in the abundance of fish; for both the sardine and frozen-herring industries have assumed important proportions, and men find remunerative employment in connection with them, thus avoiding the exposures, dangers, and hardships to which they were formerly subjected when fishing for haddock. At present only two firms engage at all in smoking haddock; one of these preparing only sufficient quantities to supply the local trade, while the other smokes small quantities for shipment to Portland. Those best informed estimate that less than 25 tons of haddock were smoked at Eastport during the season of 1885–'86, the few sent out of the city being consigned to Portland dealers.

57.—THE AQUARIUM. A BRIEF EXPOSITION OF ITS PRINCIPLES AND MANAGEMENT.

By WILLIAM P. SEAL.

The history of the discovery and application of the principles of the aquarium is so well known that it is not worth while to repeat it here. Many books have been written upon the subject, all of them in a spirit of glowing enthusiasm, but generally lacking information upon the most essential points, and often grossly misleading as to elementary principles.

A well-managed aquarium requires but little attention, and is a delight to all lovers of nature. It is a living ever-changing picture. On the other hand, under improper conditions an aquarium is a trouble, and is not calculated to give pleasure to the refined and cultivated. Certain conditions are absolutely essential to the successful working of the aquarium. The most important of these is absolute purity in the tank or vessel used, and an abundance of light. When these primary conditions are not obtainable, discouragement and eventual failure are certain. The dealer in aquaria, in his eagerness to make a sale, may advise differently. There is probably no business which has been more abused by false statements and a withholding of the truth, or from ignorance of the subject, and none is more in need of plain truth telling to elevate it to the position it should occupy in affording a means of popular amusement and instruction.

When once properly understood the aquarium, with its varied and interesting forms of life—animal and vegetable—will become as common a feature of household adornment as are birds and flowers.

The newly-awakened general interest in biological research, or, in plainer words, the study of life, has opened up an extended field for the aquarium as the medium for observation of the habits, developments, and metamorphoses of animals and plants inhabiting the water. As an adjunct to the microscope for the amateur or for the specialist, it is an absolute necessity. For the young as a means of encouraging habits of observation and feelings of humanity, as something to give a sense

of care and responsibility as well as to interest and take the mind from grosser things, nothing can have a higher value.

THE AQUARIUM TANK.

Aquarium tanks are made wholly of glass, or with a frame-work of some kind of metal, as of iron or brass, and of wood, slate, and marble, or any of these materials in combination with metal.

Glass, slate, and marble being substances devoid of properties having an injurious chemical action in connection with water, or where there is, as in the aquarium, more or less of decomposition of organic matter, need no further mention in this connection.

The iron tank, however, demands especial attention. By reason of the cheapness of the material, by far the greater number of rectangular tanks in use are made of cast-iron. Without entering specifically into the chemical actions involved in the introduction of iron rust (oxide of iron), or of the decomposition of the various varnishes or mineral paints used to prevent oxidation, in connection with decaying organic matter, it need only be stated that they are in the highest degree injurious. Galvanizing is often resorted to to overcome this difficulty, but it is not a satisfactory protection. In the French navy galvanized-iron tanks have been abandoned as receptacles for drinking-water for the reason that poisonous oxides are given off. For the same reason the U. S. Fish Commission has refused to use galvanized tanks on its ships. Undoubtedly the best material for preventing oxidation is a coating of the best grade of Portland cement, which will form, if properly applied, a solid, adhesive, protective surface, perfectly pure and practically indestructible. It is mixed with water and applied like mortar; first, however, scraping from the iron any paint or other substance of smooth and oily nature, to which it will not adhere well. After standing twenty-four hours to set, it should be soaked for two or three days before using, to remove all the lime, the water being changed several times in that interval. At any time that the tank is not in use it should be allowed to stand with water in it, for fear that the cement may crack or become loose from the unequal expansion and contraction of the two substances. Otherwise it is practically indestructible. The cement should not be allowed to touch the glass. It can be bevelled off where it approaches the glass, after it has set, but before it becomes perfectly hard. Portland cement is used exactly as is plaster of Paris, but becomes much harder; in fact, becomes an artificial stone.

THE PRINCIPLES INVOLVED IN THE ESTABLISHMENT OF AN AQUARIUM.

The vessel used is called an aquarium tank. The term aquarium implies such an adjustment of the relations between the animal and vegetable life in the aquarium tank that the one will sustain the other.

It is only when thus arranged that the term aquarium is properly applied.

There is no such thing as an *exact balance*, to be attained and regulated by a nice adjustment and the most scrupulous care, as is intimated in most works on the subject. On the contrary, there must be simply a preponderance of the vegetable or oxygenating element, or, putting it more plainly, the animal life must be limited to what will live comfortably in an aquarium under the conditions in which it is placed, which are so extremely variable that this limit can only be determined by individual observation and experience. All else is mere guesswork.

Oxygen is the element essential to the support of animal life. Carbon is the element essential to the support of vegetable life. Aquatic animals in breathing (*i. e.*, drawing the water through their gills which correspond to our lungs) absorb the free oxygen in the water, and also decompose the atmospheric air held in suspension in the water and absorb or assimilate the oxygen and exhale or throw off carbonic acid gas.

Plants, on the contrary, in growing, *under the action of strong light*, decompose carbonic acid gas—a compound of carbon and oxygen—absorb or assimilate the carbon, and liberate the oxygen. Thus there is a constant interchange of the elements necessary or vital to each. Water is a compound of oxygen and hydrogen, but the water itself is not decomposed, and the oxygen, which is a component part of the water, is not absorbed or diminished, so that in reality the fishes breathe atmospheric air like ourselves and get their supply of oxygen mainly from it.

Now, to show the conditions under which fishes must live in the aquarium, let us use human beings as illustrations. An air-tight apartment containing human beings would be analogous to an aquarium tank filled with water alone, and stocked with fish, except that a small amount of air would be absorbed by the water in the process of evaporation. The conditions are nearly enough alike, however, to illustrate the point. Any school child twelve years of age should be able to point out the fact that as soon as the air in the apartment would be breathed over sufficiently to exhaust the oxygen in it the human beings would suffocate. This is exactly what would take place in the case of the fish. Here, then, comes in the function of the plant life: To renew the oxygen absorbed by and essential to the animal life.

We see, then, that it is absolutely necessary that the aquarium should be placed where it will get strong light. Where this is impossible it is not advisable to attempt to establish an aquarium, as failure would be the inevitable result. The alternative is the fish-tank, without plants and with running water. This advice will apply to those who are attracted by the ornamental beauty of the aquarium without regard to its scientific aspects, and who think that one would be

just the thing to fill up some vacant niche or space, which space, however, would be entirely unfitted to the requirements of the aquarium. This would simply lead to waste of money, to vexation and failure, as well as to cruelty to innocent and helpless creatures. It is certainly distressing to any one having the slightest feeling of kindness for dumb animals, and fully understanding the meaning of it, to see a lot of fish gasping for air at the top of an aquarium, absolutely tortured by slow suffocation; for unless relieved, death must result.

STOCKING AND MANAGEMENT OF THE AQUARIUM.

In the internal arrangement of the aquarium we may please our individual fancy. Those, however, who imitate nature most closely, avoiding incongruities—such, for instance, as the use of sea-shells and corals in the fresh-water aquarium—will have aquaria most worthy of admiration. Aside from the unnatural appearance, the use of shells and corals is to be avoided, for the reason that, being soft and easily decomposed forms of carbonate of lime, they introduce injurious chemical action.

There are a great many plants which will thrive in the aquarium. Those most commonly sold for the purpose are Myriophyllum, Ceratophyllum, and a species of Cabomba. They seem to do the best under all circumstances and have from choice the largest sale. There are many others, however, which, although not as large or of as vigorous growth, add very much to the ornamental features of the aquarium. Aquatic plants possess a beauty all their own, and they are the crowning glory of a well-conditioned aquarium, which can be made as beautiful as a wardian case. Those plants which root at all grow readily if fastened in the terra-cotta ornaments sold for that purpose, or if simply planted in the sand and pebbles. Some plants, such as the ceratophyllum and the bladderwort, never root even in nature, but will grow freely either fastened down or floating loose. Care should always be taken not to crush them at the base by binding them too tightly with the strips of soft metal sometimes used to bunch them. The metal can be cut into fine strips, or fine copper wire may be used. If plants which root are crushed, they will rot off before they have time to send out roots and will come to the surface. In this case the fish are generally blamed for pulling them up or eating them off, as they will be seen to eat of the decaying plant as it softens. The arrangement of the plants is of course a matter of individual taste. They may be arranged with mathematical precision, as an orchard would be planted, or mingled with the graceful abandon of nature, as you will.

The use of sand, pebbles, or shingle is also wholly a matter of individual fancy, as it is principally a matter of ornamentation. Sand, or sand and pebbles mixed, forms a compact mass, and as the sediment will collect on the surface of it, it is more easily removed than where pebbles alone are used. The aquarium may be more easily kept clean

without any of them and with the plants growing in little pots filled with sand or pebbles. These may be made to look like rock by covering ordinary small earthen pots with Portland cement, or by cementing together pieces of stone.

The stereoptyped question, "How many fish can I keep in my aquarium" is simply offering temptation to the cupidity of the dealers, most of whom will sell you all the fish they can without regard to the consequences to you. In fact, with most of them the governing principle of their business seems to be that the greater the mortality of fish the greater the sale of them. The comparatively few aquaria in use, as well as hosts of abandoned ones, attest the short-sightedness of such a policy.

There can be no rule by which to determine the amount of animal life that can live comfortably in a given quantity of water, it being a question involving the size of the fish, the amount of light (upon which the activity of the plant life depends), and more than all of temperature, which is exceedingly variable. For every 16 degrees of lower temperature water will take up and hold in suspension about double the volume (approximately) of atmospheric air or of oxygen liberated by the plants. Thus it may be inferred that water at 50 degrees will support double the number of fish that could live in the same quantity at 66 degrees. When water is heated on a stove the air will be seen to leave it in bubbles as the temperature rises until all is expelled. After water has been boiled fish can not live in it at all until it is again charged with air by the use of a bellows or pouring it from one vessel into another, thus imitating the revivifying influences of nature in the dashing of the waves or in tumbling it over rocks. Water from which the air has been expelled will again recover its normal proportion of air by absorption alone, but the process will be slower. Good judgment, then, would indicate, in view of the widely-varying conditions to which aquaria are subject, that the path of safety would lie in stocking them to the minimum number of fish only. The question then naturally arises, "How can I know the minimum number?" This is a question which can only be determined by observation, and the only safe plan is to add a few fish at a time. If you should pass the safe limit, there will soon be a lack of air or oxygen in the water, and the fish will keep at the surface, with their mouths out sucking in air, or, in other words, getting their supply of oxygen from the atmosphere itself. When this occurs it will be necessary to diminish the number of fish or to change the water in part at least. The aquarium will be affected unfavorably by a change from colder to warmer weather, as a portion of the air will be expelled. Also by cloudy weather, as the plants lacking the stimulus of strong light will not liberate a sufficient supply of oxygen. If the animal life in the aquarium is limited to what can live in it comfortably under the most unfavorable conditions, it must then be uniformly successful.

Fish should not be introduced into the aquarium until at least a week after the plants are placed therein—except perhaps a comparatively small number to interest the children who are generally extremely impatient to have them—so that the plants may first begin to grow and give off oxygen freely. Others may then be introduced from time to time until the aquarium is fully stocked.

With regard to light it may be said confidently as a result of extensive observation and experiment, that it is almost impossible to get sufficient from a northern exposure, the exception being in bay windows which may catch the morning or afternoon sun for a short time and have a good light generally.

Professor Huxley goes so far as to say that "plants only liberate oxygen under the action of strong sunlight, and in the dark this action is reversed." This would account for the sometimes unaccountable deaths of fish in aquaria, which generally occur at night, when in addition to the lack of light there is less ventilation and greater escape of poisonous gases from gas-pipes and furnaces. These gases are rapidly absorbed by water, and when the conditions are such that there are no counteracting influence their presence must be baleful in the extreme.

In winter the full power of the sunlight may be allowed, but in the summer when the rays have greater heating power some modification is necessary, and the proper mean of sunshine may be found by a little experimentation.

In rooms where there is a high temperature a close-fitting glass cover to the aquarium will be found beneficial. This advice invariably induces the question, "Will not that exclude the air?" The answer is, that in a properly conditioned aquarium the water does not derive any benefit from contact with the more or less impure air of ordinary living rooms at all in proportion to the detrimental influences, but depends wholly upon the plant life for its supply of oxygen. The glass cover prevents the absorption of impurities from the atmosphere and the collection of dust, and by retaining the oxygen which is given off in excess of what the water will hold in suspension there is always a highly oxygenized atmosphere immediately over the water.

Another and very common question is, "How often should I change the water in my aquarium?" A successful aquarium is one which is so stocked and afforded the proper conditions, in accordance with the principles already given, that it will not be necessary to change the water—other than the change effected by supplying the loss from evaporation—except at long intervals, not more than once or twice a year when a general cleansing may be considered desirable.

There are many experienced aquaria fanciers who find no difficulty in keeping (both marine and fresh water) aquaria for many years without change of water. The water should not be changed unless the fish show signs of great distress by keeping their mouths out of the water and sucking in air. This denotes the exhaustion of the air or free oxygen

in the water. The water may be re-aerated by the use of a syringe or by dipping it out and pouring it back. The probability is that a small quantity dipped out and replaced with an equal amount of fresh cold water will be all that is necessary. Where the water is completely renewed it should be about the same temperature as the old. Fish are often killed or become diseased by being plunged from water of the temperature of an ordinary living room into water icy cold. Their gills (lungs) become congested, which produces inflammation and ulceration, and they show all the appearance of tuberculous diseases. The smaller the aquarium the more likely it is to be affected by either internal or external influences. The changes of temperature particularly will be more rapid. As before stated, if given proper conditions and not overstocked with animal life, such disturbances very rarely occur and only from accidental causes, such as are always occurring in all the affairs of life.

The ordinary cleansing of the aquarium consists in the cleaning of the glass and the removal of sediment, which latter is easily and efficiently accomplished by the use of a siphon or a pipette, also called lifting tube. This is simply a glass tube drawn in a little at both ends for convenience in using. This is used by holding the forefinger over the opening in the top of the tube and directing the other end over any sediment to be removed. The finger is then removed from the top of the tube when the air escaping the water will rush into the tube, carrying the sediment with it. By again placing the finger over the opening in the top of the tube it can be lifted out with its contents and emptied into some vessel by withdrawing the finger from the opening.

The usual green accumulations on the glass are due to the presence of minute plants known as confervæ. They are generally considered to render the aquarium unsightly. This feeling, however, is not shared by those who are close observers and lovers of nature, for everywhere where even dampness is found this class of plants abound, making hosts of the larger plants and clinging to stones and sticks and even to the earth itself. Viewed under the microscope they are wonderfully beautiful. They are good oxygenators and furnish food for fishes and tadpoles and are really dense forests under the microscope in which myriads of animalculæ harbor and propagate. If so desired, sufficient tadpoles and snails will keep these plants at a minimum, but if the front glass of the aquarium be kept free of them by the use of a small paddle or swab covered with rubber, felt, flannel, muslin, or chamois, they will be found to render it more beautiful by giving it the greenish tinge of nature. An excessive growth of them may also be checked by a modification of the light by the use of screens, for which purpose the use of tissue paper is as good as anything. Some interesting experiments may be made upon the growth of plants by interposing tissue paper of different colors and noting the effect of each after a few days. When the water itself becomes green and opaque from the presence of certain

forms of confervæ the best plan is to change the water, although they may be destroyed by diminishing the light sufficiently or by introducing a number of tadpoles.

FEEDING FISH IN AQUARIA.

In feeding the fish care must be taken to introduce no more food than they can eat in a short time, as what is not eaten will soon decompose and make the water cloudy, and generate noxious gases as well. If due care is observed in regard to quantity it does not matter how often fish are fed except that if fed abundantly they will grow rapidly, which is not generally desired. Fish may be fed every day or but two or three times a week with equally good results apparently. They will always find a small amount of food in the aquarium in the vegetation. Where they are not fed sufficiently they are apt to strip the plants of their leaves. In a natural condition fish are feeding continually and grow very rapidly.

The wafer food which is universally sold for gold-fish and other vegtable feeding fishes is a good, nutritious food. Bread, cake, and cracker sour more quickly, and are therefore somewhat objectionable unless carefully used. Most fish, even those supposed to be strict vegetarians, are fond of raw beef. It should be scraped to get the pulp free from muscular fiber, or chopped very fine. Lean beef, unsalted, may be dried quite hard and can then be scraped quite fine. It soon softens in the water, but does not give off the blood as when raw. The fish, however, prefer it raw. Ants' eggs are excellent food. They can be generally bought at bird stores. Oysters and clams, well washed to get rid of the juices and chopped fine, are enjoyed by most fishes. Worms, chopped fine for small fish, are enjoyed most of all. All chance of contaminating the water in feeding the fish may be avoided by having an ordinary confectionery or other jar into which the food may be dropped after placing it in the aquarium. The fish will soon find their way into it. Many of our common brook and pond fishes will eat animal food only, and some of them only living things. Among such are the various sun-fishes, sticklebacks, etc. They are perhaps more lively and interesting in their habits than the more peace-loving vegetarians, the gold-fish and others of the cyprinidæ, but there is more difficulty in finding food for them. A small scoop-net made with cheese cloth and used in almost any quiet water, among the dead leaves, will often yield large numbers of insect larvæ, small crustaceans, which afford them natural and needed food.

DISEASES OF FISH.

Fish are subject to diseases very similar to those of other animals. They are sometimes infested with parasites, some of them microscopic, which will eventually kill them if not removed. The manifestations

of disease in a fish are a generally drooping appearance, the fins being closed or depressed, its movements being slow and languid—altogether different from its usually lively and graceful motions. The presence of the microscopic parasites which often infest the gold-fish in aquaria is made known by an inclination in the fish to keep the fins close to the body, at times flapping them rapidly and darting about as if intensely irritated. There will be generally in this case a raw or bloody appearance about the bases of the fins, and at the edges of the scales, and the fins may become closed, the rays being drawn together and terminating in a sharp point. Fish may be freed from these pests by taking them up carefully in a soft net and dipping them in strong salt water for a few seconds once or twice a day, or brushing them with a soft brush or sponge dipped in salt water. Carbolic acid diluted is sometimes used and other remedies are sometimes recommended, but the salt bath is quite as efficacious as any of them, and less dangerous to the fish. Diseased fish may often be cured by putting them in a tub of water with some aquatic plant out in the open air when the weather will permit, or in winter in a light place if with plants, and in semi-darkness if without. Sudden changes of temperature in changing the water are sure to produce inflammation of the gills (lungs) and other diseases apparently analogous to those of mankind produced by similar causes. But little is known of the diseases of fish, and there is plenty of room for experiment in treatment. Very strangely the minute parasites so common to the gold-fish do not appear to infest other kinds. There is a disease quite common among gold-fish and carp, in which there is a quantity of water between the skin and body of the fish, and the scales stand out from the body almost at right angles. They rarely recover and no cure is known. Where fish have proper conditions and are not crowded these diseases are very rare. Fungous growths occur where the scales or mucous covering are scratched or rubbed off. The germs of this class of parasitic plants are generally present in water, and are sure to develop upon any animal, and sometimes vegetable matter which may be present in a state of inflammation or of decomposition. Sometimes the fins of fish will be destroyed by these growths, but will soon grow again when the fungus is removed. The salt-water bath is the simplest and best means of removing or destroying it.

RECAPITULATION.

A brief recapitulation recalls four points demanding especial consideration as absolutely essential to success in the management of the aquarium. They are, first, *absolute purity in the vessel used;* second, *an abundance of light;* third, *to avoid overstocking with fish;* and, fourth, *great care in introducing food into the aquarium.* A careful observance of these principles will lead to success. To ignore them is to invite failure.