the limestone deposits of the tertiary, of the cretaceous, or of the oolitic, nay, even of the palæozoic periods; and the whole vegetable carpet covering the present surface of the globe, even if we were to consider only the most luxurious vegetation of the tropics, and leave entirely out of consideration the whole expanse of the ocean, as well as those tracts of land where under less favourable circumstances the growth of plants is more reduced, would not form one single seam of workable coal to be compared to the many thick beds contained in the rocks of the carboniferous period alone.

XXXIV.—*Memoranda of Observations made in small Aquaria, in which the Balance between the Animal and Vegetable Organisms was permanently maintained.* By Robert Warington, Esq.

Fresh Water.

Memorandum 1.

In my communication, dated September 1852*, I gave a detailed account of my observations on the thread or web which some species of the freshwater snail form to effect or facilitate their passage from one spot or object to another, and thus either ascending or descending by its means; and the instances noticed up to that period had reference only to the varieties of the *Limneæ*. In continuation of my observations on the same subject, I have now to state that the varieties of *Planorbis*, as also *Neritina fluviatilis* and *Physa fontinalis*, have, since that date, been noticed to possess the same power; and in the case of the latter, *Physa fontinalis*, the thread or web was so tough and strong, that on one occasion I was able, by means of a small rod introduced between the creature and its point of attachment, to move it out of its straight course a considerable distance, and by then slowly drawing the rod upwards, I succeeded in raising the snail completely out of the water a space of about 7 inches, suspended by its thread, so that, under these circumstances, the thread itself became distinctly visible.

From the observations which I have been enabled to make, I consider that I am justified in stating that all the freshwater snails are possessed of this power.

Memorandum 2.

As an evidence of the permanency of the balance capable of being established between the animal and vegetable organ-

* Annals and Magazine of Natural History, Oct. 1852.

isms by the introduction of the water-snail or other phytophagous mollusk, as I have elsewhere described*, I may state that the same water in which my original experiments were made in March 1849 has been in continual use up to the present time, several fish living constantly in it, without disturbance, and that it is now as bright and in as healthy a state as at the first period of its being employed.

Again, in a small jar of about one pint capacity, having a single plant of *Vallisneria spiralis* growing healthily in it, and with a few small water-snails as scavengers, I succeeded during the spring of 1853 in hatching and rearing a young trout. The egg was obtained from Mr. S. Gurney, jun., and had been removed from his preserves in the river Wandle; the shell ruptured the day after my receiving it, and it was maintained in a perfectly healthy state during the whole of the period required for the development of the respiratory organs, and the complete though gradual absorption of the ovum. This development was perfected in fifteen days from the bursting of the shell, till the period that the fish could sustain itself continuously in the water and was able to swim strongly. Having arrived at this stage of maturity, the vessel became far too small for the free use of its active powers of locomotion, and it was therefore transferred to a small tank containing several minnows, when to my great annoyance it was immediately seized and devoured.

As another instance of the voracity of the finny tribe and their destruction of each other, I may mention here that I had on a previous occasion placed several small trout fry overnight in an aquarium containing some gold-fish, but they must have been rapidly preyed upon, as no trace could be seen of them the following morning. These facts will demonstrate clearly the havoc which must take place in the rivers and streams among the young fry of various fish under ordinary circumstances, when they are proved to be devoured with such extraordinary rapidity even by such species as the gold-fish or carp tribe and the minnow.

Memorandum 3.

Care should be taken in the aquarium for fresh water to exclude the ordinary Polype or *Hydra fusca*, particularly where certain species of fish are to be preserved, as with the minnow (*Leuciscus Phoxinus*), for these creatures, insignificant as they may appear, after a short time cause their death, and that under most extraordinary circumstances, as the following observations

* Quarterly Journal of the Chem. Soc. for April 1850, vol. iii. p. 52.

will tend to show:—In a small aquarium that had had gold-fish kept in it for a length of time, but which had been removed into one of larger dimensions and more fully exposed to the light, an enormous number of the *Hydra fusca* were observed to have made their appearance very soon after this removal. Wishing therefore to ascertain if the appearance and rapid increase of these polypes had been prevented by the gold-fish, the following experiments were made:—Fifteen individuals of the *Hydra fusca* were placed in the aquarium containing the gold-fish, but they very soon disappeared, having I presume been devoured by the fish; a second fifteen were then introduced, but with the same result. At the same time as this experiment was made, fifteen hydras were placed in a tank containing four minnows (*Leuciscus Phoxinus*) and a pair of small eels, but as the minnows did not appear to touch them, the same number of polypes being counted over several times during a period of three weeks, they were soon forgotten altogether. After a space of about seven months had elapsed from this time, the minnows were observed to assume a most extraordinary aspect, the head appeared very much swollen, and the eyes of all of them looked as though starting out of their heads, being forced upwards and in an outward direction and much enlarged; by degrees the gills of some of them became streaked with bloody markings, and this gradually extended to the base of the pectoral fins. The whole appearance was most distressing to contemplate, particularly as it was impossible, from ignorance of the cause, to adopt any remedial measures. Judging from their appearance my impression was that they had been poisoned, and assuming that it must have arisen from something putrescent which they might have raked out of the materials at the bottom of the aquarium, the whole of the water was drawn off clear by a siphon, the gravel and sand thoroughly washed, and everything replaced in the tank with the fish; no improvement however appeared to follow, the fish got worse and ultimately died. This was in June 1853. Before this extraordinary change came on, the fish had been observed to cluster together in one particular secluded spot, and rarely came out as they had been accustomed to do, and when they did venture forth they rubbed or jerked themselves with much force against the gravel and rock-work, as though something was irritating the skin; nothing however was visible. I had had these fish for about eighteen months in the same aquarium. As the water was perfectly bright and clear, and free from all odour or unpleasant taste, I procured six fresh minnows and placed them in the tank; for about ten days they appeared to be pretty healthy; they did not however swim about freely, but herded together in one corner of the aquarium, and then the same ex-

traordinary change gradually came on which had been observed in the others, and after lingering for seventeen days they all died. On carefully scrutinizing the different parts of the tank with a magnifying-glass, my attention was at once arrested by observing the enormous numbers of the *Hydra fusca* which were present, particularly on the parts of the aquarium where the fish had been accustomed to feed; that is, along the water-line towards the light, at the base of the plants of *Vallisneria spiralis*, about half an inch above the gravel, and on the whole of the rock-work around the space where the minnows delighted to hide; here they might have been seen stretching out from the sides, hanging down from the top, in fact in every possible direction—here then was a solution of all the evil. It now became a question how these pests were to be eradicated, and after canvassing in my mind a variety of suggestions, I determined to endeavour to remove them individually, and by this means they were speedily got rid of; from fifty to a hundred being taken out daily. The method by which this operation was effected was as follows:—A long glass capillary tube open at both ends was introduced into the water, having the finger kept tightly over the upper orifice, while, with the edge of the lower opening, the polype was detached from its hold; the moment this was effected and the hydra began slowly to fall through the water, the finger was removed, and the water with the polype was thus rapidly driven into the tube by the pressure of the external column of water; on replacing the finger the contained water and polype were removed. By persevering in this course they were caught with the greatest rapidity and dropped into another vessel before they had time to attach themselves to the interior of the tube, falling through the water like a miniature parachute. When situated in places where this mode of capture could not be employed, as on the leaves of the Vallisneria, or on the under sides of the rock-work, they were pulled off with a jerk by means of a small pair of forceps. In this manner between four and five hundred polypes were removed from a small aquarium holding about six gallons of water. Since this some small carp and also minnows have been placed in the same water, and have continued now for upwards of sixteen months in perfect health.

It is a curious problem as to the manner in which this destruction of life was brought about; my own impression is that the hydras seized on the minnows whenever their extended tentacula were touched by the swimming fish,—stinging them, and causing a great degree of irritation; and that the polypes were torn from their position by the greater strength of the fish and carried to their places of retreat, where, by consequence, the mischief was continually accumulating. A similar removal from

one place to another of an analogous creature, the young of the *Actinia*, takes place in sea water, from their attaching themselves by their tentacula to some moving denizen, the hold being released very soon after they are forced from their original attachment.

Sea Water.

Memorandum 1.

In my previous experiments in this branch of the subject, commenced in January 1852*, and of which some results were communicated to the British Association at their meeting last year at Hull †, I stated that the result of my experiments to ascertain the kind of sea-weed best fitted for maintaining the balance with the animal life was, under ordinary circumstances, in favour of the Chlorosperms, and that the Rhodosperms submitted to the like conditions did not answer the purpose desired and at the same time retain their colour and beauty, inasmuch as they very soon became coated with a growth of short green and brown Confervæ (*Conferva tortuosa*?), which entirely mantled the whole surface of the fronds and destroyed their characteristic appearance. During these investigations, however, it occurred to me that it might be possible to obviate this drawback, and I have, I believe, succeeded, after a series of experiments, in overcoming this inconvenience, and can now retain them in all their natural loveliness and render them quite efficient for all the purposes required, that is, as consumers of carbonic acid and generators of oxygen.

The ground on which I have reasoned as a basis for these experiments has been the consideration, that nearly the whole of these red or pink-coloured sea-weeds are found either in deep water or under the shade of other Algæ, and from the fact that they were also often known to occur in shallow rock-pools; it was hence fair to assume that the pressure of the column of water could not be an important element in the production of these coloured growths, and therefore that it must depend upon a modification of the light. Hence my idea was that the effects of the depth of the water might be capable of being imitated by tinting the light through the interposition of coloured media, and thus all the results observed in the vegetation, and much even of the healthy animal life of deep sea water could be, under this arrangement, assimilated; and this, I am happy to state, has proved experimentally to be the case, so that, by very

* Garden Companion, January 1852; and Annals and Mag. Nat. Hist. for October 1852.

† Annals and Mag. Nat. Hist. November 1853.

simple means and with very little trouble, we shall be enabled to grow and preserve these elegant and beautiful plants in all their varied hues, as well as many of the wondrous forms of animal life usually found associated with them, for any length of time; and thus a much enlarged field for observation will be brought within the limits of our aquarium.

In order to obtain this desideratum, a medium having a blue or green tint has been had recourse to, and of such a nature as merely to colour, soften or diffuse the light, without materially diminishing its quantity. This was at first accomplished by the employment of a thin film of paint of the desired shade, of a thin silk gauze of a blue colour, by layers of tissue paper tinged blue and green, sometimes oiled to render them more transparent, at others the sheets of paper being superposed until the desired effect was produced, or by coloured varnishes, blue, and blue and yellow, and mixed to the tint required. These materials should be applied to the surface of the glass, or interposed between the source of light and the water, in such a way, that the whole of the light which directly illuminates the aquarium may be tinted of the proper colour. In proportion to the quantity of light at command and the varying aspect to the sun's rays, so must the transparency of the colouring medium be adjusted. In my own case I have been obliged partially to employ coloured glass, as the other methods were found to impede too much of the direct light; but it must be borne in mind that this is in the midst of a crowded city, in a smoky atmosphere, and surrounded by tall houses. To such an extent has this plan succeeded, that several small attached pieces of delicate red seaweed which I had received in October 1852, and had become thickly mantled with the brown and green confervoid growth already alluded to, and which had not exhibited the least signs of vitality, on being placed in a small glass jar arranged with tinted and oiled tissue paper, soon lost the whole of this parasitic growth, from its gradually decaying and being then consumed by the mollusks, the fronds assuming their deep crimson hue, becoming perfectly clear, and even after so long a period throwing out numerous young shoots or leaflets; and on one of these pieces several beautiful specimens of the *Coryne sessilis* made their appearance, together with groups of Lepralia and corallines.

Memorandum 2.

Another very interesting experiment that I have had progressing very successfully for some time past, is the preserving sea water in a perfectly transparent and healthy state without the use of vegetation of any kind, or, in some cases, even of a scavengering mollusk. The adoption of these experiments was

in a great degree forced upon me from circumstances which have been already published. In the paper read before the Meeting of the British Association at Hull, I stated that in consequence of the ravenous propensities of the crabs and the varieties of rock-fish, I had been obliged to establish several small imitation rock-pools, so as to separate these various depredators from each other; and as some of these, the blennies, also attacked the common periwinkle and other mollusks which were employed as scavengers, the plant or vegetation consequently became of little use, and was therefore omitted altogether from the arrangement. It may be asked then, how can the sea water under such circumstances be possibly kept in a healthy state? Why, thus: by exposing a very extended surface of it to the action of the air, and at the same time limiting its depth. The means that I have been adopting for upwards of twelve months consist in the employment of shallow circular stone-ware pans of about eighteen inches internal diameter by five inches deep; these are filled for about two inches with water, the bottom is supplied with sand and shingle, and numerous fragments of rock-work are arranged at the sides, some close below the surface of the water, others rising in gentle slopes above, and others again grouped to form cavities of retreat, so as to accord with the habits of the crabs, blennies, &c. placed in them. The whole is covered with a sheet of common window glass, raised about one-fourth of an inch from the edges of the pan by means of slips of wood, so as to allow a free current of air over the surface of the water, and at the same time impede the evaporation and prevent the greater part of the dust and soot from settling on it. By this arrangement a very extended surface of water is submitted to the oxidizing influence of the air, and the fish and crabs by their continual movements cause sufficient motion in the fluid to expose a fresh surface frequently to its action and thus keep up its aëration. But it must be borne in mind, that the oxygenation of the water thus effected is a very delicate equilibrium, and the maintenance of a healthy aëration is liable to be disturbed by very slight interfering causes; nor do I conceive that this method would be applicable except to such marine denizens as are either of such low organization as to require but little aëration of the water, or to such as the crab tribe, the blennies, cotties, gobies, and those creatures which delight in very shallow water, or which have the power of climbing out of their liquid element. The varieties I have myself kept in perfect health for the period mentioned, are crabs, blennies, gobies, cotties, and varieties of Actinia. *Cancer Mænas* has under these circumstances cast its skin three times during the present year, having increased in its dimensions most extraordinarily each time.

Memorandum 3.

The form of aquarium which, after upwards of five years' experience and observation on the natural habits of the various animated tenants, I have now adopted, consists in a four-sided vessel having the back gradually sloping upwards from the bottom at an angle of 45 to 50 degrees, and the consequently extended top sloping slightly downwards and resting on the upper part of the back. The bottom, therefore, becomes necessarily narrow. The front for the purposes of observation, and the top for the admission of light, are to be of glass; the back, ends, and bottom being constructed of slate; the whole fixed in a stout framework.

The advantages of this arrangement are:—

First. That it allows of a most extended view of the whole interior of the aquarium.

Secondly. That it enables the occupants to resort to water of any depth they may desire, or even to ascend the sloping back and emerge from the water.

Thirdly. It admits of a much larger surface of water being exposed to the action of the light; and

Fourthly. The sloping top allows the water which condenses on the glass, from the effect of radiation, to trickle off and return to the aquarium without first resting on the zinc or iron framework.

I need hardly mention that the sloping back is to be covered with light rock-work extending to a short distance above the water line.

XXXV.—*On a Mode of giving permanent Flexibility to brittle specimens in Botany and Zoology.* By Prof. J. W. Bailey, U.S.*

The excessive fragility, in the dry state, of many plants, and particularly of those which secrete carbonate of lime, is well known to botanists. There is no herbarium in existence in which the specimens of *Amphiroa*, *Jania*, *Corallina*, *Halimeda*, *Liagora*, *Chara*, &c. are not in a more or less mutilated condition, which becomes worse every time the plants are examined. In studying a large collection of the stony Algæ I was led to remark their perfect flexibility while moist, which passed to great brittleness when dry, and it occurred to me that if they could be kept permanently moist they would remain permanently flexible. I then remembered that General Totten, of the U.S. Engineers, had mentioned to me, some years ago, his success in preventing the cracking and peeling-off of the epidermis of various shells, by impregnating them with chloride of calcium. I also remem-

* From Silliman's Journal for July 1854.