attention, finally, among the schizopods, to Gnatauphausia, of large size, and of a scarlet color. The lower crustaceans, Amphipoda and Isopoda, were found in large numbers; but a study of them is much less interesting than that of the forms of which we have just spoken. The species of Nymphon is abundant at great depths; and a giant form, whose stomach extends to the end of its claws, Colossendeis titan, was taken at four thousand metres.

With crustaceans, as with fishes, it is very interesting to inquire whether the circumstances surrounding them cause modifications and adaptations in their organisms. The changes in the tissues are often noticeable in the structure of the carapace and muscles. I have already called attention to Pentacheles, Polycheles, and Willemoesia, whose tissues are so transparent as to allow the viscera to be seen; and the flesh is tender, and lacking flavor. The exterior colors are either a bright red, a rose-white, or a pure white. The macruran Crustacea are specially noticeable for their brilliant colors: and one cannot restrain a feeling of admiration for Aristes, of a carmine color; Notostomus, of a pure, deep red; and Pasiphae, spotted red and white. At very great depths, rose-white or pure white are the only tints observed.

With the fishes, as we have seen, the visual organs are always well developed, at whatever depth these animals are taken. It is not so with the Crustacea, several species of quite different groups having experienced atrophy, and sometimes a complete disappearance of the eyes. It is, however, a very singular fact, that some species in the same genus are blind, and others are not. Thus Ethusa granulata, living in the German ocean, between two hundred and thirteen hundred metres, is blind; while Ethusa alba, taken in the Atlantic, at five thousand metres, is not blind. The disappearance of the eyes seems to be gradual, and to be related to the depth at which the animal lives. The cornea first disappears, the ocular stalk remaining, and being movable. Then these parts become fixed, and, losing their characters, are changed into spines. Thus, says Norman, "Ethusa granulata, dredged between one hundred and ten and three hundred and seventy fathoms, has two remarkable ocular stalks, smooth and rounded at the extremity, where ordinarily the eyes are placed. With the specimens from the north, living at a depth of from five hundred and forty-two to seven hundred and five fathoms, the ocular stalks are no longer movable: they become fixed in the sockets, and their function is changed. Their dimensions are much enlarged; they approach their foundation; and, instead of being rounded, they end in a very firm rostrum. No longer serving as eyes, they serve as rostra." We have on exhibition one blind species, Galathodes Antonii (fig. 1), taken on the Talisman; and near this strange form, whose eyes are replaced by sharp spines, may be seen Pentacheles, Polycheles, Willemoesia, and Cymonomus, whose eyes are more or less changed.

Crustaceans of great depths emit phosphorescence. The light is shed, sometimes by the whole surface of the body, and sometimes, as with Aristes, in a special manner, by the eyes themselves. With some of them it seems as if there were, in certain parts of the body, organs arranged for the production of this light, — a fact which recalls what was said about fishes. Thus in Acantephyra pellucida, a new species, the claws are furnished with phosphorescent bands. The organs of touch are considerably developed, the most remarkable example of which is found in the long antennae of Aristes. With certain crustaceans, as in Benthesisymnus, the last pair of claws assume the character of antennae, and have the same function, probably, as these organs.

THE WOBURN ROTATION EXPERIMENTS.

FOR the past six years some very interesting field-experiments have been in progress at Woburn, Eng., under the conduct of Dr. Voelcker, chemist of the Royal agricultural society. A portion of these experiments are upon the continuous growth of wheat and barley on the same land, and closely resemble the celebrated Rothamsted experiments, differing from them in being made upon light land. Other of the experiments are rotation experiments, and are designed to test the comparative agricultural value of artificial fertilizers, and of barnyard-manure made from different feeding-stuffs. These experiments are to be continued for a series of years; but a brief description of their plan, and a statement of the results obtained up to the present time, may not be without interest.

The rotation is an ordinary four-course rotation; viz., roots, barley, grass, and wheat. Sixteen acres are under experiment; so that, in any given year, four acres are covered by each crop, while, in the course of four years, each plot of four acres bears successively the crops above enumerated. The following table shows at one view the crops thus far carried by each plot: —

Date.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
1877	Grass	Roots	–	–
1878	Wheat	Barley	Grass	Roots
1879	Roots	Grass	Wheat	Barley
1880	Barley	Wheat	Roots	Grass
1881	Grass	Roots	Barley	Wheat
1882	Wheat	Barley	Grass	Roots
1883	Roots	Grass	Wheat	Barley

Each plot of four acres is subdivided into four one-acre sections, and these are fertilized in different ways. As each of the four plots is treated exactly alike in successive years, it will suffice to follow one plot through the four years, in order to understand how each section of it is fertilized. Plot No. 1 was in grass in 1877, the grass being a mixture of clover and rye-grass. Sheep were pastured on each of the four sections of this plot sufficient to consume the grass. To the sheep on the first section were given 728 pounds of decorticated cottonseed-meal, and to those on the second section the same weight of corn-meal, while on the third and fourth sections the sheep had only the grass. The droppings of the animals were left on the land; and, as fattening animals retain practically none of the fertilizing ingredients of their food, these droppings were richer on the first and second sections by the amount of plant-food contained in the cottonseed-meal and corn-meal respectively. In the fall the land was sown to wheat; and in the spring, sections 3 and 4, on which no ground-feed was fed, were top-dressed with commercial fertilizers. Section 3 received fertilizers containing amounts of nitrogen and mineral ingredients equal to the nitrogen and ash of the 728 pounds of cottonseed-meal fed on section 1; and section 4, in the same way, received nitrogen and ash equal to the amounts contained in the 728 pounds of corn-meal fed on section 2.

Thus the four sections of this plot permitted a comparison of the relative value for the wheat-crop, first, of stable-manure made from corn-meal and cottonseed-meal respectively, and, second, between the value of stable-manure and a quantity of commercial fertilizers containing the same amounts of plant-food. Following the wheat, mangolds were grown in 1879, variously manured on the four sections. On section 1 they received stable-manure made from 1,728 pounds of straw as litter, 5,000 pounds of mangolds, 1,250 pounds of wheat-straw, and 1,000 pounds of cottonseed-meal; on section 2, stable-manure made from the same amounts of food and litter, except that 1,000 pounds of corn-meal were substituted for 1,000 pounds of cottonseed-meal. On plot 3 they received stable-manure made from the same quantities of roots and coarse feed as were mentioned above, but without either cottonseed- or maize-meal, and, in addition to this stable-manure, commercial fertilizers equivalent to all the ash, and two-thirds of the nitrogen, of 1,000 pounds of cottonseed-meal. On plot 4 they received the same stable-manure as on plot 3, and, in addition, chemicals equivalent to the ash and nitrogen of 1,000 pounds of corn-meal.

Here, again, we have a comparison of stable-manure from different fodders with equivalent amounts of concentrated fertilizers. The stable-manure, in this case, was made by steers which were fed in so-called feeding-boxes, in which all the excrements and litter were retained, and compacted by the movements of the animal.

The mangolds produced on each section were weighed, and then fed out to sheep on the land. Following the mangolds came, in 1880, barley. This received no manure but the droppings of the sheep to which the mangolds were fed, except that section 2 received the remaining third of the nitrogen of 1,000 pounds of cottonseed-meal in the form of a top-dressing of nitrate of soda.

In 1881 the barley was followed by grass, to be fed off by sheep as described, thus beginning the rotation anew.

It will be seen, that, in the course of the four years' rotation, each plot furnishes three tests, with as many crops, of the manurial value of cottonseed-meal as compared with maize-meal, and of each as compared with an equivalent amount of concentrated fertilizers. Moreover, since each one of the four plots is treated alike, three such comparisons can be made each year in different plots. Thus, by continuing the experiments for a series of years, it will be possible to eliminate from the results, to a certain extent, the errors which may arise from unequal quality of the soil on the different sections, and also to judge how the character of the season affects the action of the manures.

The subject is a very interesting one, and one which has received comparatively little attention experimentally. We know, indeed, with sufficient accuracy, the relations between the composition of food and that of the manure made from it. We know that in the manure of working, and of mature fattening animals, is found practically all the plant-food which their fodder contained. We know, that, in the case of growing animals and of those giving milk, more or less of the elements of plant-food pass into the new growth, or into the milk, and are lost to the manure; and we know approximately what proportions of them are thus lost on the average. With the necessary data as to amount and kind of food consumed, it is a comparatively easy task to compute the amount of valuable matters contained in the manure produced; but as to what modification the agricultural value of these matters may have undergone, and how it compares with the various forms of artificial fertilizers, we are comparatively ignorant. For example: we know that practically all the phosphoric acid of the food of a fattening animal passes into the excreta; but how the manurial value of this phosphoric acid compares with that of the soluble, the reverted, or the insoluble phosphoric acid of a superphosphate, with that of raw bone, or of native phosphates, can be, at best, only conjectured.

The Woburn rotation experiments promise to contribute to the solution of some of these questions. It would be premature to seek to draw definite conclusions from the results thus far obtained; for only a considerable length of time can enable us to estimate the effect of *continuous* treatment, of the sort described, upon the yield of the several crops. At the same time, a brief statement of them may furnish some interesting suggestions.

The following table contains the results, up to 1882, in pounds per acre, of the experiments on mangolds, barley, and wheat. Under the head of manuring are included only the amounts of cottonseed- or corn-meal fed to the sheep, or their equivalents in commercial fertilizers. It should be understood that this was not all the manure used, as will be evident on comparing the detailed description of a rotation given above.

In interpreting these results, there are some things which should be borne in mind. In the first place, we find in the reports of the above experiments, in the *Journal of the Royal agricultural society*, very meagre details as to their conduct. It is to be supposed that all four of the sections in each plot were

Results of Woburn rotation experiments.

MANGOLDS.

Sect.	Manuring.	1877 — Plot No. 2.			1878 — Plot No. 4.			1879 — Plot No. 1.			1880 — Plot No. 3.			1881 — Plot No. 2.		
		Roots.	Tops.	Total.	Roots.	Tops.	Total.	Roots.	Tops.	Total.	Roots.	Tops.	Total.	Roots.	Tops.	Total.
1	1000 lbs. cottonseed-meal	6,920	4,650	11,510	29,475	6,025	35,500	10,033	4,739	14,772	43,820	8,345	52,165	50,023	8,024	58,047
2	1000 lbs. maize-meal . .	4,625	3,925	8,550	26,350	6,021	32,371	9,993	4,617	14,610	34,231	7,416	41,647	48,667	7,965	56,632
3	Ash and ⅔ of nitrogen of cottonseed-meal . .	16,188	7,575	23,763	40,820	8,125	48,945	17,676	6,433	24,109	55,050	8,306	63,356	54,718	9,100	63,818
4	Ash and nitrogen of maize-meal	8,400	5,650	14,050	28,537	7,130	35,667	12,847	4,875	17,722	46,838	7,420	54,258	48,600	8,356	56,956

BARLEY, AFTER MANGOLDS FED ON THE LAND.

Sect.	Manuring.	1878 — Plot No. 2.			1879 — Plot No. 4.			1880 — Plot No. 1.			1881 — Plot No. 3.		
		Grain.	Straw.	Total.	Grain.	Straw.	Total.	Grain.	Straw.	Total.	Grain.	Straw.	Total.
1	No fertilizers	2,008	3,132	5,140	1,781	2,966	4,747	1,947	2,782	4,729	2,256	3,067	5,323
2	No fertilizers	1,880	3,165	5,045	1,912	3,180	5,092	1,717	2,698	4,415	2,136	2,952	5,088
3	Nitrate of soda, containing ⅓ the nitrogen of 1000 lbs. cottonseed-meal	2,291	3,825	6,116	2,085	3,132	5,217	1,897	2,989	4,886	2,267	3,158	5,425
4	No fertilizers	1,750	3,195	4,945	1,543	2,624	4,167	1,575	2,480	4,055	2,316	2,827	5,143

WHEAT, AFTER GRASS FED ON THE LAND.

Sect.	Manuring.	1878 — Plot No. 1.		
		Grain.	Straw.	Total.
1	728 lbs. cottonseed-meal	2,177	4,874	7,051
2	728 lbs. maize-meal	2,304	4,623	6,927
3	Fertilizers containing ash and nitrogen of 728 lbs. cottonseed-meal	2,686	6,376	9,052
4	Fertilizers containing ash and nitrogen of 728 lbs. maize-meal	2,118	5,479	7,597

Sect.	Manuring.	1879 — Plot No. 3.			1880 — Plot No. 2.			1881 — Plot No. 4.		
		Grain.	Straw.	Total.	Grain.	Straw.	Total.	Grain.	Straw.	Total.
1	672 lbs. cottonseed-meal	1,884	5,793	7,677	1,033	3,676	4,709	2,997	4,700	7,697
2	728 lbs. maize-meal	1,931	5,991	7,922	1,201	4,100	5,301	3,077	4,717	7,794
3	Fertilizers equivalent to 672 lbs. cottonseed-meal	2,034	7,168	9,202	999	4,218	5,217	3,114	5,369	8,483
4	Fertilizers equivalent to 728 lbs. maize-meal . .	2,022	6,377	8,399	1,116	3,976	5,092	2,943	5,149	8,092

cultivated, seeded, and otherwise treated, exactly alike; but no mention is made of the means adopted to secure accuracy in these respects. We are not told whether the composition of the fodders and fertilizers used was actually determined by analysis, or whether average composition was assumed for them. We have no comparison of the crops on the several sections as to the proportion of water they contained when weighed. Above all, we have no proof of the uniform quality of the land, and no knowledge of its natural capacity, as neither unmanured plots nor duplicate manurings were employed.

Under these circumstances, it is evident that no great weight can be given to small differences of yield, or to single results. On the other hand, a result which is repeated year after year, or which is very striking in amount, may serve as the basis of at least tentative conclusions.

Taking first the results on mangolds, we find, that, in every case, the manuring with cottonseed-meal was followed by a larger crop than was that with corn-meal; further, that in every case the fertilizers equivalent to the cottonseed-meal were followed by a larger crop than were those equivalent to the corn-meal; finally, that in every case but one (1881 — Plots 2 and 4) the commercial fertilizers were followed by a heavier crop than was the corresponding stable-manure.

Taking next the barley, and taking the figures as they stand, in three cases out of four the manuring with cottonseed-meal was followed by a larger yield, both of grain and of total crop, than was that with corn-meal.

In three cases out of four the grain, and in every case the total crop, were greater after the fertilizers equivalent to the cottonseed-meal than after those equivalent to the corn-meal. In four cases out of eight the fertilizers were followed by a heavier crop than was the stable-manure. Many of the differences, however, are comparatively small.

In the wheat experiments the corn-meal manure proved superior to the cottonseed manure in every case as regards grain, and in three out of four cases as regards total yield. The fertilizers equivalent to the cottonseed-meal proved superior to those equivalent to the corn-meal in three cases out of four as regards grain, and in every case as regards total yield. The fertilizers surpassed the corresponding stable-manure in seven cases out of eight as regards total yield, while as regards grain the proportion is four to four.

Some of these results are quite different from those which we should have expected. Cottonseed-meal of good quality contains more than two and a quarter times as much nitrogen, four and a half times as much phosphoric acid, and four times as much potash, as corn-meal, and consequently the manure made from the former in these experiments must have been much the richer. The greater growth of the mangolds on the cottonseed sections accords with this fact, while the still greater effect of the commercial fertilizers corresponds with their greater solubility and consequent prompter action. With the barley and wheat, these results are far less marked. With the barley, they are mostly the same in kind. With the wheat, cottonseed-meal was excelled by corn-meal as a manure-producer, while otherwise the results were in the main the same as with the other crops.

A more careful examination, however, shows that the differences, both as to barley and wheat, are too small to be of very much significance. The greatest difference of yield of grain between the corn-meal and cottonseed sections was, in the case of barley, two hundred and thirty pounds per acre, equal to about five bushels, and, in the case of wheat, a hundred and sixty-eight pounds per acre, equal to less than three bushels. The differences in the total yield (grain and straw) are correspondingly small. It is certainly questionable, whether these differences are not less than the errors of experiment; and the only safe conclusion which we can draw is, that the yield was not greatly different in the two cases.

The commercial fertilizers showed greater differences; the richer manuring, containing the equivalent of the cottonseed-meal, generally proving decidedly superior, particularly as regards the total yield, the grain being not so much affected.

As compared with the stable-manures, the fertilizers show but a slightly larger yield of wheat. The barley, it must be remembered, received no manure or fertilizers directly, except a light top-dressing of nitrate of soda on section 3, but only the droppings of the sheep fed on the mangolds of the preceding year.

It is not the purpose of this article to theorize as to the reasons of the results obtained in these experiments, and such theorizing would be premature at present. One thing is shown very plainly by them, however; and that is, that, in all discussion of methods and systems of fertilizing the soil, two aspects of the question must be clearly distinguished. We may regard manures either as direct sources of food to the plant, or as means of enriching the soil, and accordingly distinguish between the immediate returns which they yield, and their value as an investment. In these experiments there can be no doubt that the cottonseed sections received more plant-food than the corn-meal sections in every case, and we have no reason to suppose that this plant-food would not all become available at some time; but the immediate returns were not always greater. In the comparatively short time during which the experiments have been in progress, it has been the immediate value of the manures and fertilizers used which has manifested itself.

Whether, after a number of years, the richer manuring will not show better results on the grain-plots, is a question which, *a priori*, would receive an affirmative answer; and the testimony of experiment on this point will be awaited with interest.

H. P. ARMSBY.

THE AMERICAN FISH-CULTURAL ASSOCIATION.

THE annual meeting of this association was held in the lecture-room of the National museum at Washington, on May 13, 14, and 15. President Benkard made an address of welcome, and briefly reviewed the work of the association for the past year.

Many papers were read, and the attendance was good throughout. Mr. F. Mather gave an account of the hatching-work at Cold Spring Harbor, stating that the eggs of the tom-cod had been successfully hatched there this spring.

Prof. H. J. Rice related his experiments with various substances used to destroy the Saprolegnia, the fungus which attacks fishes in aquaria. The most successful results were obtained by the use of a bath of common salt. Fishes which were badly infested with the fungus, after immersion in a moderately diluted solution of salt and water for a minute or so, after a while had the adherent film of fungus loosened in large flakes. This method, if applied in time, would prove effectual, if one were afterwards careful not to introduce into the aquarium organic material which would decompose, and afford a nidus for the nourishment and multiplication of this pest from its spores.

Mr. L. Stone read a paper on the artificial propagation of salmon in the Columbia-River basin, taking the ground that it was probably now too late to begin propagating these fishes in some of the most depleted branches of the Columbia.

Mr. C. G. Atkins gave some important data respecting the rate of growth, and facts regarding the habits of land-locked salmon. In reply to questions by Mr. G. B. Goode, the speaker thought that the land-locked salmon did not hybridize with the common salmon under natural conditions; nor did he think that there was evidence at present to prove that the