Caring For an Aquarium

Caring for an aquarium need not be a terrible chore, and anyone can learn how an aquarium works. Even if you consider yourself a rank amateur, you should have a good grasp of the basics by the end of this chapter. I'll cover basic aquarist skills you will need to develop in order to take proper care of your tank.

Water

Water is the most obvious component of any aquarium system. Aquarists of long experience sometimes make much ado about the chemistry of their aquarium water. Its degree of acidity or lack thereof, the concentration of dissolved minerals, the presence of disinfecting agents in municipal supplies, any or all of these can become the stuff of vigorous debate. From a practical standpoint, however, you will need to make do with whatever comes out of your tap unless you are prepared for a major effort. Commercial preparations for altering the two important water parameters, pH and hardness, abound, but using them to bring tap water in line with desired aquarium conditions becomes a never-ending proposition. Finding out the present condition of your tap water and choosing an aquarium habitat accordingly makes more sense. For example, suppose your water is hard and slightly alkaline. It will be great, as is, for the livebearing fishes of Central America such as swordtails and platies (*Xiphophorus* sp.). On the other hand, discus require soft, acidic water, and may not do as well for you unless you alter the tap water accordingly. Determining your water conditions involves no more than a phone call or a check of your utility company's Web site. Simply search the site or call and ask for information regarding the pH and hardness. With luck, your water will already test within a range that is acceptable to most common tropical fish species, that is, at or just above or below neutral in pH (6.5–7.5) and moderately hard (160–220 ppm).

Water Hardness

Throughout this book, water hardness preferences for fish and plant species will be given in parts per million of calcium carbonate (ppm $CaCO_3$), because many utility companies use this unit of measure. Various other units will be found in the aquarium literature, in particular, German degrees of hardness (dKH, dGH). Knowing the relationships among the commonly given units permits simple conversion among them.

50 ppm $CaCO_3$ is the same amount of hardness as:

2.8 dKH when hardness is expressed as German degrees, dGH, or KH;

2.92 grains per gallon (gr/gal $CaCO_3$) if this somewhat outdated English unit is used;

1 milliequivalent per liter (meq/L) when hardness is expressed as *alkalinity*.

No standard applies to general descriptive terms for water hardness often given in aquarium books. Here is my interpretation:

very soft means water with <75 ppm $CaCO_3$
soft means water with 80–150 ppm $CaCO_3$
moderately hard means water with 160–220 ppm $CaCO_3$
hard means water with 230–360 ppm $CaCO_3$
very hard means water with >360 ppm $CaCO_3$

Your local dealer may do nothing to alter tap water conditions, as this represents an ongoing operating expense. A quick check of the fish that look particularly vibrant in the dealer's tanks may provide clues to choices that will thrive in your local water. If your dealer does make the effort to adjust tap water conditions to meet the demands of certain species, ask for advice on how to do this most cost effectively at home.

The most common and popular tropical fish tolerate a range of water conditions. No doubt, this is one reason for their popularity. Some species, unfortunately, do not adapt so readily to captivity unless their demands for a particular kind of water are met. When this is the case, I include specific recommendations for water conditions. If you choose to create one of these habitats, be prepared to supply sufficient water of the appropriate kind, which may mean altering your tap water.

Altering water to suit tropical fish can be done at home, though the effort requires regular repetition. For example, if you need softer water, you can simply dilute tap water appropriately with distilled water from the grocery store. To reduce the hardness from 200 ppm to 100 ppm, you would mix equal parts of tap water and distilled water. If you have need for more than a few gallons of purified water at a time, you may find it more convenient to install a deionization tank or reverse osmosis unit. Removing something from water is always harder than adding something to it, hence the need to install special equipment to reduce hardness. Lowering the hardness of significant quantities of water imposes a considerable additional expense. For example, a reverse osmosis unit requires regular maintenance and replacement of filter media. Most units waste several gallons of water for each gallon of product. These costs add up.

Increasing the hardness, on the other hand, is easy. Simply add a measured quantity of the appropriate mineral salts. Commercial products abound for this purpose. Many contain common household chemicals, such as baking soda or Epsom salt. The cost per gallon of water treated is small, since these chemicals are cheap. Among aquarium fish, African cichlids in particular benefit from water treated to increase its hardness. No tap water is likely to be as hard and alkaline as these fish prefer. Similarly, fish from estuarine habitats, where seawater mixes with fresh water, do best with added salt. In this case, synthetic seawater mix, sold dry in plastic bags, serves the purpose well. Aquarium stores that stock saltwater fish will have one or more brands on hand. Additions of commercial hardness increasers or seawater mix will typically raise the pH to an alkaline (8.0–8.3) range. Therefore, you seldom need a second additive for pH maintenance.

Lowering the pH can be tricky. Because hard water may be difficult to adjust, beginning with soft water gives the best results. Distilled water or water from a deionization tank or reverse osmosis unit should have a pH close to neutral (7.0). To provide the slightly acidic (6.5) to strongly acidic (5.0) water that some fish insist upon necessitates adding acid. For this purpose, sodium phosphate often appears in a little bottle on the shelves of aquarium shops. Adjusting the pH by adding acid in chemical form is easily overdone, however, because a little of the chemical goes a long way. The added sodium probably does not do plants or fish much good, either, unless they come from an estuarine environment. A more natural method of pH reduction involves passing the water through a small amount of horticultural peat, or introducing commercial additives derived from peat. Organic acids leached from the peat reduce the pH gradually over a period of weeks. The mixture of organic compounds from the peat also confers a buffering effect. (*Buffering* refers to the ability of the aquarium to remain stable with regard to pH over a long period of time.) With time and regular maintenance, under peat filtration the aquarium water remains stable at the target range of pH ± 6.0. Some of the most exquisite small species require such soft, peaty water. Pencilfish (characins in the genera *Nannobrycon* and *Nannostomus*) provide but one example. I consider the brownish color imparted by the peat, giving the water the appearance of weak tea, a desirable, natural effect. If you insist on diamond-clear water, you may want to avoid species demanding soft, acidic water. You can also try removing the color by passing the water over activated carbon. This may thwart your pH control efforts, however, and will require experimentation with different brands of carbon. Then there is the matter of replacing the carbon regularly. I say stick with the natural look.

The necessity for chlorine removal, usually accomplished by adding a small amount of a product containing sodium thiosulfate, is (gasp!) questionable. The use of dechlorinator in aquarium water strikes me as somewhat like carving pumpkins for Halloween. We do it because of tradition, not because it serves any real purpose. Changing 50 percent of the water in my outdoor pond, for example, using replacement water straight from the garden hose and without any dechlorinator added, has never harmed my goldfish. Admittedly, goldfish durability is the stuff of legend, but many aquarium books would have you thinking fish will be dying left and right from the least whiff of chlorine. Were I betting, my money would lie with the following proposition: More fish die from lack of water changes than failure to use dechlorinator when a water change is finally carried out. I seldom use dechlorinator. If you feel more comfortable doing so, go ahead.

The bottom line for water quality: use what you have. Choose species of fish and plants that are naturally adapted to the water conditions found at the sink. Otherwise, prepare to invest time and money to correct those conditions for the needs of your fish. My personal preference is to select the tank's inhabitants with great care, putting the effort into designing a beautiful, natural aquarium that will not require more maintenance than I can comfortably handle.

Physical and Chemical Cycles

Every aquarium book devotes several pages to a discussion of the important physical and chemical cycles that govern the health of the closed aquarium system. All of this discussion can be summarized in four sentences:

- Without a biological filter, an aquarium requires water changes so frequently as to be impractical.
- Life in an aquarium cannot exist without exchange of oxygen and carbon dioxide at the surface.
- A proper initial design and regular maintenance takes care of both these requirements.
- The number of fish an aquarium can adequately support depends on factors beyond basic life support.

Biological Filtration

Fish excrete their wastes directly into the water. Under natural conditions fish population density, considering the total volume of water in a stream or lake, is much lower than that of even the largest aquarium. Dilution, therefore, immediately counters fish waste pollution in natural waters. Additionally, in a short time natural processes degrade the wastes into simple compounds that can be taken up by plants, or utilized in some other ecological process.

When we establish an aquarium system we harness these same natural processes to keep the water sufficiently unpolluted to promote the survival of our fish display. The totality of these processes as they occur in an aquarium is *biological filtration*. Biological filtration is the detoxification of wastes by beneficial bacteria known as *nitrifiers* or nitrifying bacteria. Coating every available surface that lies in contact with oxygenated water, these organisms chemically convert ammonia (the primary component of fish waste) into nitrate (a relatively harmless compound taken up by plants). Biological filtration, or *biofiltration*, readily develops in the aquarium. All that is required is an ammonia source (fish) and the right kinds of bacteria. The latter are automatically transferred along with fish or plants or any other item taken from natural waters or from a previously established aquarium (the dealer's inventory system, for example). Within a month, nitrifying bacteria will have colonized the aquarium system sufficiently to process a moderate amount of waste. This gradual development of biofiltration capacity prompts the widely offered recommendation always to stock the aquarium slowly, over a period of several months. Within six months to a year, the population of beneficial nitrifying bacteria will have matured completely and biofiltration will be adequate to permit fish to be stocked at full capacity indefinitely.

Though biofiltration is a totally natural process, most aquariums are outfitted with some kind of filtration system. If nothing else, a recirculating pump, such as the one in my outdoor pond, oxygenates the water and creates a modest current that causes debris to collect near the pump intake where it may be easily removed. Most filtration equipment is considerably more elaborate. Designed to maximize biofiltration capacity, aquarium filtration equipment may employ a variety of techniques to increase the surface area available for colonization by nitrifiers. The bacteria refuse to carry out the desired chemical transformations when they float freely; they need to be stuck to a solid surface. Thus we have rotating bio-wheel devices, wet-dry systems, and fluidized bed technology. All these filtration methods provide extremely efficient biofiltration, converting all the ammonia generated within the tank to nitrate in a short period of time. Aquarium system design sometimes focuses on biofiltration to the exclusion of other important factors, because the aquarist is often seen as trying to squeeze the maximum number of fish into the minimum number of gallons. Although you can buy a highly efficient filter system and have the tank teeming with fish, doing it that way invites disaster, nearly guarantees it, eventually, in fact, because you will have exceeded what I like to call the *true* carrying capacity of the system.

Carrying Capacity

We can debate all day about carrying capacity; that is, how many fish of what size a particular aquarium can support. If by *support* we simply mean "adequately detoxify the ammonia waste produced" we can bump up the number of fish to high population densities indeed. Consider how many fish might be packed into a dealer's inventory system, for a case in point. Fifty fish in a twenty-gallon tank would not be considered unusual. For the home aquarium display, on the other hand, biofiltration is not the whole story. We must think about the long-term success of an aquarium whose residents will be there for the rest of their lives. Fish and plants need what I like to call *ecological space*. A given species may need swimming room, or a minimum number of companions of its species, or a certain level of water movement, to really thrive. The ability of the aquarium to provide for these needs as well as waste removal is a measure of the true carrying capacity. Taking into account not only waste removal, but also the need for ample oxygen, swimming room, and benign social interactions, ecological space must be allotted in the process of designing the aquarium. Care must be taken not to exceed the true carrying capacity of the system. One test of carrying capacity being met appropriately has to do with fish spawning in a community tank.

For how many kinds of fish do you see in the aquarium literature advice to spawn them in a tank set up especially for the purpose? The answer is "most of them." Yet, fish successfully spawn in the wild, often when surrounded by numerous individuals of other species. Recently, I visited a public aquarium and observed *Cichlasoma nicaraguense* and *Cichlasoma labiatum* both tending healthy, free-swimming broods of young in a giant community tank. In the home aquarium, either of these would be considered far too aggressive to be housed with other species. Provided with a volume of space that roughly corresponds to the size of a natural territory, however, the fish remain preoccupied with their young and only show aggression when a tank mate strays too close. I have observed this same phenomenon in Everglades National Park. All along the Mahogany Hummock trail through the park, introduced cichlids, especially the Oscar, *Astronotus ocellatus*, inhabit the sluggish, blackwater slough traversed by the trail. When spawning, each fish hollows out a depression in the sandy bottom, and drives away anything approaching within about a meter of this spot. So do the math. If the aquarium tank provides less than a circular territory of about a meter in radius, an Oscar large enough to raise a family will sooner or later decide that the entire space should be rid of potential competitors. A smaller tank will not provide enough true carrying capacity for one Oscar and several other fish to live peaceably together indefinitely. On the other hand, even a large Oscar will survive (though likely not exhibit any inclination to breed) in a thirty-gallon tank with a suitably efficient biological filter.

Gas Exchange

Other physiochemical factors affect the carrying capacity of an aquarium. Gas exchange is crucial. The water must continuously contain sufficient oxygen for the fish to breathe (and for both fish and plants at night) and must be continuously rid of carbon dioxide. While plants absorb carbon dioxide during daylight periods, at night this may not be enough to prevent the accumulation of CO_2. Carbon dioxide dissolves in water to produce carbonic acid, which drives down the pH and can inhibit critical respiratory processes in the fish. In sufficient concentration, CO_2 is lethal. Merely agitating the water at the surface facilitates most, if not all, needed gas exchange. Surface agitation can be provided by a simple airstone bubbling in the tank. All filtration systems require water movement, and this usually creates plenty of surface action. Problems sometimes do occur when accumulated debris clogs the filter and causes it to slow down, and the resulting change in flow rate goes unnoticed. However, the most common reason for poor gas exchange is too little surface area for the volume of water in the tank. A tall, narrow tank has considerably less surface area per gallon than a shallow, broad one. Consider the following comparison between two commercially available sizes of tanks:

Filter Numbers

Filter throughput should be three to five times the total tank capacity per hour. For example, a 100-gallon tank needs 300–500 gallons per hour of turnover. Pumps capable of delivering such flow rates will necessarily create water currents. The higher turnover rate might be chosen for a riverine habitat, while the lower flow rate would be more appropriate for a lake-inspired habitat design.

A fifty-gallon "breeder" tank (36 x 18 x 18 in.) has 4.5 square feet of surface, or a ratio of 0.09 square feet per gallon. A seventy-seven-gallon "show" tank (48 x 12 x 24) has only 4.0 square feet of surface, or 0.05 square feet per gallon. The ratio of surface area to water volume is roughly half that of the fifty-gallon tank. The surface to volume ratio determines how quickly oxygen can be replenished from the atmosphere as it is depleted from the water by fish. The difference can be overcome only by using a pump to circulate water within the aquarium, bringing low-oxygen water from the bottom to the surface and carrying oxygenated water in the opposite direction. Much more turnover will be required to maintain the oxygen content of the water in the larger tank, as compared to the smaller one.

Gas exchange must be taken into account in developing an aquarium design. A tall tank may be dramatic in appearance, but it needs to be correspondingly broad (most aquarium shop owners would say "deep") to provide adequate surface area. One company advertises a "picture" aquarium that hangs on the wall. Such tanks are necessarily quite slender in profile, and offer minimal surface area per gallon. This creates sufficient husbandry challenges that the company offers a list of recommended species that are hardy enough to cope with the suboptimal environment the aquarium provides.

Oxygen enters the aquarium, and carbon dioxide escapes it, via the water surface, but water must also circulate within the tank so that oxygen remains constantly available to the fish. Similarly, carbon dioxide must not accumulate. Plants can account for significant oxygen production during the daylight hours, during which time they also remove carbon dioxide. At night, surface exchange must be relied upon. Creating water movement is a secondary benefit of all available filter designs. If the turnover rate meets the standards suggested above, water movement should facilitate adequate gas exchange.

Water Changes

Regardless of its design, every aquarium needs regular partial water changes. I suggest removing 10 percent of the water weekly and replacing it with freshly drawn water. Depending upon your schedule, you might elect to change 20 percent every two weeks or 40 percent monthly, but the aquarium will look better and the fish will appear more vibrant with more frequent, smaller changes.

Lighting

Aquarium lighting should show off the underwater scene to its best advantage and provide energy for photosynthesis by aquatic plants. If the design relies solely on plastic plants, a single fluorescent lamp positioned over the tank may be enough unless the tank is quite deep. Even in an all-plastic ecosystem, more light will always make the tank appear inviting, and will foster the growth of filamentous algae upon which many fish feed. Sometimes, unconventional lighting (by which I mean anything in addition to, or other than, the standard fluorescent strip across the top of the tank) can be used to produce striking effects. For example, a spotlight shining in can direct the eye toward a particular underwater feature, in much the same way that stage lighting directs the attention of the audience.

On the other hand, if you're using aquatic plants, you may need to think more about your lighting choices. Aquatic plants reach their greatest abundance and diversity in clear, shallow waters, such as the spring runs for which west-central Florida is famous. Under such conditions, sunlight penetrates well. Even under the most favorable circumstances, however, the amount of available light under water will only be a fraction of that shining on the surface. Reflection, absorption with increasing depth, and shading by vegetation all limit light availability in natural bodies of water. Even so, enough light for photosynthesis can reach the bottom to support dense plant growth, because sunlight is quite intense. Few home aquariums rely on sunlight as the main light source and most make do with artificial lighting. Choosing an artificial lighting system for a particular aquarium design requires knowledge of the available types of lighting equipment and their respective capabilities. (Check out Appendix B for more information.)

Several factors conspire to limit the efficiency of aquarium lighting. For example, the reflector housing the lamps cannot be 100 percent perfect, and therefore not

Knowing Light Lingo

The amount of light energy emanating from a source is measured in units known as *lumens*. The light intensity, or irradiance, over a given area is measured in *lux* or lumens per square meter. Over a cornfield in Iowa in the middle of summer, the midday sun may provide irradiance of 100,000 lux or more. You'll be lucky to find an aquarium lighting system that can deliver 10 percent of this amount to the plants in the tank underneath it.

all light emitted will reach the water surface. Reflection from the water surface itself reduces light penetration, too. Further, as the tank becomes taller, the amount of light reaching the bottom decreases dramatically due to the Inverse Square Law of optics. Light intensity decreases in proportion to the square of the distance between the source and the object illuminated. In practical terms, this means the same light fixture over a tank 12 inches in height will deliver only one-fourth as much light to the bottom if the height of the tank is increased to 24 inches. Double the distance and illumination decreases fourfold. Further, the greater height of the water column means more absorption by the water itself. This again reduces the effective light intensity.

The implications for aquarium lighting design are straightforward. For aquariums up to about twelve inches in height two fluorescent lamps of the maximum length that can be accommodated across the length of the tank should be used. For deeper tanks up to four feet long, use four fluorescent lamps of the maximum possible length. For larger tanks, use one to several metal halide lamps to provide extremely bright light. Although I suggest here choosing lamps by length, in actual practice it is the wattage that matters. The higher the wattage, the brighter the lamp. For example, a lamp four feet long consumes 40 watts of electricity and produces about 3,000 lumens. Data on the lumen output of various types of lamps can be found on lighting manufacturers' Web sites. Appendix B provides lighting recommendations for all the standard types of aquarium tanks. The recommended lighting should allow you to grow a handsome underwater garden in every aquarium you design.

I have included special lighting recommendations for some of the model designs given later in the book.

The Needs of Aquarium Plants

You cannot grow aquarium plants without sufficient light, but unless the water conditions are also correct, you will end up growing only algae, even if you have the best lighting system on the market. Besides light, aquatic plants need water of appropriate pH and hardness levels, sufficient fertilizer for growth, and the absence of harmful organisms. Plants should therefore be chosen with the same care as fish.

Light Requirements

To get an idea of the lighting needs of typical aquarium plants, consider where they grow in natural bodies of water. Common sense suggests that those nearest the surface need the most light, and those capable of growing in deep water need the least amount. As is also the case in the wild, flowering plants need relatively more light than those that do not flower. Thus, aquatic ferns and mosses tolerate more shade than, say, Amazon sword plants.

Floating aquatic plants, such as water lettuce (*Pistia*), need 2,000 lux or more to thrive. Water lilies, whose photosynthetic leaves float even though the roots anchor in the mud several feet below, need about 10,000 lux to bloom. Plants that grow on the bottom, such as many cryptocorynes, need around 300 lux. Plants that grow upright though seldom reaching the surface do best with about 1,500 lux. The majority of aquarium plants will fall into this middle category. When in doubt, provide more light rather than less.

The length of the day is an important factor in regulating the growth of all plants, and aquatic species are no exception. Tropical and subtropical types, the most commonly grown aquarium plants, usually do best with 12 to 14 hours of light daily. Use a timer to control the lighting system and provide a consistent day-night cycle.

Water Chemistry

As with fish, plants have specific needs regarding water chemistry. For example, hard water has less available carbon dioxide for plant growth, because in hard water the formation of insoluble carbonates is chemically favored over the formation of carbonic acid. Plants adapted to soft, acidic water fare poorly in hard, alkaline conditions because they are starved for carbon dioxide. Plants adapted to hard, alkaline water may suffer from nutrient imbalances if placed in water that is too soft and acidic. Specific recommendations are given for each plant species mentioned in this book.

Fertilizer

Gardeners know plants need feeding from time to time. Aquatic plants also require fertilization, but should be fed sparingly. In the closed system of an aquarium too much fertilizer can be worse than none at all. Overfertilization can result in yellowing of the leaves, and may also contribute to excessive growths of algae. Fish wastes provide plenty of nutrients, so artificial fertilization may be needed only while the plants are becoming established. During the early stages of the aquarium's development, while the fish population remains low, the addition of fertilizer allows plants to overcome the stress associated with transplanting, and to develop strong roots and lush foliage. Later, when all the fish have been added, fertilization may be reduced or eliminated altogether.

Although fish wastes may provide basic nutrition, you will probably need to add an iron supplement to your planted aquarium after each water change. Iron is essential to prevent yellowing in the leaves of aquarium plants, a condition known as *chlorosis*. Yellow leaves with green veins are a sure indication that the water is deficient in iron. Iron participates in the formation of chlorophyll, without which plants cannot synthesize sufficient carbohydrates for growth. While natural waters may contain as much as one milligram per liter (1.0 mg/L) of iron, experience has shown that aquarium plants will thrive with about half this much (0.05 mg/L). Too much iron, by the way, interferes with the plant's metabolism, so it is best to monitor the level with a test kit. Replenish iron only as needed. Most shops that stock aquatic plants also stock iron test kits and iron supplements.

The chemical form of the iron makes a difference to plants. Iron can exist in either the *ferrous* or *ferric* form. Plants need ferrous iron, but in water the ferric form is chemically favored. Aquarium iron supplements get around this problem by supplying iron in "chelated" form, to help assure than the amount dosed is actually available for plant nutrition. Ethylenediaminetetraacetate, or EDTA for short (thank goodness!), will likely be listed as an ingredient on any brand of chelated iron supplement. If the tap water contains sufficient iron, it can be made available to plants by the addition of EDTA alone. An iron test kit will not distinguish between the two forms, and measures only the total amount of iron present. Therefore, before beginning a program of iron supplementation, test the water directly from the tap to establish a baseline. The baseline amount should be subtracted from the amount detected when the aquarium itself is tested. For example, if you determine that your tap water contains 1.0 mg/L of iron, you would need to add enough supplement to the tank to give a reading of 1.5 mg/L, in order to ensure that you have 0.5 mg/L of ferrous iron for the plants.

Additional elements are required in small amounts for proper plant growth. Most people know that plants need nitrogen, phosphorus, and potassium. These elements are the major components of all types of fertilizers, whether for houseplants or corn. In smaller amounts, plants also need manganese, magnesium, calcium, sulfur, and various other things. Aquatic plant fertilizers are commercially available that contain all the necessary plant nutrients. If you use these products, ignore the directions on the label, as it is impossible to predict nutrient needs. Tap water will contain varying levels of plant nutrients from one place to the next, so different aquariums will start out differently in this respect. Furthermore, any given aquarium will have a greater or lesser number of individual plants, with their needs varying by species, age, and other factors, and more or fewer fish producing varying levels of nutrient-rich wastes, than another tank sitting next to it. Because an excess of some nutrients can interfere with the uptake of others, problems can be compounded by uninformed fertilization. This can make the whole business seem too complex for most aquarists, who give up on plants altogether and resort to plastic. This need not be the case, and nearly every aquarium can successfully house a thriving garden with minimal effort. The only exceptions would be those in which plant-eating fish are exhibited, for obvious reasons.

Before adding fertilizer, make sure the plants really need it. First, the lighting should be adequate, conforming to the recommendations previously given. Without enough light, plants won't grow well no matter what other measures you take. Second, basic water conditions should be correct. Water that is too hard is often to blame for plants being reluctant to grow. Fix these kinds of problems before you try fertilization.

If you think your plants will benefit from fertilization, start with 25 percent of the dosage recommended on the label, be patient, and see if the plants look better after two weeks. Beneficial effects of fertilization on common aquarium plants would include an increase in the rate of growth. This will be noticeable after two weeks' time. Slower-growing plants may respond to fertilization by producing new leaves that are larger and more robust than was previously the case. I emphasize not to add more fertilizer on whim. If the plants don't respond on the first try, you can always slightly increase the amount of fertilizer given, but it will be difficult to undo the effects of an overdose.

Discuss with the dealer from whom you purchase plants the suitability of your local water supply. A dealer with thriving plant tanks will know which species do best in the water as it comes from the tap, and which ones will demand special care. That way, you will avoid having to do a lot of testing and experimentation to get the water chemistry right.

Another type of fertilization popular among aquatic plant enthusiasts is the addition of carbon dioxide. Carbon dioxide is arguably the most important plant nutrient, as it supplies the basic carbon skeleton for virtually all cellular activities and metabolic syntheses that the plant is capable of carrying out. Plants preferentially take up this important nutrient as the free gas. When the available supply is depleted, plants then typically turn to bicarbonate assimilation to meet their carbon needs. The harder the water, the more free carbon dioxide is needed to meet the plants' requirements. For this reason, plants accustomed to soft, acid water will benefit from carbon dioxide fertilization when grown in harder, more alkaline water, but may require no added carbon dioxide when grown in water optimized for their needs.

Aeration depletes carbon dioxide, and can reduce the level to zero in soft, acidic water. Thus, carbon dioxide fertilization may be needed for optimum plant growth even in water with low pH and hardness values if the fish population is so large, or if the ratio of surface area to volume is so low, that aeration is required for proper oxygenation. Various brands of carbon dioxide fertilization equipment are on the market. They all operate basically the same way: gas from a pressurized tank is injected into the aquarium water gradually under the control of a valve. Usually, the gas flows into a reaction chamber installed in the return pipe from the filtration system. Automated control is possible by using an electronic pH monitor. Deviations of the pH from a predetermined set point cause the CO_2 valve to open and close, in the same way a thermostat controls a heater. If you cannot afford the expense of an automated system, you must determine the valve setting by trial and error, using a device called a "bubble counter." The way it works is simple. The fewer bubbles flowing through the counter, the less CO_2 is flowing into the aquarium. You adjust the valve, wait a while and test the pH. By trial and error, you determine the proper setting to keep the aquarium at the target pH.

My friend, Sidney Arnold, was a great intuitive gardener. He seemed to know the needs of plants under his care without resorting to the library. His home was always filled with tropical foliage, and during warm weather his gardens overflowed with flowers, vegetables, and herbs. When I encouraged him to grow some aquatic plants, he gave it a try, but with disappointing results at first. Upon hearing my suggestions regarding the need for carbon dioxide in the hard, alkaline water in our city, he created his own CO_2 fertilization system. His first design consisted of a large jug in which a mixture of grape juice, sugar and cranberry juice were slowly fermented by the addition of yeast. Fermentation gives off carbon dioxide. This is what produces the bubbles in beer and champagne, for example. By running a tube from the neck of the jug to the aquarium filter box and controlling the flow of CO_2 with a valve Sidney was able to maintain a beautiful underwater garden. Early on, he fiddled with the valve until the growth and appearance of the plants were to his liking. Later, he did nothing other than replenish the fermentation jug. Of course, the contents of the jug, which were converted to wine after about two weeks, could be put to other uses.

Foods and Feeding

Aquarium shops stock dozens of kinds of fish food. Choosing the ones for your aquarium should pose little difficulty if you keep a few basic points in mind. Most common aquarium fish emphasize animal products in the diet, though they also consume small amounts of vegetable matter. Food items include protozoans, water fleas, insect larvae, adult insects, worms, snails, and other fish. The main source of vegetable matter in the aquatic diet is algae, although a few commonly kept species eat plants. Vegetarian fish include many kinds of catfish, many African cichlids, and some characins. All of these consume small amounts of animal matter incidentally while grazing on algal mats, and thus obtain a complete and balanced diet.

Commercial fish foods can consist either of a single ingredient, such as freeze-dried brine shrimp, or can be compounded of many ingredients, such as most flake foods. The trick to providing a balanced diet for your aquarium is to feed a wide variety of foods, alternating among two or three kinds during the course of a week. If your fish are primarily vegetarian, you will find products made just for them. Supplement these with small amounts of animal protein, such as frozen brine shrimp. Conversely, if your fish are primarily carnivorous, supplement their diet with small amounts of vegetable matter, such as products containing the algae *Spirulina*.

Fish food may be supplied as flakes or pellets, in freeze-dried form, or frozen. Many dealers also stock live foods, at least during part of the year.

Beginning aquarists usually give too much food. This results in an excessive load on the filtration system, since uneaten food simply decays on the bottom of the tank. The notion that fish will eat themselves to death is nonsense, but the pollution in an overfed aquarium can certainly wipe out its inhabitants.

A fish's stomach approximates the size of its eye. Obviously, it will not take a lot of food to fill it up. One rule of thumb is to feed only as much as will be consumed in ten minutes. You can determine the correct amount for your situation by trial and error. When in doubt, feed less. Fish can go for a surprisingly long time, weeks in many cases, without eating, so the likelihood of starving them is quite small in comparison to the likelihood of polluting the tank with uneaten food.

Most people find twice-daily feedings work best with their schedule. If your schedule permits, though, feed a community of smaller fish about five times daily with just a tiny pinch of food at each feeding. Feed about an hour after the lights come on in the morning, and again about an hour before darkness falls, and space out other feedings in between. You will need to modify this schedule if you have, for example, large predators like some South American cichlids. For these, the usual feeding regimen is three or four times a week. On the other hand, vegetarians feed almost continuously. These fish do best when there is plenty of algae growing in the tank to supplement the twice-daily feedings.

Be careful not to feed vegetarian fish a diet rich in animal protein, even though they may eat such food greedily. The vegetarian digestive system is not designed to cope with such a diet, and problems will develop. Similarly, fish that need plenty of animal protein will not get enough to eat if kept on a diet better suited to vegetarians.

In the natural environment, of course, fish eat mostly living foods. If you have access to live food, by all means use it, even occasionally. If there is a single secret to long-term success with a freshwater aquarium, the use of live food may be it. Some of these can be cultured at home, provided you have the time and inclination. Ideally, one would feed only live food, but this is usually impractical at home.

Live Foods from the Aquarium Store

Virtually all aquarium dealers stock "feeder goldfish." They sell by the dozen, and keep well for a week or so in a small, aerated container. Ten gallons of water will accommodate about one dozen. Instead of a glass tank, you can use a plastic trash can outfitted with an airstone. Goldfish do fine in cold water, and can be kept outside year round, as long as the water does not freeze. If you only purchase, let's say, a dozen a week, change the water between batches of goldfish. Unfortunately, only large, predatory tropical fish will consume them, so feeder goldfish are not for every aquarist.

You can also buy "feeder guppies" by the dozen at the aquarium shop. They will be eaten by any fish large enough to swallow them. Since they breed continuously, you can have many different sizes of guppies, from newborn to adult, available at all times to suit the varied sizes of fish in your aquarium. Fifty adult guppies will be fine in ten gallons of water, provided it is well aerated and the water is changed between batches of feeders. They can tolerate water temperatures down to about 50°F, and so can be kept in an unheated garage or outbuilding during the winter. In warm weather, they will thrive in a small outdoor pond or child's plastic wading pool located away from direct sunlight. To maintain a high population density, the aquarium or pond will require filtration or a weekly change of half the water.

Some shops stock live blackworms. These are small relatives of the earthworm that live in clean, cold water. Shops sell them in portions of a tablespoon or two. Purchase a shallow plastic food storage container at the grocery store. The ones designed to hold a sandwich are perfect. Place the blackworms in the container and cover them with no more than a quarter inch of tap water. Store in the refrigerator. Remove a few worms every day with a spoon and feed them to your fish. Rinse the worms and change their water each day. Simply pour off as much as you can and replenish with cold water straight from the tap. Repeat a couple of times until the water rinses off clear. Treated this way, the worms will keep a week or two easily. The hard part about keeping blackworms is negotiating with the other members of the household regarding the refrigerator space.

Live adult brine shrimp can be found on the menu at many good aquarium shops, particularly those that stock saltwater fish. They are usually sold in portions amounting to about two teaspoons when the shrimp are drained in a net. Because they don't keep too well without careful attention, it is best to purchase a small quantity and feed them to the tank within a couple of days. Use a net to separate the shrimp from the strong salt solution in which they grow. Rinse under the tap before adding to the aquarium. They will die within about an hour in fresh water. Therefore, make sure to feed only the amount likely to be eaten by your fish within a short time.

Earthworms not only show up in aquarium shops, but are also widely available as bait for sport fishermen. Usually sold in a container of potting soil, the worms should be cleaned before feeding them to aquarium fish. To clean them, transfer the earthworms to a container of long-fiber horticultural sphagnum moss, obtainable at garden centers. Thoroughly rinse the moss under the tap, then squeeze out most of the water so that it is barely damp. Since they cannot eat the sphagnum, after a couple of days the worms will have purged themselves of ingested soil and grit. Feed earthworms whole to large fish, or chop them into pieces for smaller ones.

Culturing Live Foods

Devoting a corner of the garage to food cultivation will pay off in healthier fish with vibrant coloration. During warm weather, you can even cultivate live foods outside, in a small "pond" set up for the purpose. Here are some suggestions for live food cultivation at home.

Brine Shrimp Nauplii

Larval brine shrimp, known as *nauplii* (singular, nauplius), have been used for decades as tropical fish food. They are rich in nutrients, and can be easily hatched from the resting cysts, often incorrectly referred to as brine shrimp eggs. The ability to breed and subsequently rear many types of aquarium fish in hatcheries depends upon the use of brine shrimp nauplii. The cysts, nearly indestructible, will keep for months, even years, with proper storage. They are collected from evaporation ponds and other highly saline environments, and look like coarsely ground cinnamon. Hatching them is a cinch.

Fill an empty wide-mouth quart jar with water up to the shoulder and add two tablespoons (about an ounce, or 30 grams) of synthetic seawater mix. Seawater mix is available wherever saltwater aquariums are sold. Drop in an airstone and connect it to a pump. Aerate the water vigorously. You will want to locate your brine shrimp hatchery where the salt spray will do no harm, as it is impossible to keep it from splattering out of the container. The jar should be in a spot that remains around 75 to 80 degrees F. Bright, indirect light will improve the yield of the hatch, but keep the jar out of direct sun, or it will get too warm. As soon as the salt mix dissolves, add ¼ teaspoon of the cysts. They will hatch in 24 to 48 hours, depending upon the temperature. The warmer the water, the quicker the hatch. You can see the tiny nauplii swimming jerkily in the water. When you are ready to harvest, turn off the aeration. This will allow the empty cysts to float to the top of the container. Separating the cysts from the shrimp is the main difficulty in using brine shrimp nauplii. If the cysts are added to the aquarium, they will form an unsightly ring just above water level, and they can be harmful if fish ingest them.

The nauplii are attracted to light, and you can exploit this trait to collect them. Make a sleeve out of thin cardboard that will encircle the jar, cutting a one-inch hole just above the bottom. When you are ready to harvest shrimp, place the sleeve around the jar and shine a flashlight into the hole. The shrimp will gather at this point, from which they can be siphoned out with a length of flexible plastic tubing. Trap the nauplii with a net, and rinse under the tap before adding them to the aquarium. They will be relished by virtually all tropical fish. Like the adults, the nauplii survive only about an hour in fresh water, so feed accordingly. Try to feed your entire hatch within forty-eight hours, because the nauplii will lose much of their nutritional value during that time.

Brine Shrimp Adults

Nauplii can be grown to adulthood if you have the space. Fill a shallow container holding at least fifty gallons, such as a child's plastic wading pool, with synthetic seawater prepared at the ratio of four ounces of dry seawater mix per gallon. The container should be located in bright light but out of direct sun. Add a pinch of soluble garden fertilizer (such as Miracle-Gro) and a quart of either natural seawater collected from the ocean or water from an established saltwater aquarium. After a couple of weeks the water in the rearing container will be green with algae growth. Hatch the cysts as just described, and add the nauplii to your rearing pond. They will feed on algae and grow to adulthood in about two weeks. You can feed them to your fish at any point. About once a week, add another batch of nauplii. In this way you will be able to grow a continuous supply of adults. When harvesting the adult shrimps, use a net with relatively open mesh, so smaller individuals can escape and grow.

Daphnia

Culture daphnia, or water fleas, in a container holding twenty gallons or more. They feed on algae, so the rearing tank needs to be located where it will receive lots of indirect sunlight. Outdoors, locating the tank on the north side of a building or in the dappled shade of a deciduous tree works well. Fill the rearing container with tap water, and add a pinch of soluble garden fertilizer. When the water turns green, add a starter culture of daphnia. Your dealer can probably order a starter culture for you, or you can find suppliers online or in the classified section of an aquarium magazine. Wait a few weeks before harvesting the daphnia with a fine mesh net. If you try this in an area where mosquitoes are a problem, you will need to cover the daphnia tank with a screen top to prevent female mosquitoes from laying their eggs in the water. If you have a suitable spot, this is one of the easiest ways to provide your freshwater fish with a continuous supply of nutritious live food. Daphnia will survive the winter, as long as their tank does not freeze solid, but will pass the cold months as dormant cysts resting on the bottom. When the weather warms again, the tank will quickly fill with new generations of daphnia. Unlike brine shrimp, the daphnia will survive in the aquarium until eaten.

Microworms

Microworms, as they are known in the aquarium world, are nematodes about a quarter of an inch in length. They can be easily cultivated at room temperature on cooked oatmeal to which a small amount of yeast has been added to cause fermentation. Shallow plastic food storage containers with covers work best for this purpose. The cover needs a couple of holes punched in it to provide air circulation. Starter cultures and recipes for culturing microworms can be ordered through aquarium magazine classifieds or online. Their main drawback is the funky smell of the fermenting culture medium. You will want to locate the microworm farm in a heated garage or basement. As they grow, the worms crawl up the sides of the container, and thus are easily harvested. Simply swab a few from the container with a cotton swab and swish them off in the aquarium. Using a small portion from an old culture to start a new one every two weeks ensures a continuous supply.

Mosquito Larvae

I mentioned earlier that a water flea hatchery should be screened against the deposition of eggs by female mosquitoes. Any container of water left outdoors in warm weather will attract these little blood suckers, so they are a cinch to raise. Just leave a plastic dishpan half full of water in a sheltered spot. Check the pan daily for mosquito larvae, and feed them to the fish promptly. Your neighbors may revolt if they find you are cultivating adult mosquitoes in the back yard! Scoop the larvae from the dishpan with a fine mesh net, rinse briefly under the tap and plop them into the tank. Pour out the water in the pan and start over, lest any larvae escape. They will mature in days, producing biting adults, if left to their own devices.

Routine Maintenance

There is really only one rule for aquarium maintenance. Change water regularly. I recommend changing 10 to 15 percent per week, but you can do it biweekly or monthly, so long as roughly half the water is changed per month. This simple, low cost procedure will do more to enhance the appearance of the tank and the health of the fish and plants than anything else you do as an aquarist.

Purchase a length of plastic hose sufficient to reach from the bottom of the tank, over the top edge, and down to the floor. The inside diameter of the hose should be about three-quarters of an inch. You will also need a couple of plastic five-gallon buckets. These items will be cheaper if purchased at your DIY store instead of the aquarium shop. Just make sure you use them only for aquarium maintenance. Don’t mix garden fertilizer or paint in a bucket and then later use it to carry water for your tank. You may inadvertently overfertilize your plants, or, worse, poison the fish with paint chemicals.

Before removing water from the tank, make certain to turn off all equipment, especially the heater, which should be unplugged.

To carry out a water change, place one end of the hose in the tank and suck on the other end to start siphoning water. Aquarium shops sell various types of siphons, including self-starting ones for the squeamish, if you are afraid of getting a mouth full of aquarium water. I have never heard of anyone becoming sick from aquarium water, however, so such fears are likely groundless. Fill the buckets and discard the used water until you have removed the correct amount. Refill buckets from your supply if you use distilled or softened water, or just turn on the tap. Adjust the hot and cold water faucets to approximate the temperature of the tank. Most people can judge this by feel, but use a thermometer if you are uncertain. The replacement water should be within five degrees of the tank temperature. Slightly warmer is always better than colder. A sudden chill can stress both fish and plants, and may result in an outbreak of disease. Add a dechlorinating agent if you wish. If you add anything else to the water, such as African cichlid salts or an acidifying agent, add the appropriate amount to the replacement water at this point.

WARNING If you expose the heater to the air, it will get hot enough to blister you if it should switch on. Subsequent contact with water is likely to cause the heater to crack, which may create a dangerous electrical hazard, and will certainly ruin the heater.

Carefully pour the replacement water into the tank. I try to aim the flow toward a solid object, such as a rock or driftwood, to prevent stirring up the gravel and uprooting plants. If this maneuver is awkward, place a saucer on the gravel and pour the water on top of it. You are unlikely to do harm, but why disrupt things unnecessarily? If the tank is a large one, you may find hoisting heavy buckets to its rim too much of a chore. In this case, purchase a small submersible pump and a suitable length of hose to take care of the work. A five-gallon bucket full of water weighs over forty pounds. Please don't hurt your back trying to lift this much weight in a controlled manner, unless you are physically up to the task.

The fish, of course, will freak out over the disturbance, but it is doubtful any will suffer long-term harm. Since you have to remove the light fixture to get at the tank, the darkness will help some in this regard. Once the tank is full again, switch everything back on and check for normal operation. I suggest leaving the lights off until the next day, to allow the fish to calm down. Don't feed them, either, on water change day.

For a large built-in aquarium, the plumbing system should be designed to permit draining and filling the tank via the filter sump, as will be discussed in chapter 4.

You may want to do some housecleaning as part of your water change routine. This is a good time to clean algae from the front and sides of the tank, to prune plants or remove dead leaves, and to siphon out any noticeable accumulations of debris. It is likely that you will stir up fine debris in the course of maintenance. It will be removed once the filter is restarted. This is the ideal time to check and replace filter media, which may become clogged with particulate matter. I save the major work for once a month, but you may want to clean the inside of the glass weekly. Use a plain plastic scouring pad (such as Scotch Brite) from the supermarket for this purpose if you have a glass tank. Acrylic tanks require the use of a cleaning pad made especially for them. In either case, always be careful not to get a piece of gravel or a grain of sand between the pad and the tank wall, or you will scratch it.

Before replacing the cover, clean it thoroughly on both sides with plain water and the scouring pad you use for algae removal. Water spots, dust, and algae on the cover glass can seriously reduce light penetration, and your plants need all the light the fixture can provide. Also wipe off the fluorescent lamp itself. You will be surprised how it picks up household grime due to the electrical charge it bears when in operation. Make a note when the tank is first set up, and on the anniversary date each year replace all the lamps in your fluorescent fixture. Light output decreases as the lamps age, even though you may not notice this visually. If using metal halide lighting, follow the manufacturer's directions regarding lamp life. Most last two years before they need replacement.

Now and then you will need to replace worn parts, such as the impeller in your filter pump. Plan to do this, too, while the equipment is shut down for a water change.

Once you complete the water change and other routine maintenance, you will be amazed at how the tank sparkles. Colors will brighten on your fish, and the plants will have the lush look of a garden just after a spring rain. The benefits of a short time spent on maintenance will be clearly apparent.

Record Keeping

Get yourself a calendar, notebook, or three-ring binder and make notes regarding water changes, lamp replacement, and other routine maintenance. You can also jot down your observations about plant growth, fish spawnings, or anything that you deem important. Not only will having such a record help you remember things like when to change the filter pads, but also with time the notebook will become a history of the tank that you will enjoy looking back upon. If you find yourself wondering how old that catfish is, you can check your records and find the date you placed it in the tank. This, for me, is part of the fun, and is also a good way to spot trends.

Water Tests

I am not a huge fan of routine water testing in freshwater aquariums. In the first place, if you are keeping fish that like the conditions prevailing in your tap water, why bother? The water company will go to great lengths to make sure the water leaving the treatment plant is consistent with regard to the parameters important to aquarium fish, namely pH and hardness. If the tank has been set up properly and maintenance carried out on schedule—and if you don't overstock or fail to feed the fish with restraint—it is unlikely that ammonia or nitrite, the two major pollutants that pose a threat to fish health, will accumulate. If you do regular water changes, excess nitrate accumulation is unlikely, especially if healthy plants are growing in the tank.

With that in mind, it still pays to be prepared to take quick action in case the fish or plants show signs of distress. It is always worthwhile to have a basic water chemistry lab available for troubleshooting purposes. For that I suggest purchasing test kits for the following:

- ammonia
- nitrite

Aquarium water should never have any detectable ammonia or nitrite. The presence of either one indicates that biofiltration is not proceeding as it should. Immediate action should be taken to reduce the concentration of either of these compounds should you discover them. Change enough water to substantially reduce the level. Keep testing on a daily basis, changing water as needed, until the system returns to normal. Stop feeding during this time. The fish will not starve, and more food will only exacerbate the problem.

Nitrate is another matter. If you check nitrate just before doing a water change, you will note that it increases by about the same amount every month. Immediately after the water change, it will have been reduced in proportion to the amount changed, that is, a 50 percent water change will reduce nitrate by 50 percent. By the next water change, more nitrate will have accumulated. The difference between the nitrate level immediately after a water change and the level immediately before next month's (or next week's) change represents the normal amount of nitrate production for your particular situation. A deviation from that norm means that something has upset the equilibrium established between ammonia production, biological filtration, and absorption of nitrate by plants. Several factors can produce this deviation. Obviously, the more fish you have the more ammonia will be produced. Adding a fish produces a noticeable change, for example. Similarly, rotting food or a dead snail decomposing behind a rock adds ammonia, and this will eventually result in nitrate accumulation. Thus, it is important to keep a record of each nitrate test. Should an anomaly appear, try to identify an obvious explanation, e.g., I added new fish. Otherwise, you need to track down the culprit.

Ask yourself the following questions:

- Did I carry out the test correctly? (It is always worth doing a confirming test before looking for other explanations.)
- Have water changes been skipped?
- Have fish been added?
- Have I fed more than I normally do?
- Is everyone present and accounted for? (Snails, in particular, sometimes die unnoticed.)
- Have I added anything out of the ordinary? (Medications, especially, may disrupt bacterial activity and thus change the nitrogen equilibrium.)

Nitrate may be removed by natural processes, the most obvious being absorption by plants, but often your partial water changes constitute the main way nitrate leaves the aquarium. Remember, the amount of nitrate produced per unit of time remains constant as long as conditions do not change. Measuring nitrate accumulation allows you to spot anomalies that may be a sign of trouble.

Re-read the discussion on page 69 of the typical pattern of nitrate accumulation over time. This trend will always be upward unless 100 percent of the water is changed each month. At some point—I suggest every six months—you will need to do an extra-large water change to return the tank to a baseline position with regard to nitrate. If excessive nitrate accumulates beyond the needs of the plants, they react as if overfertilized (which is indeed the case). Leaves turn yellow and become thinner. The plant may even die. If you have ever added too much fertilizer to a houseplant, you know that it can be "burned" by the overfeeding. So, too, can aquatic plants.

Invisible nitrate, therefore, can be an indicator of the overall biological activity in your aquarium. Thus, it is worth carrying out this one test on a regular basis.

Not all nitrate tests are created equal. Some test total nitrate and some test nitrate nitrogen. Without going into the details, suffice it to say that you must always record the same parameter if your test results are to be of any value for comparison purposes. Don't switch brands of test kits, unless you are sure that the new kit is measuring the same thing your old one did. (Different brands that test the same parameter may give different results with the same water sample, but the difference will be slight.) If you simply cannot find, for example, a total nitrate test and are forced to rely on one for nitrate nitrogen, multiply the result by 4.4. Similarly, to convert total nitrate to nitrate nitrogen, divide by 4.4.

If you modify your tap water in some way, such as diluting it with softened water, or adding an acidifying agent, you will of course need test kits to make sure you are getting the results you expect. For this, you will need kits for hardness and pH. You should also, as mentioned previously, be using an iron test kit if you are adding an iron supplement for your plants.

Maintenance Service

If, after reading the foregoing, you decide that aquarium maintenance is not something you have the time or inclination to do, you can still have a beautiful aquarium by hiring a maintenance service. An aquarium maintenance service makes a lot of sense if you lack the time required to give the aquarium the weekly attention it needs. On a daily basis, checking to make sure all is well and feeding the fish are the only duties. Neither will occupy more than a few minutes, so you should be able to handle these tasks easily. On a weekly basis, however, an hour or so will be required to carry out more extensive care, and once a month some of the water should be removed and replaced with freshly drawn water. Plants require regular pruning, algae may grow in places where you don't want it, and equipment will need servicing. Depending upon the size of the tank, maintenance may thus involve more time than you can spare. Because conditions in even the best-designed system quickly tend to deteriorate without regular maintenance, if you cannot do the work yourself you will need to hire someone to carry out these chores to avoid disaster. Time may not be your only constraint. A disability, for example, might prevent you from moving heavy buckets of water.

If you decide to go this route, choose the service with care. Make sure responsibilities, yours and theirs, are clearly understood. Confirm that the price quoted covers both labor and materials, such as filter media, that will be replaced in the course of normal care. If supplies cost extra, you should have the option of shopping for them yourself, rather than purchasing only from the maintenance company. Everything should be spelled out in a written agreement. The cost for professional maintenance can be considerable, and most companies charge a monthly minimum. However, proper care is the key to long-term enjoyment from an aquarium. Failing to appreciate this fully has resulted in many a would-be aquarium owner's disappointment.

SUMMARY

You don't need a scientific background, nor a lot of experience, to have a successful freshwater aquarium with thriving fish and lush plantings. All you need to do is use common sense and stick with my basic rules. In summary, they are as follows:

- Set up the largest aquarium that your resources can accommodate.
- Know the condition of your tap water and choose fish naturally adapted to those conditions.
- Choose a lighting system adequate for the plants you intend to grow. There is no substitute for light. Otherwise, use plastic reproductions.
- Add plants first, along with an initial dose of fertilizer to get them growing. Wait until new growth appears before beginning to add fish.
- Understand the critical process of biofiltration.
- Add fish gradually. Start with no more than 10 percent of the total number you eventually will keep in the tank. This allows biofiltration to keep pace with the fish population.
- Add hardy fish first. Save delicate species for later, when the tank is more stable.
- Always choose fish and plants with care. Even if you follow a recipe from this book precisely, bringing home a sick fish will create problems. See the next chapter for suggestions.
- Understand why nitrate is an indicator of the overall condition of the aquarium.
- Feed a varied diet in small amounts.
- Carry out partial water changes on a regular schedule without fail.
- Keep a notebook of observations, such as water test results, to refer to when making changes or diagnosing a problem.

Most importantly, sit quietly near the tank for a short while each day and watch what's going on. Not only will you learn a lot about the aquatic environment, your stress level will decrease, you'll learn to relax and, hopefully, you will live longer. Not a bad trade-off, in my view.