan, and held the post of chemist and metallurgist there for six years. During the next eleven years he acted as assayer, metallurgist, and chief of the foreign staff at Osaka, and was for some time adviser to the Imperial Arsenal. His work was of a decidedly varied nature, and he did much to introduce Western metallurgical and chemical methods into the departments with which he was associated. It was during this period that he acquired the knowledge of Japanese methods of extracting, refining, and working metals for which he afterwards became so famous. He carried out exploration work in Korea on behalf of the Japanese Government, in the course of which his expedition had some lively skirmishes with the natives.

As a young man Prof. Gowland was a keen oarsman, and was the first to introduce rowing into Japan. He had two modern "eights" built to encourage boat-racing among the staff of the mint, but they found these craft too unstable for their liking. Eventually they decided to choose their own boats and presented two for his inspection. He found they had selected a pair of "cutters" and had fitted each with port and starboard lights. He was also the first to initiate the Japanese into the use of the wheelbarrow. He had occasion to do this in connexion with some excavation work in the copper mint, and provided the labourers with barrows. The next morning he was astonished to find that the wheels had been removed and the sturdy Japanese were carrying the loaded wheelbarrows. On leaving Japan in 1889, the order of "Chevalier of the Imperial Order of the Rising Sun" was conferred on him personally by H.I.M. the Emperor of Japan. During his residence there he gradually built up a very fine Japanese art collection, which included some valuable kakemonas.

Returning to England, Prof. Gowland acted as chief metallurgist to the Broughton Copper Company for some years, and in 1902 was appointed professor of metallurgy at the Royal School of Mines, in succession to the late Sir William Roberts-Austen. This post he held for seven years and retired in 1909.

So far as metallurgy is concerned, his chief interest lay in the non-ferrous metals, principally copper, silver, gold, lead, and their alloys. His knowledge, in particular, of the metallurgy of copper was unique, based as it was upon experience of the best methods in vogue, both in the East and West. In 1914 he published a textbook on the metallurgy of the non-ferrous metals which quickly became recognised as an authoritative work on the subject, and is now in its third edition. He also contributed various papers to the Institution of Mining and Metallurgy, the Chemical Society, and the Society of Chemical Industry. He was an original member of the Institute of Metals, its third president, and its first May lecturer. In 1907 he was elected president of the Institution of Mining and Metallurgy, and in 1909 was awarded the institution's gold medal.

There was, however, another side to his intellectual interests, as shown by his membership of the Society of Antiquaries, the Royal Anthropological Institute, and the Numismatic Society. His publications under these heads were numerous and varied, dealing with, *e.g.*, the early metallurgy of silver and lead, the remains of a Roman silver refinery at Silchester, the burial mounds and dolmens of the early Emperors of Japan, and silver in pre-historic and proto-historic times. From 1905 to 1907 he acted as president of the Royal Anthropological Institute.

Prof. Gowland was a man of great personal charm and distinction. He was extremely thorough in all he undertook, and never spared himself in the execution of his duty. His lectures were very carefully prepared and well delivered. The geniality of his disposition made him a general favourite with his colleagues and students, and he will always be affectionately remembered at the Royal School of Mines. H. C. H. C.