WHO INVENTED THE AQUARIUM?

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INTRODUCTION

Any attempt to pin down "firsts," such as "the first aquarist," is fraught with difficulties. The following is from Newman (1873):

"The birth of the aquarium is of such remote antiquity that we fail to ascertain the date with any certainty. The point at which, any vessel containing water and fishes becomes an aquarium is equally open to discussion. There is abundant reason to suppose that the Chinese and the Japanese had their fresh-water aquariums thousands of years before the Christian era; the Romans certainly had theirs; but in neither of these instances is there any evidence of their being considered, as now, a noteworthy institution; by the Romans they were established for economic purposes and nothing more."

Newman goes on to mention Pepys, who established the fact that fishes were kept in confinement at Lady Pen's in 1665, but was not aware of Guillaume Rondelet's wife, Jeanne, whom Rondelet claimed had kept a fish alive in a glass of water for three years (Klee, 2003). In 1790, Sir John Graham Dalyell (1775-1851) - who might be termed a legal consultant but one who had a keen interest in natural history - managed to keep a sea anemone alive for twenty-eight years (and numerous other marine animals for lesser periods), but only because he was wealthy enough to be able to arrange for a fresh supply of salt water to be brought round to his house every morning. This was an expensive proposition until about 1850 when the development of the railroad system facilitated access to the coasts. However, Sir John knew nothing of employing plants to evolve oxygen and so did not apply any particular principles of fish keeping.

Figure 1: Charles Robert Alexandre des Moulins (1798-1875)

THE FRESHWATER AQUARIUM SANS FISHES

Charles Robert Alexandre Des Moulins (1798-1875) was a French (Bordeaux) botanist and malacologist. He was president of la Société linnéenne de Bordeaux. Moulins named and described numerous species of snails and in turn, in recognition of his services to malacology, a number of species of mollusks were named after him, e.g., *Pisania desmoulinsi* and *Nerita desmoulinsiana*. These species included both fossil and recent, both bivalves and gastropods and were mainly non-marine. In 1831 he published his "Etudes sur les échinides."

Perhaps the earliest mention of keeping aquatic life alive in artificial containers was by Moulins in his "Note on the means of preventing the corruption in jars in order to keep aquatic animals alive" (Moulins, 1830a):

"Le 25 Avril, je rapportai de la campagne une pincée de Riccia fluitans et de Lemna minor que je mis dans le bocal avec des Planorbes, des Physes et des Limnées que je voulais étudier. J'y versai en même temps l'eau que j'avais rapportée des fossés stagnans où j'avais récolté ces divers objets. Elle contenait de gros Cyclopes verts avec leurs paquets d'œufs, et une autre espèce plus petite, blanchâtre, ainsi que des Daphnies. La température était élevée pou la saison, et l'eau, recueillie depuis plus de 24 heures, était fort sale et déjà sensiblement puante. Mon étonnement fut grand, lorsque le lendemain, je trouvai toute l'eau du bocal pure et transparente comme du cristal, et absolument sans, odeur. Je résolus de ne plus changer l'eau du tout, cette expérience m'a parfaitement réussi. Je me suis borné, lorsque l'évaporation en avait enlevé un demi-pouce ou un pouce, à y ajouter soit de l'eau propre, soit de l'eau de ruisseau ou d'étang que je rapportais de mes excursions. Je me suis procuré un bocal plus grand où; j'ai versé tout le contenu du petit; là, la touffe de Riccia a triplé de volume; les lentilles d'eau ont pullulé dans la même proportion, et les détritus qui proviennent de leur décomposition successive forment au fond du bocal une sorte de vase très-fine et peu abondante qui suffît pourtant à la demeure des animaux qui ne vivent pas habituellement en pleine eau. Il est donc hors de doute que c'est à la végétation vigoureuse de ces plantes flottantes que je dois la conservation de la transparence, de la pureté et de la salubrité du liquide.

"L'expérience que je viens de relater nous conduit à une remarque générale et bien importante : sans les plantes flottantes que la bonté de la divine Providence a répandues avec tant de profusion sur les eaux stagnantes, les habitant des contrées marécageuses périraient dévorés par les fièvres épidémiques. Mais le carbone dégagé par la décomposition des tissus organiques est absorbé par ces végétaux aquatiques, employé à leur nutrition, et ils fournissent en échange une exhalation abondante d'air respirable et salubre."

What follows is my translation:

"On April 25, I brought from the countryside a pinch of *Riccia fluitans* and *Lemna minor* that I put in the jar with the Planorbis and Physa snails I wanted to study. I used the same water from the stagnant ditches where I collected these objects. It contained large Green Cyclops with their packages of eggs, another smaller species (whitish) and Daphnia. The temperature was somewhat high because of the season, and the water, collected over 24 hours, was very dirty and already stank significantly. My astonishment was great when the next day I found the whole jar of water pure and clear as crystal, and absolutely free of odor. I decided not to change the water at all and my experience has been very successful. I restrained myself when evaporation removed half an inch or an inch of water, or to add clean water or water from a stream or pond that I brought from my excursions. I bought a larger jar and poured the entire contents into it from the smaller one; the clump of *Riccia* has tripled, the duckweed has multiplied in the same proportion and the detritus from their successive decomposition formed at the bottom of the jar was of a very fine mud and that will do, however, for the abode of animals that do not usually live in open water. There is no doubt that it is the vigorous vegetation of these floating plants I have been able to conserve the transparency, purity and safety of the liquid.

"The experience I have just described leads us to a general remark and a very important one: without floating plants that the goodness of Divine Providence has showered so profusely on stagnant water, the inhabitants of marshes would perish, devoured by an epidemic of fever. But the carbon released by the decomposition of organic tissue is absorbed by these aquatic plants and used for their nutrition, and in exchange they provide abundant and healthy oxygen for breathing."

Moulins also set out the type of vessel to be used, i.e., a shape where the animals are not distorted by the glass, i.e., cylindrical with a flat bottom and thin enough so the colors of the animals can be observed. He recommended canning glass available from pharmacies.

In another article (Moulins 1830b) Moulins wrote, "Notice sur la ponte de la Planaire lacteé (Instructions on spawning the Milky Planar)" on breeding *Planaria lactea*, a non-parasitic flatworm, he states: "Enfin, le 26 Avril, j'ai mis dans le bocal un paquet de *Riccia fluitans* et de *Lemna minor* qui, jointes aux conferves , entretiennent par leur végétation la pureté de l'eau" ("Finally, on April 26, I placed in the jar a bundle of *Riccia fluitans* and *Lemna minor* which, together with conferva, maintain the purity of the water").

It should be noted, however, that Moulins' experiments were with univalve and bivalve snails, microscopic crustaceans (such as planaria, daphnia and cyclops) and leeches. He mostly used floating plants such as *Riccia* and *Lemna*. He also used *Myriophyllum* but let it float.

THE FRESHWATER AQUARIUM WITH FISHES

In short, Nathaniel Bagshaw Ward (1791-1868) was an English doctor who popularized a case for growing and transporting plants which was called the Wardian case, the forerunner of the modern aquarium tank. (A much more detailed biography can be found in Klee, 2003.) A case for the development of the freshwater aquarium by Nathaniel Bagshaw Ward (and also for the marine aquarium by Anna Thynne) was made by Ward's son, Stephen H. Ward (Ward, 1859):

"Now, these counterbalancing actions of animal and vegetable life which are ever going on in the world without, and which are among the greatest marvels in the economy of Nature, may be realised most completely in one of these cases. Mr. Ward felt this, and accordingly in 1841 established in his largest fern-house, in a capacious earthenware vessel given to him by Mr. Alfred White, an aquarium for fish and plants. In this vessel, which contained twenty gallons of water and which he surrounded with rock-work raised several feet above its margin, he placed gold and silver fish in Company with several aquatic plants, viz. *Valisneria spiralis*, *Pontederia crassipes*, *Pistia stratiotes*, and *Papyrus elegans*. In this miniature lake, the water of which was never changed, but kept in a constantly pure state by the action of the associated plants, the animals lived in a healthy condition for many years. This aquarium or vivarium soon gave the hint to Mr. Bowerbank who procured a large glass-jar, in which he placed stickle-backs, minnows, and snails, with plants of *Valisneria*, and covered in the jar with a piece of glass. Mr. Mitchell of the Zoological Society states that the jar just noticed, gave him the suggestion for the interesting vivaria at the Gardens. Aquaria in open bottles would seem to have been orna-

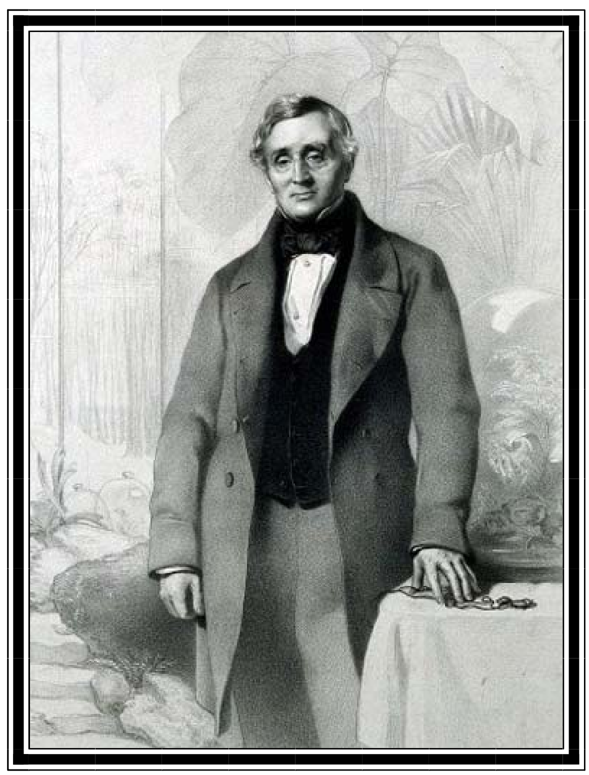


Figure 2: Nathaniel Bagshaw Ward (1791-1868)

ments of the philosopher's study nearly a hundred years ago, as a coloured illustration in a work by Leder-müller, published in 1763 will prove. All that Mr. Ward claims credit for, is the having introduced them into his closed cases, and depended for success entirely upon the counterbalancing actions of animal and vegetable life."

The problem here is that Ward did not publish his findings. All of his publications had to do with growing plants in "closely glazed cases," as the expression of the day went; fish were never mentioned. I have no doubt that what his son said was true, but publishing priority is a generally accepted and important factor in deciding who gets the credit. After all, if you discover something but don't tell anyone about it, it does no one any good at all.

William Stimson is another one who is credited with the invention of the freshwater aquarium (Anon., 1858):

"In our own country William Stimson, the collector and curator of the aquaria in the Smithsonian Institution at Washington, without any previous knowledge of Dr. Johnson's experiments in England, had, as early as the year 1849, made seven or eight small aquaria, which were perfectly successful; inasmuch as he kept some of them in a healthy condition for several months without change of water. He published no account of his success, not knowing that it was a subject which was just beginning to awaken attention in England, and fated eventually to excite such universal interest. To him may safely be assigned the credit of having made the first systematic attempt at constructing an aquavivarium, although in all the works before us that honor is given to Mr. Robert Warrington, who in 1850 communicated to the Chemical Society of London a paper On the Adjustments of the Relation between the Animal and Vegetable Kingdoms."

The difficulty here is the same as just mentioned for Nathaniel Bagshaw Ward.

The man who did meet the criterion, however, was Robert Warington. Warington (1807-1867), a chemist, started a movement in 1839 to found the Chemical Society of London (from 1848 the Chemical Society) and was elected honorary secretary. He was appointed chemical operator to the Society of Apothecaries, a position which he held to within a year of his death. The primary purpose of the Society was to exercise control over the practice of what we should nowadays recognize as the greater part of the twin professions of medicine and pharmacy, and as such was responsible for the standardization and prevention of adulteration of drugs.

In 1846 he took part in the formation of the Cavendish Society, of which he was secretary for three years, and from this time onwards he had many engagements as a chemical expert in legal cases. In the year 1844 he began a series of investigations into the adulteration of tea, and gave evidence at the parliamentary inquiry on adulteration in 1855. He was also one of the founders of the Royal College of Chemistry. In 1851 he revised the *Translation of the Pharmacopeia of the Royal College of Physicians* into English, left unfinished by Richard Phillips. In 1854 Warington was appointed chemical referee by four of the metropolitan gas companies, and held this post for seven years. In 1864 he was elected fellow of the Royal Society and the Society's catalogue contains a list of forty-seven papers written by him. In this same year, Warington was also engaged in the construction of the *British Pharmacopeia*.

In 1849 he began his investigations on aquaria and the means necessary to prevent the water therein from becoming stagnant. His position in the Society of Apothecaries was a full time occupation and Warington's interest in the aquarium perforce had to be an avocation. He wrote several papers (his work actually was the origin of our modern aquaria) and in 1857 delivered a lecture at the Royal Institution on this subject.

Robert Warington is generally acknowledged as being the first to maintain a balanced freshwater aquarium and the following is the article that establishes the claim (Warington, 1850):

"Observations on the adjustment of the relations between the Animal and Vegetable Kingdoms, by which the vital functions of both are permanently maintained.—

This communication will consist of a detail of an experimental investigation, which has been carried on for nearly the last twelve months, and which appears to illustrate, in a marked degree, that beautiful and wonderful provision which we see everywhere displayed throughout the animal and vegetable kingdoms, whereby their continued existence and stability are so admirably sustained, and by which they are made mu-tually to subserve, each for the other's nutriment, and even for its indispensable wants and vital existence. The experiment has reference to the healthy life of fish pre-served in a limited and confined portion of water. It was commenced in May, 1849, and the subjects chosen were two small gold-fish. These were placed in a large glass receiver of about twelve gallons capacity, having a cover of thin muslin stretched over a stout copper wire, bent into a circle, placed over its mouth, so as to exclude, as much as possible, the sooty dust of the London atmosphere, without, at the same time, impeding the free passage of the atmosphere air.

"This receiver was about half filled with ordinary spring water, and supplied at the bottom with sand and mud, to-gether with loose stones of larger size of limestone tufa, from the neighbourhood of Matlock, and sandstone; these were arranged so that the fish could get below them, if they wished so to do. At the same time that the fish were placed in this miniature pond, if I may so term it, a small plant of the *Vallisneria spiralis* was introduced, its roots being inserted in the mud and sand, and covered by one of the loose stones, so as to retain the plant in its position. The *Valisneria spiralis* is one of those delicate aquatic plants generally selected by the microscopist for the exhibition of the circulation of the sap in plants. It throws out an abundance of long, wiry, strap-like leaves, of about a quarter of an inch in breadth, and from one to three feet in length; these leaves, when the sun shines on them, evolve a continued stream of oxygen gas, which rises in a current of minute bubbles, particularly from any part of the leaf which may have received an injury.

"The materials being thus arranged, all appeared to go on well for a short time, until circumstances occurred which indicated that another and very material agent was required to perfect the adjustment, and which, from my not having thought of it at the time of commencing the experiment, had not been provided against. The circumstances I allude to arose from the internal decay of the leaves of the *Vallisneria*, which became yellow from having lost their vitality, and began to decompose; this, by accumulation, rendered the water turbid, and caused the growth of mucus, or green, slimy matter on the surface of the water, and on the sides of the receiver. If this had been allowed to increase, I conceive that the healthy life of the fish must have suffered, and probably their vital functions have been destroyed. The removal of these decaying leaves from the water, therefore, became a point of per-

Figure 3: Robert Warington (1807-1867)

manent importance to the success of the experiment. To effect this, I had recourse to a very useful little scavenger, whose beneficial functions have been too much overlooked in the economy of animal life,—I mean the water-snail, whose natural food is the very green, slimy growth, or mucus and decaying vegetable matter, which threatened to destroy the object which was wished to be obtained. Five or six of these creatures— the *Limnaea stagnalis*—were consequently introduced, and, by their continued and rapid locomotion and extraordinary voracity, soon removed the cause of interference, and restored the whole to a healthy state, thus perfecting the balance between the animal and vegetable inhabitants, and enabling both to perform their vital functions with health and energy.

"So luxuriant was the growth of the *Vallisneria* under these circumstances, that, by the autumn, the one solitary plant that had been originally introduced, had thrown out myriads of off-shoots and suckers, thus multiplying to the extent of upwards of thirty fine, strong plants; and these threw up their long, spiral, flowering stems in all directions, so that, at one time, more than forty blossoms were counted lying on the surface of the water. The fish have been lively, bright in colour, and appear very healthy, and the snails also—judging from the enormous quantity of gelatinous masses of eggs which they have deposited on all parts of the receiver, as well as on the fragments of stone—appear to thrive wonderfully, and, besides their functions in sustaining the perfect adjustment of the series, afford a large quantity of food to the fish in the form of the young snails, which are devoured as soon as they exhibit signs of vitality and locomotion, and before the shell has become hardened. Thus we have an admirable balance sustained between the animal and vegetable kingdoms, and that in a liquid element.

"The fish, in its respiration, consumes the oxygen held in solution by the water as atmospheric air; furnishes carbonic acid; feeds on the insects and young snails; and excretes material well adapted as a rich food to the plant, and well fitted for its luxuriant growth. The plant, by its respiration, consumes the carbonic acid produced by the fish, appropriating the carbon to the construction of its tissues and fibre, and liberates the oxygen in its gaseous state to sustain the healthy functions of the animal life, at the same time that it feeds on the rejected matter, which has fulfilled its purposes in the nourishment of the fish and snail, and preserves the water constantly in a clear and healthy condition, —while the slimy snail, finding its proper nutriment in the decomposing vegetable matter and minute confervoid growth, prevents their accumulation by removing them from the field, and, by its vital powers, converts what would otherwise act as poison, into a rich and fruitful nutriment, again to constitute a pabulum for the vegetable growth, while it also acts the important part of a purveyor to its finny neighbours.— *Robert Warinqton.*

The paper was subsequently published in the *The Zoologist* (Vol. 8, pp. 2868-2870, 1850), the *Quarterly Journal of the Chemical Society of London* (Vol. 3, pp. 52-54, 1851), and also in the *Literary Gazette, Gardeners Chronicle,* and *Bicks Floristry.* Talk about literary overkill! In some of these papers the following addendum appeared: "Since the reading of this paper, twenty-eight strong plants of *Vallisneria have been weeded out of the glass receiver as being more than sufficient for the purpose required. —R.W."*

Warrington also added additional material in the *The Garden Companion, and Florists' Guide* a few years later that showed he was actively pursuing an interest in the marine aquarium as well (Warington, 1852):

"At present I am attempting the same kind of arrangement with a confined portion of sea water, employing some of the green sea weeds as the vegetable members of the circle, and the common winkle or whelk to represent the water snails."

In addition to technical journals, Warington published his material in many of the popular periodicals of the day, especially those involved in gardening. However, when pressed to give to the world a little manual of instructions for amateurs, he always stated as a reason for non-compliance with the request, that the book market was overcrowded already with the "worthless compilations of many scribblers on the subject."

THE MARINE AQUARUM, SANS FISHES

Although there was really never any disagreement that Warington was the first with regard to freshwater, the marine aquarium is quite a different case. Ward's name is also mentioned in this case: "As early as June, 1849, Mr. Ward stated, at a meeting of the British Association at Oxford, that he had succeeded, not only in growing sea-weeds in sea-water, but in sea-water artificially made. This must certainly be regarded as the first stop towards realizing the marine Aquavivarium. [Lankester, 1856, p. 10-11]." However, priority is established only by being published.

Another contender for the title of inventor of the marine aquarium is Félix Dujardin (1802-1860), a French biologist born in Tours. He is mostly remembered for his research on protozoans and other invertebrates. In 1840 he was appointed professor of geology and mineralogy at the University of Toulouse, and during the following year was a professor of zoology and botany at Rennes. Later in his career he became a member of the French Académie des sciences. Concerning his educational background, Dujardin was largely self-taught.

His studies of the microscopic animal life frequently found in decaying organic materials led him in 1834 to propose a new group of one-celled animals that he called Rhizopoda. He named the seemingly formless life substance that oozed outward through openings in certain shells *sarcode*; later it became known as protoplasm. This work led him in 1835 to argue against Christian Gottfried Ehrenberg's theory that microscopic organisms have the same organs as higher animals. Dujardin also studied jellyfish, corals, and sea stars; his study of flatworms laid the foundation for the later development of the study of parasites and parasitism.

In an article on the l'Aquarium du Jardin d'Acclimatation, the director, Etienne Rufz de Lavison, had this to say (Rufz de Lavison, 1863):

"M. de Quatrefages m'a fait observer que j'avais fait tort à un savant français, Dujardin, à qui doit être rapportée l'application première du principe fondamental des aquariums; je reproduis textuellement la note de M. de Quatrefages:

"'Dès 1838, M. Dujardin faisait des voyages sur nos côtes dans l'intérêt de ses éludes zoologiques. Il rapportait tous les ans à Paris de nombreux flacons contenant des animaux vivant dans l'eau de la mer, et pour entretenir la pureté de cette eau, il plaçait dans chaque flacon quelques frondes d'Ulva lactuca. Nommé professeur à Toulouse, il y transporta son musée ou son aquarium, qui s'accrut de nombreux flacons rapportés de Cette. Appelé plus tard à la chaire

Figure 4: Edwin Lankester (1814-1874)

de zoologie de Rennes, il se fit suivre de sa collection, qui s'accrut encore d'une foule d'espèces recueillies sur les côtes de la Bretagne. C'est dans un de ces flacons qu'un des premiers, il constata l'organisation des Méduses. J'ai eu le plaisir d'observer moi-même chez mon ancien collègue une de ces Méduses développées en captivité.'"

The Jean Louis Armand de Quatrefages de Bréau (1810-1892) mentioned above was a well-known French naturalist. My translation is as follows:

"M. de Quatrefages pointed out that I had wronged a French scientist, Dujardin, who must be credited with the first discovery of the fundamental principle of the aquarium; I reproduce verbatim, M. de Quatrefages's note:

"'In 1838, Mr. Dujardin was traveling on our shores in the interest of his zoological studies.

Figure 5: Félix Dujardin (1802-1860)

He brought back many jars of marine animals to Paris every year, and to maintain the purity of the water, he placed in each jar a few fronds of *Ulva lactuca*. Appointed professor at Toulouse, he moved his museum or aquarium, and his collection grew. Later called to the chair of zoology at Rennes, his collection followed, which included even a greater variety of species collected on the coast of Brittany. Here, in one of these jars, is where he established his first collection of jellyfish. I had the pleasure of personally watching my former colleague growing one of these jellyfish in captivity.'"

The problem here - once again - is in priority of publication.

Anna Thynne (1806-1866) is frequently cited as the inventor of the marine aquarium. She was the wife of the Reverend Lord John Thynne, sub-dean of Westminster Abby and spent many years in the respectable surroundings of her London drawing room, studying the intricate forms and intimate sex lives of stony corals called "madrepores." Initially, she had supplies of seawater brought from the coast, which she - and later her maid - aerated by hand, pouring it repeatedly between vessels to stave off fouling of the water. In 1849, she tentatively tried adding some seaweed to her tanks, expecting them to help enrich the water with oxygen much like the captive atmosphere inside Nathaniel Ward's fern cases. In doing so, Thynne kept her corals alive for an unprecedented three years, along with clusters of other marine animals and plants. In addition to what he had to say about his father and the freshwater aquarium, Stephen Ward (*loc. cit*) also had this to say about Anna Thynne and the marine aquarium:

"The individual to whom is due the merit of having introduced marine vivaria into London is Mrs. Thynne. Having procured some living madrepores when at Torquay in the autumn of 1846, she placed them in some sea-water in a bottle covered with a bladder, and brought them safely to town. They were then transferred to two glass bowls, the sea-water being kept aerated by being daily poured backwards and forwards, and being, moreover, periodically renewed by a fresh supply from the coast. In the spring of 1847, Mrs. Thynne sent for some pieces of rock, shells, &c. to which living sea-weeds were attached, and subsequently depended upon the action of these for the purification of the water."

In addition to Stephen Ward, Thynne's biographer, Rebecca Stott (2003), also credits her as being the inventor of the marine aquarium. In addition to Dayell's experiments, Stott mentions those of Robert Grant (1793-1874), one of the foremost biologists of the early 19th century, Edward Forbes (1815-1854), a distinguished British naturalist and the young Charles Darwin (who had been a student of Grant's), all of whom had kept sundry marine creatures alive for several days at a time in the 1820s and 30s. However, as Stott points out:

"But such experiments… depended upon either constant changing of the seawater or a tiring process of aeration. For these students of zoology the Firth of Förth was never more than half an hour's walk away. She (Thynne) was in London and, even with her riches and domestic servants, shipping seawater into the capital seemed a frivolous waste of money. So she had been forced to discover other means of establishing vitality in her glass tanks."

However, Stott overlooks the fact that Thynne did aerate her water. From Thynne's own account (Thynne, 1859):

"My next consideration was as to the possibility of keeping them alive, and this I accomplished in the following manner. I placed them in glass bowls, holding about three pints of water each, which I changed every other day; and as I could not have a continual supply sufficient for such a demand, I thought of having it aerated by pouring it backwards and forwards through a small watering-pot, before an open window, for half or three-quarters of an hour, between each time of using it. This was doubtless a fatiguing process; but I had a little maid, who, besides being anxious to oblige me, *thought it rather an amusement;* so that as the service was cheerfully performed, it was also done well; and the exertion was diminished by her standing for only ten minutes or a quarter of an hour at one time.

"From this time I regularly placed sea-weed in my glass bowls; but, as I was afraid I might not keep the exact balance required, *I still had the water refreshed by aeration."*

Stott also apparently was unfamiliar with the works of George Johnston (1798-1855), a Scottish medical doctor and naturalist. Amid his many arduous professional duties, he cultivated natural history with an enthusiasm and a success which rendered the place of his residence "one of the most classic localities in Great Britain." Apart from numerous papers contributed to the *Edinburgh Philosophical Journal* and other scientific periodicals, he published two works of first-rate importance: "History of British Zoophytes" (2d ed., 2 vols. 8vo, London, 1847) and "History of British Sponges and Litho-

Figure 6: Anna Thynne (1806-1866) with her two children, Selina and Emily

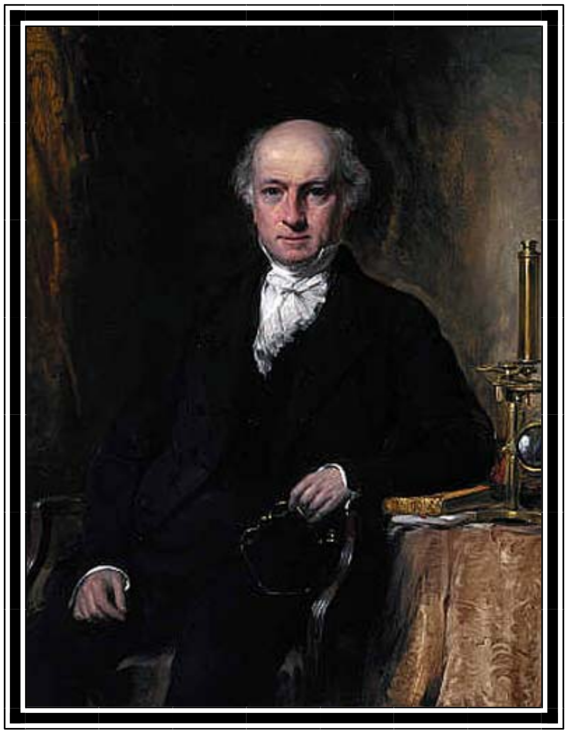


Figure 7: George Johnston (1798-1855)

phytes" (8vo, 1842). In 1850 his "Introduction to Conchology" appeared with an abundance of illustrations and later he published "The Natural History of the Eastern Borders" (vol. I., "Botany," 8vo, 1854). He was engaged at the time of his death upon a complete work on British annelids. He is considered one of the most accomplished contributors to the literature of natural history, and was one of the founders of the Ray society.

The following is taken from his "History of British Sponges and Lithophytes" (Johnston, 1842):

"Was there a need of adding any additional proof of the vegetability of the Corallines, an experiment now in progress before me would seem to supply it. It is now eight weeks ago since I placed in a small glass jar, containing about six ounces of pure sea-water, a tuft of the living *Corallina officinalis*, to which were attached two or three minute confervae, and the very young frond of a green Ulva, while numerous Rissoae, several little mussels and annelids, and a star-fish, were crawling amid the branches. The jar was placed on a table, and was seldom disturbed, though occasionally looked at; and at the end of four weeks, the water was found to be still pure, the mollusea and other animals all alive and active, the confervae had grown perceptibly, and the coralline itself had thrown out some new shoots, and several additional articulations. Eight weeks have now elapsed since the experiment was begun,—the water has remained unchanged,—yet the coralline is growing, and apparently has lost none of its vitality, but the animals have sensibly decreased in numbers, though many of them continue to be active, and show no dislike to their situation. What can be more conclusive? I need not say that if any animal, or even a sponge, had been so confined, the water would long before this time have been deprived of its oxygen, would have become corrupt and ammoniacal, and poisonous to the life of every living thing."

It is interesting to note that Johnston used no aeration nor did he change the water during this time. One may argue that Johnston's experiment lasted only eight weeks whereas Thynne kept her madrepores for three years, but it is irrelevant here since precedence in publication once again is the deciding factor. Johnston, therefore, was the originator of the marine aquarium sans fishes. Note, however, that being first doesn't always mean being best or the most important. Johnston's material was a short footnote consisting of 247 words; Thynne's was an article consisting of 12 pages. Her account was much more detailed and added significantly more to our knowledge of the marine aquarium of the times.

THE DRED STOTT DERISION

Stott writes: "Other individuals, however, made bolder claims for their work. And indeed Anna's description of her visitors as 'professed naturalists' may reveal a degree of suspicion or resentment on her part about their ethics. In a culture in which many naturalists saw a distinction between the-orists and mere collectors or experimenters, her visitors would have not have had any conscience about using her experiment for their own profits or to provide evidence for their own theories."

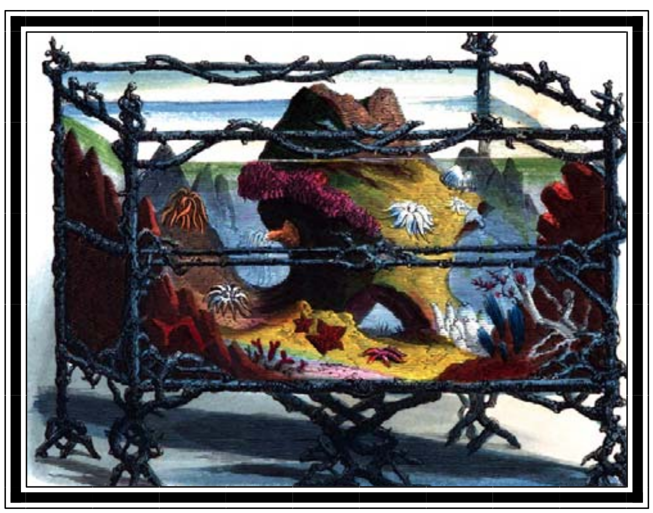
I can certainly appreciate Thynne's situation and what she and other women of the time had to endure. Another woman for whom I have the greatest respect was Helen Beatrice Potter, best known for her children's books that featured animal characters such as Peter Rabbit. At the time, the only way to record microscopic images was by painting them, so Potter made numerous drawings of fungi, and as the result of her observations, she was widely respected throughout England as an expert mycologist. Potter was one of the first to suggest that lichens were a symbiotic relationship between fungi and algae. She studied the life cycles of fungi extensively and in 1897, her paper on the germination of spores was presented to the Linnean Society by her uncle as women were then barred from attending meetings. Similarly, the Royal Society also refused to publish at least one of her technical papers. In 1997, 100 years after she submitted her paper, the Linnean Society held a meeting in her honor and issued a posthumous official apology to Potter for the way she had been treated.

Two individuals Stott singles out as possible visitors with such ulterior motives are Robert Warington (which she misspells as "Warrington") and Philip Henry Gosse. In point of fact, however, there is no evidence whatsoever that either of these gentlemen ever visited Anna Thynne. She is particularly hard on the first: "The chemical operator of the Society of Apothecaries, Warrington began a series of experiments with the chem-ical properties of aquatic vitality in 1849. Why 1849? Was he one of the visitors to Anna's Westminster Abbey drawing-room that spring? Was this visit the motivation for his subsequent experiments?"
This is, in my opinion, tantamount to a character assassination of this most distinguished gentleman. In her quest to "prove" that a woman was the inventor of the marine aquarium, some men got trampled.

THE MARINE AQUARUM WITH FISHES

In spite of Stott's attempt to show that it was Thynne rather than Warington who should get the credit for the first marine aquarium, Warington gets the credit here, also. The following is the paper that did the job (Warington, 1853):

"In the published notices of my experiments of 1849, to maintain the balance between the animal and vegetable organisms in a confined and limited portion of water, the fact was demonstrated, that, in consequence of the natural decay of the vegetation, its subsequent decomposition and the mucus-growth to which it gave rise, this balance could only be sustained for a very short period, but, if another member were introduced, which would feed upon the decaying vegetation and thus prevent the accumu-lation of these destructive products—a function most admirably performed by the various species of water-snail—such balance was capable of being continuously maintained without the slightest difficulty and I may add, that the experimental proof of this has now been carried on, in a small tank in the heart of London, for the last four years and a half, without any change or disturbance of the water; the loss which takes place by evaporation being made up with rain or distilled water, so as to avoid any great increase of the mineral ingredients originally present. It follows then, as a natural deduction, from the successful demon-



stration of these premises, that the same balance should be capable of being established, under analogous circumstances, in sea water. And in a paper published in January 1852 (*Gardeners' Botanical Magazine and Garden Companion*, Jan. 1852) I stated that I was, at that time, attempting the same kind of arrangement with a confined portion of sea water, employing some of the green sea-weeds for the vegetable member of the circle, and the common periwinkle as the representative of the water-snail.'

"The sea water with which the experiments I am about to detail were conducted, was obtained through the medium of one of the oyster-boats at the Billingsgate fish-market, and was taken from the middle of the English Channel.

My first object was to ascertain the kind of sea-weed best fitted, under ordinary circumstances, for keeping the water clear and sweet, and in a sufficiently oxygenated state to sustain ani-mal life. And here opinions were at variance, for one naturalist friend whom I consulted, advised me to employ the Rhodosperms; another stated that it was impossible to make the red weeds answer the purpose, as he had tried them, and strongly recom-mended the olive or brown-coloured Algae; while, again, others thought that I should be more successful with those which had in theory first suggested themselves to my own mind, namely the Chlorosperms. After making numerous unsuccessful expe-riments with both the brown and the red varieties of Algae, I was fully convinced that, under ordinary circumstances, the green weeds were the best adapted for the purpose.

"This point having been practically ascertained, and some good pieces of the *Enteromorpha* and *Ulva latissima* in a healthy state, attached to nodules of flint or chalk, having been procured from the shore near Broadstairs, several living animal subjects were introduced together with the periwinkle. Everything progressed satisfactorily, and these all continued in a healthy and lively condition.

"My first trials were conducted in one of the small tanks which had been used for fresh water; but as it was necessary, during the unsuccessful experiments with the brown and red sea-weeds, to agitate and aerate the water, which had been rendered foul from the quantity of mucus or gelatinous matter generated during the decay of their fronds, until the whole had become oxidized, and the water rendered clear and fitted for another experiment, it was, therefore, for greater convenience, removed into a shallow earthen pan and covered with a large glass shade to protect the surface of the water, as much as possible, from the dust and soot of the London atmosphere, and at the same time impede the evaporation. In this vessel then I had succeeded perfectly in keeping a large number of beautiful living specimens in a healthy condition up to the close of 1852. I therefore gave instructions for the making of a small tank as a more permanent reservoir, and one more adapted for carrying on my observations and investigations on the oeconomy and habits of the inhabitants.

"From the experience I had obtained in my experiments with the freshwater tank, I was induced to modify slightly the construction of this vessel; thus, at the back, or part towards the light, the framing was filled with slate in the same way as the ends and bottom; for I had found that the glass, originally employed, very soon became covered with a confervoid growth which had an unpleasing appearance to the eye, and in consequence of which I had been obliged to paint the glass on the exterior to prevent this growth from increasing to too great an extent. It was also an unnatural mode of illumination, as all the light should pass through the surface of the water. The front towards the room and the observer was constructed of plate-glass, the whole being set in a stout framework of zinc, and cemented with what is known under the name of Scott's cement, and which I have found to answer for the purpose most admi-rably. Within this tank were arranged several large pieces of rock-work, thrown into an arched form, and other fragments were cemented in places against the slate at the back and ends, and at parts along the water-line, so that the creatures could hide themselves at pleasure; a short beach of pebbles was also constructed in order that shallow water could be resorted to if desired. The whole tank was covered with a light glass shade to keep out the dust and retard evaporation.

"With the sea water obtained in January 1852, I have been working without cessation up to the present time, agitating and aerating when it became foul during the unsuccessful experiments on the sea-weeds, but since then it has been rarely ever disturbed; the loss which takes place from evaporation being made up, as before stated, with rain or distilled water.

"For a considerable period, after commencing these experiments, I was much troubled to obtain living subjects in a healthy condition, but having alluded to this, and the success of my investigations, in a short notice appended to a paper published in the 'Annals of Natural History' for October 1852, my friend Mr. P. H. Gosse, who was then sojourning at Ilfracombe for his health, offered in the kindest manner possible to supply me with materials, and from that period he has always most heartily responded to my wants. It must not be imagined for a moment that the beautiful creatures I have thus received have been all preserved alive or always quite healthy. In experimental investi-gations this would be unreasonable to expect, as the very fact of experimenting implies a disturbance of the then state of things. Besides which, from want of a sufficient knowledge of natural history, from want of forethought and experience and other causes, I have lost many very fine specimens; and as the detail of these losses may prevent the occurrence of the like annoyances to others, I shall venture to occupy your time for a short period with their history.

"My greatest loss arose from too great an anxiety to transfer the collection I had preserved in a healthy condition to the end of December 1852 into the new tank. As soon as it arrived from the maker's I lost no time in introducing my numerous family to their new abode, and dearly I paid for my precipitancy, for on the next morning I found many of my most beautiful spe-cimens dead; thus I lost two fine Holothurias (*H. Pentactes),* a small freckled Goby (*Gobius minutus*), a beautiful little Pipe-fish (*Syngnathus lumbriciformis*), and several others, and on opening the door of the case the cause of this mortality was at once evident,—an iridescent film of oily matter was floating on the sur-face of the water, arising from the paint with which the angular joints and edges of the small tank had been coloured not having become sufficiently hardened.

"Another source of loss arises from the several creatures attacking and devouring each other, and it therefore becomes a point of great importance—and highly necessary to be carefully observed, where their preservation is an object—to ascertain what varieties may be safely associated in the same tank; as, for in-stance, I have found that the Shrimps and Prawns attack, and very soon devour, all the larger varieties of Corallines and Polyps, Sabellae, Serpulae, Rock-borers, Cirrhipeds, some of the Annelids, many Bivalve and Univalve Mollusks that are unprotected by an operculum, or have no power of closing their valves. The instances which have come under my own immediate observation have been the destruction of the *Pholas dactylus, Saxicava rugosa, Cypraea Europaea,* and several specimens of Sabellae, Serpulae, Coryne sessilis and many others.

"The common Crab (*Cancer Maenas)* is likewise a most destructive agent; and the tribe of

rock-fish, the Blennies, Gobies, &c. are also most voracious, devouring all the varieties of Cirrhi-peds, Corallines, Polyps, Annelids, &c.; they will also attack the shrimps and prawns, and even seize upon the horns of the periwinkle, which they bite. If the mollusks do not keep a very firm hold of the rock or tank sides, they are rapidly turned over by these fish on their backs and lie helplessly exposed to their attacks. It is doubtless their seeking food of this kind which causes these little fish to be so generally found in the shallow rock-pools of the coast. In consequence of these ravenous propensities I have been obliged to establish several small tanks and imitation rock-pools, so as to separate these various depredators from each other : thus in one I have varieties of *Actiniae,* Shrimps, Nudibranchs, Holothurias, and some Annelids; in a second the rock-fish, as the Blennies, Gobies, Cottus, with Crabs and Actinia; in a third Corallines, Annelids, Polyps, Rock-borers, Sabellae, Serpulse, Holothurias, and *Actiniae.*

"Another curious instance of loss I may detail which has quite recently occurred, and which may prove interesting; it was in a small rock-pool containing Blennies, Gobies, Crabs, &c. I had procured two live oysters for the purpose of feeding my numerous small fry in these vivaria, and one of these having proved ample for the purpose of one meal, the other was placed on the sandy bottom; on the second day after this the oyster was observed to have opened the valves of hid shell to a great extent, which were afterwards seen closed, but a small *Gobius niger*, inhabiting the pool, could nowhere be seen. The day after this the oyster was opened for the general feeding, when, lo! within the shell was found the unfortunate *Gobius*, quite dead. Whether this little gentleman had been attracted within the trap by curiosity or the ciliary motion of the oyster, it is impossible with certainty to say; but that he must have seized on some sensitive part of the oyster is more than probable, so as to have caused such a rapid closing of the valves of the shell as could entrap so active a burglar.

"Another important point is the gravity of the sea water; this should be very carefully regulated, for it must be borne in mind that many of the marine creatures are supplied by a per-meation of water through their tissues or over their delicate and beautiful organs. The specific gravity should not rise above 1.026 at 60° Fahr., and a small hydrometer should be at short periods introduced to ascertain that this point is not exceeded, particularly during the hot months of summer. The reduction to this gravity can be readily effected by the addition of rain or distilled water. Many of the creatures will of themselves afford indications of this increase of density; some of the *Actiniae* will remain closed and become coated with a white slimy covering within which they remain for a length of time, and if the specific gravity of the water be lowered this is very soon ruptured by their expansion, thrown off, and the tentacula become soon extended.

"All putrescent matter or excess of food or rejecta of the *Actiniae* should be carefully removed from the water, as the noxious gaseous compounds generated by the decay of such matters appear to diffuse themselves rapidly through the water, act as a virulent poison, and speedily destroy the vitality of the occupants. Thus many beautiful subjects were lost in a few hours from the introduction, into a small glass jar, of a large Pecten shell, encrusted with corallines, which had become loaded with putrescent matter by partial submersion in a foul muddy bottom.

"Great care should also be taken in moving the *Actiniae* that the foot or sucking disc with which it attaches itself to the rocks, stones, or mud, be not injured, as, when this occurs, they rarely survive, but roll about without attaching themselves, and gradually waste away and die.

"With these exceptions then, everything has gone on very satisfactorily, care being always taken not to overload the water with too large a proportion of animal life for the vegetation to balance, as, whenever this has been inadvertently attempted, the water has soon become foul, and the whole contents of the tank, both animal and vegetable, have rapidly suffered, and it has required some time before the water could be restored to its former healthy condition.

"In one of the numbers of the 'Zoologist' of last year, I stated that besides the *Ulvae, Enteromorpha* and *Cladophora,* I had found the *Zostera marina* a very useful plant for oxygenating the sea water; but this observation has reference only to the case of a tank supplied with a ground where its roots will find a sufficiency of food for its growth, as in a clear shingle or sand it soon de-cays ; and it should be associated with such animals as delight in a ground of this nature, as many of the Annelids, Crabs, burrowing Shrimps, &c. There are several interesting observations which have been made from time to time connected with this subject, which I hope to lay before the natural-history world as soon as I can find leisure time for the purpose.

"Since the reading of this paper at Hull I have received a Blenny of larger size, being about inches in length, and although it has become so tame that it will allow itself to be touched by the hand and takes its food from the fingers, yet its destructive propensities are so great, that it very soon killed four small Crabs; and to save three others, of rather a larger size, I have been obliged to remove the Blenny to a rock-pool in asso-ciation with his own species and a few ***Actiniae.*** The only refuge the poor Crabs had was to bury themselves in the sand, and whenever they attempted to move out of their refuge they were immediately pounced upon and only escaped by burrowing rapidly again."

It was a squeaker, however, since Gosse lost the competition by only a few months. The following is Gosse's book, "A Naturalist's Rambles on the Devonshire Coast" (Gosse, 1853):

"It is a curious circumstance that experiments exactly parallel to these, founded on the same prin-ciples, have been simultaneously prosecuted with the same results by another gentleman, whose name is well known in the scientific world. Mr. Robert Warington of Apothecaries' Hall has now (Dec. 1852) at his residence in London a marine aquarium, with living Algae and Sea-anemones in a healthy condition. I find, on comparing notes, that Mr. Warington has precedence of me in instituting these experiments; but the particulars that I have above detailed of my own success were fully recorded before I had the slightest knowledge that the thought of such a project had ever crossed the mind of any person but myself."

Although briefly acknowledging Warington's experiments and priority, Gosse described in great detail his own marine aquarium experiments, even though they were unsuccessful and Warington's were. As time went on, Gosse believed that he should have been credited with the invention of the marine aquarium (Gosse, Edmund, 1890):

"There was no sort of rivalry between these earnest and amiable investigators, but a little later on, when the aquarium had become a fashionable thing, Philip Gosse was accustomed to say that if it was needful to dispute about an invention which was virtually simultaneous, it might be said that Warington had invented the vivarium (*AJK: i.e., the freshwater aquarium*) and he the marine aquarium."

Figure 8: Philip Henry Gosse (1810-1888)

Nonetheless, the following, taken from Humphreys, 1857: pp. 27-28, pretty sums up who gets the credit for the "invention" of both the freshwater and marine aquarium:

"These successful experiments, both in freshwater and marine Aquaria, assign to Mr. Warington, beyond dispute, the credit of being the originator, or inventor, if the term may be so used, of these charming additions to our conservatories, corridors, and even living-rooms, to which they are certainly a much more attractive and instructive addition than the old globe of blank water, with its pair of goldfish swimming around and round in ceaseless gyrations, tiresome to behold, in the vain hope of escaping from their glaring and inconvenient prison; in which they would inevitably have perished very shortly but for the daily changes of water, which, previous to our knowledge of air-emitting plants and their use, was absolutely necessary."

MUSINGS ON "WHO INVENTED THE AQUARIUM?

Before one attempts to pin down a "first," one must devise a set of criteria. In Great Britain in the early 1850's the de facto definition of an aquarium in the sense of the whole concept, not just the container, was a vessel containing water and plants, plus aquatic animals (excluding, of course, mammals and water fowl) in which the water was not aerated nor changed. Note that fish were not necessarily included. Implicit in this definition was that basis for the aquarium be the relationship between plants and the animals, i.e., that plants absorbed the carbon dioxide that the aquatic animals generated whilst the animals absorbed the oxygen that the plants generated.

Another part of the requirement for "first" was priority of publication, a criterion required in the 1800's and also present-day. "Previous to the year 1850, many experiments had been made in London of keeping sticklebacks, gold fish, and other animals in jars containing *Valisneria*. I find, from some of my own notes, that I had sticklebacks in a jar containing *Valisneria* and Water Starwort, in 1849 [Lankester, p. 11, 1856];" However, none of these would vie for "first" because they were not published.

To simplify the analysis, I have considered four categories for "firsts" in this monograph: freshwater aquarium sans fishes, freshwater aquarium with fishes, marine aquarium without fishes and marine aquarium with fishes. Using these criteria, Charles des Moulins - a man mostly overlooked in aquarium hobby history - comes in first (1830) for the freshwater aquarium sans fishes, Warington (1850) for the freshwater aquarium with fishes, Johnston (1842) for the marine aquarium sans fishes and Warington for the marine aquarium with fishes.

If, however, we add another criterion, that of the impact on the aquarium hobby in the Nineteenth Century, then Warington remains in the first place for the freshwater aquarium, with Gosse and Warington in a close tie for the marine aquarium title. It is difficult to break this tie, since Warington published first whereas Gosse had the greater impact.

In today's hobby, neither plants, aeration nor water changes are a part of our definition of the aquarium. Plastic plants abound, water is frequently changed and aeration (either directly or through filtration) is almost a given. The only criterion is that there is at least one fish in the container; thus a Betta in a jar qualifies as an aquarium today. Even in Great Britain in the 1870's the aeration criterion was modified or removed. Lloyd (1872), for example, relaxed the aeration requirement but maintained the necessity for plants: "The water must be kept not only in a pure and respirable condition by its absorption of atmospheric air at its surface, *which absorption may or may not be increased by putting the water in motion in any convenient manner*, but this purity must be assisted by the presence of vegetation growing in it…" Hughes (1876) relaxed the aeration criterion even more: "The word Aquarium is, therefore, in use popularly as signifying a collection of aquatic animals maintained in health by plants, or by artificial means supplying their place…"

In 1846, Jean Jacques Marie Cyprien Victor Coste published his paper, "Nidification des épinoches et des épinochettes," i.e., "The nest building of sticklebacks" (Coste, 1846). (Coste, by the way, was never recognized in the literature with a forename, and he never gave the secret away! He was mostly referred to as M. Coste, the French abbreviation for Monsieur; in American publications he was frequently given the initial P, but sometimes B and C.)

Coste (1807-1873) studied medicine at the Faculty of Medicine of Montpellier and, after graduating, he taught anatomy at the Ecole Pratique de Paris from 1836 and embryology at the Collège de France from 1844. He devoted himself to the study of the natural sciences, notably of embryogeny. His work attracted the attention of learned men, and the Academy of Sciences awarded him a gold medal in 1834. He became a member of the Academy in 1851and later was a recipient of the Cross of the Legion of Honor.

During the later years of his life Coste was much occupied with the art of increasing fish populations via artificial insemination. The art of pisciculture, although discovered in Germany in the previous century, was not yet applied. In 1851 Cost designed and built a model piscine establishment at Huningue that, in two years, supplied 600,000 salmon and trout for the seeding of the Rhone. In 1852, he was appointed by Napoleon III to head a mission to study the production of natural oyster beds and is generally accredited with saving the oyster fisheries of the country. Close to the Emperor and the Empress Eugenie, to whom he was her personal physician, he was appointed by the Emperor in 1862 as Inspector General of the rivers and coast fisheries of France.

Using a circular tank a little over 6-1/2 feet in diameter and 13 inches high, Coste placed in it a large number of male and female sticklebacks. The tank contained plants, but were mostly intended as material for the nest-building. Because of its large size and physical configuration, it did not need aeration or a change of water. In this tank Coste observed the fish court, lay eggs, care for and rear their young. Clearly this satisfies the criteria for the first freshwater aquarium with fish.

Other than impact, (Coste's paper had non), what then is the difference between Warington's and Coste's experiments with regard to who is first? The difference is in intent. Coste was not concerned with showing that fish can survive without aeration of water changes by utilizing plants, i.e., the "balanced aquarium" principle; he was only interested in describing the breeding behavior of sticklebacks. Technically Coste had the priority, but not the spirit of the criteria. However, using today's relaxed criteria, Coste is inventor of the freshwater aquarium with fishes (and, by the way, because of his paper, the stickleback might therefore be considered as the first fish - excepting perhaps the goldfish - bred in an aquarium).

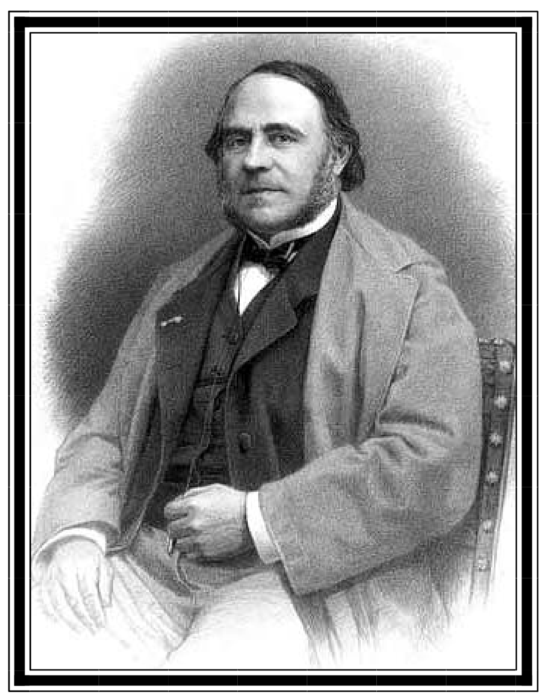


Figure 9:
Jean Jacques Marie Cyprien Victor Coste
(1807-1873)

We are all familiar with the following discourse from “Alice in Wonderland”:

‘I don’t know what you mean by “glory,”’ Alice said.
Humpty Dumpty smiled contemptuously. ‘Of course you don’t — till I tell you. I meant “there’s a nice knock-down argument for you!”’
‘But “glory” doesn’t mean “a nice knock-down argument,”’ Alice objected.
‘When I use a word,’ Humpty Dumpty said, in rather a scornful tone, ‘it means just what I choose it to mean — neither more nor less.’
‘The question is,’ said Alice, ‘whether you can make words mean so many different things.’
‘The question is,’ said Humpty Dumpty, ‘which is to be master — that’s all.’

We consider this to be a bit of nonsense and smile, but if Humpty Dumpty had answered, ‘The question is,’ said Humpty Dumpty, ‘what are your criteria— that’s all,’ it would have been regarded as a sage remark, indeed!

THE ARTIFICIAL SEAWATER CONTROVERSY

William H. Brock (Brock, 1991) published a paper involving a controversy over the composition of artificial seawater between two of the best knows aquarists of the day, Robert Warington and Philip H. Gosse (an abridged version can also be found in Klee, 2003).

Gosse had written a paper (Gosse, 1854b) describing his experiments with an artificial seawater formula based on analysis of seawater in the English Channel near Brighton by a chemist in Brighton who sold the salts of evaporated seawater for medicinal use (Schweitzer, 1839). Shortly afterwards, Warington wrote a paper (Warington, 1854a) pointing out a number of errors Gosse had made in converting Schweitzer’s formula to his own. Although Brock thought that the differences between Warington’s and Gosse’s formulae “were not all that significant,” I disagree. The table below is a comparison between the two and there are considerable differences.

Gosse admitted the errors but defended his formula, citing the omission of the three components as being unimportant and an attempt to simplify things for the average aquarist, a somewhat puzzling argument since he kept the potassium bromide but omitted the calcium sulfate which was twice as important. His main argument, however, was that it worked, citing his own experiments with his formula and those of William Alford Lloyd (Lloyd, 1855) who also had success with it. However, neither of these gentlemen had ever used fish in their experiments, so although it was certainly a success for the marine aquarium sans fishes, it was not a successful formula for the marine aquarium *in toto*. In discussing the use of Gosse’s artificial sea-water, Humphreys [1857: p. 111] stated: “The artificial salt water has been found sufficient for Zoophytes, but not for fish and other of the higher class of marine animals, except for a certain given time.”

However, it not the chemical side of this controversy that I wish to explore here, but the basic reason for the dissention between the once amiable friends. The following is Gosse’s introduction to his paper (submitted on June 9, 1854):

“The inconvenience, delay and expense attendant upon the pro-curing of sea-water, from the coast or from the ocean, I had long ago felt to be a great difficulty in the way of a general adoption of the Marine Aquarium. Even in London it is an awkward and precarious matter; how much more in inland towns and country places, where it must always prove not only a hindrance, but to the many an insuperable objection. The thought had occurred to me, that, as the constituents of sea-water are known, it might be practicable to manufacture it; since all that seemed necessary was to bring together the salts in proper proportion, and add pure water till the solution was of the proper specific gravity. **Several scientific friends to whom I mentioned my thoughts, expressed their doubts of the possi-bility of**

the manufacture; and one or two went so far as to say that it had been tried, but that it had been found not to answer; that though it looked like sea-water, tasted, smelt, like the right thing, yet it would not support animal life. Still, I could not help saying, with the lawyers, 'If not, why not?' *Experientia docet.* I determined to try the matter for myself."

I have bold-faced the part that was the cause of the dissention between Warington and Gosse. There is no doubt that this was included in the introduction to assure readers that he, Gosse, had no assistance from any of the scientific community. This, however, is not true since Gosse visited Warington in 1854 on two occasions at Apothecaries Hall, on January 16th and again on January 21st to discuss, among other things, the feasibility of using artificial seawater. One can imagine Warington's surprise when he read Gosse's introduction. Accordingly, he replied thusly (Warington, 1854a), submitted on November 1, 1854:

"In the 'Annals and Magazine of Natural History' for July last, you published a short communication from Mr. Gosse, on the artificial formation of sea water, and having lately had my atten-tion especially directed to this paper by a friend who wished to put the formula given into practice, I was surprised at the difference in the proportions of the ingredients as compared with what I had myself employed in the course of 1853, more par-ticularly from the circumstance, that when Mr. Gosse called upon me in January last, and consulted me on the feasibility of the plan, I told him that there could be no difficulty in the matter, as I had made and had then in use several small quan-tities artificially produced, and that all that was required was that a good analysis should be taken as the basis for deducing the proportions, and at the same time referred him to the source from which I myself had worked, namely Dr. E. Schweitzer's analysis of the water of the English Channel taken off Brighton. Now, as numerous parties have been inquiring respecting this subject, and the erroneous formula has been copied into other journals, it may prevent much annoyance as well as disappointment if this matter is set right."

Gosse's reply (Gosse, 1854c) submitted on December 20, 1854 was shorter:

"If Mr. Warington supposes that I obtained from him one atom of information previously unknown to me, on the subject of making seawater from its constituent salts, he is most thoroughly mistaken. He is no less wrong in saying

jINGREDIENT Ounces/10 gallons water*	(1) WARINGTON	(2) GOSSE	% INCREASE OF (1) OVER (2)
Sodium chloride	43.25	35	23.4
Magnesium sulfate, anhydrous	7.5	2.5	300
Magnesium chloride	6	4.5	33
Calcium sulfate, anhydrous	2.75	-	
Potassium chloride	1.24	0.9	38
Magnesium bromide	0.048	-	
Calcium carbonate	0.048	-	

*Actually 9.6 gallons because the original analysis is on a given weight of seawater of which the ingredients constitute a part.

that I "consulted" him; since I merely mentioned what was on my mind in familiar conversation. With this, however, the public are of course not concerned, and I shall say no more on that head."

Not all believed him. The following appeared in the *Leisure Hour*, January 25, 1855:

"It is now some months ago that Mr. Gosse, the gentleman on whom the care of the marine vivarium belonging to the Zoological Society devolves, and to whom the public are indebted for some most interesting works on natural philosophy, pub-lished a formula for the generation of sea-water artificially, and having supplied some marine pets with the liquid, found that they thrived in it well. The analysis of sea-water chosen by Mr. Gosse was that made by Dr. Schweitzer, the formula of which it appears was suggested to that gentleman by Mr. Warington of Apothecaries Hall."

Brock may be putting the cart before the horse when he opines that the reason the relationship between the two men soured was because Warington was jealous of Gosse's success in which he had made the major scientific breakthrough. Since it was Gosse who precipitated the controversy, it was more likely because Gosse was jealous of Warington's standing in the scientific community in spite of his overwhelmingly popular successes with "A Naturalist's Rambles on the Devonshire Coast" and "The Aquarium: an unveiling of the wonders of the deep sea." Perhaps we can agree that both men were to blame.
In any event, Warington and Gosse never communicated again. However, the seawater controversy was never mentioned in Edmund Gosse's biography of his father, so it was apparently not the sort of bitter rife that characterized the famous fossil-finding competition known as the "Bone Wars" between Edward Drinker Cope and Othniel Charles Marsh.

Finally ,it should be noted that Gosse's artificial sea water was not a success: from Hibberd, 1856: "But artificial water is quite unsuited for animal life of any kind, until it has been brought into condition by means of growing weeds for eight or ten days, and for Crustaceans, Starfishes, and Fishes proper, it is not suitable till it has been in use for many months, and even then some species lose their health in it, and at last perish, and from Hughes, 1874: "Much has been said about artificial sea-water, but my experience is not very favourable to it - I found it crude and harsh in its effects on the anemones, they refused to expand, and shrank up and died."

WHO WAS THE FIRST AQUARIST TO USE THE WORD "AQUARIUM"?

"Aquarium" existed in the Vulgar Latin but in Roman times it meant a watering place, in particular a drinking place for cattle. As the world entered into the Nineteenth Century, however, gardeners used the term as a place for growing aquatic plants. In essence they were green-houses, either stand-alones or attached to a house, containing tanks (gardeners called them "cisterns") that held the water and plants. Some were simple structures but others were exceedingly complex and ornate as shown in Figure 10.

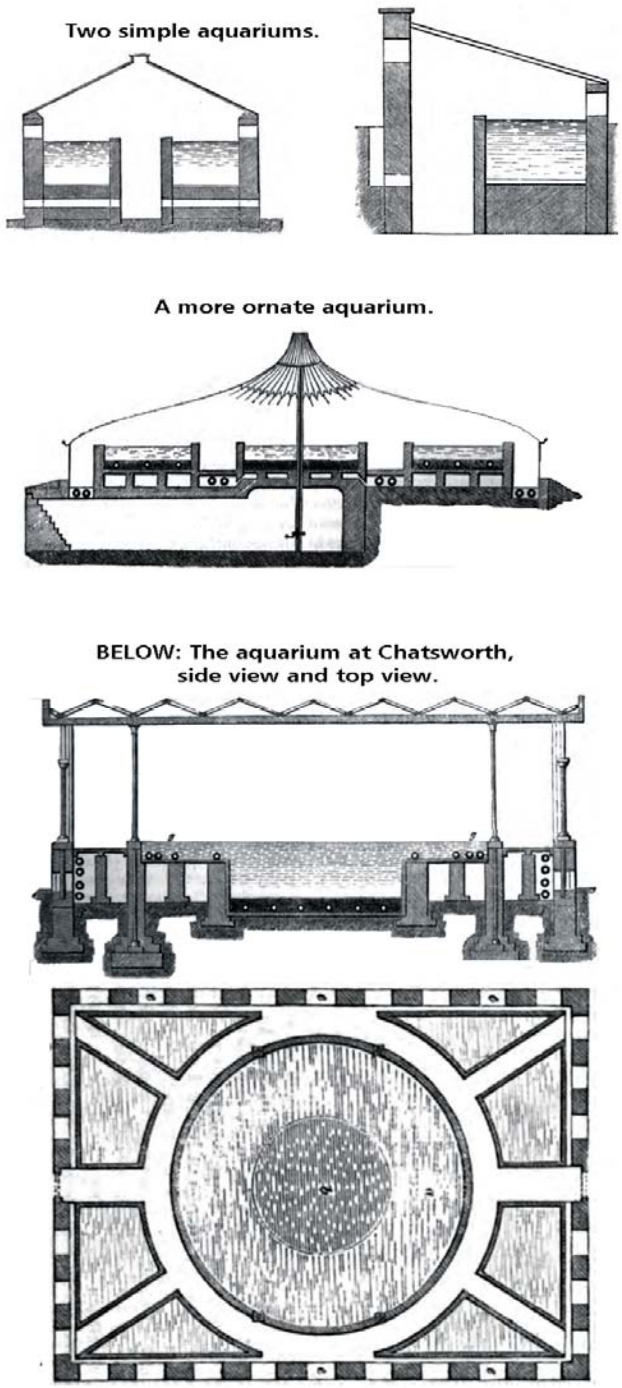


Figure 10: Examples of the gardeners "aquarium."

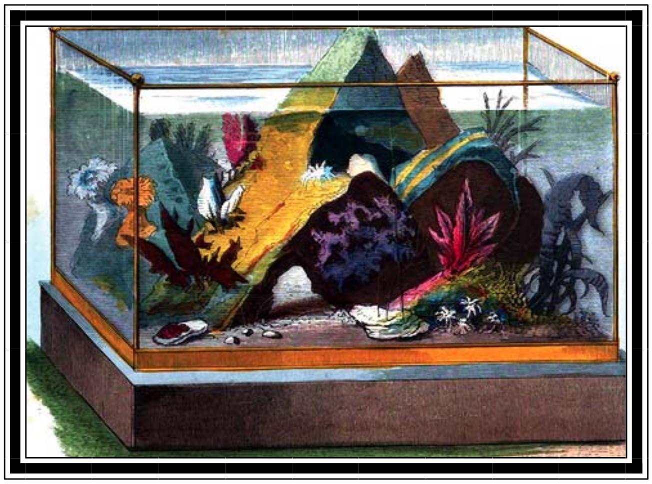
John Claudius Loudon (1783-1843) was born in Lanarkshire, Scotland to a respectable farmer and, as he was growing up, developed a practical knowledge of plants and farming. As a young man, Loudon studied chemistry, botany and agriculture at the University of Edinburgh and in 1815, he was elected a corresponding member of the Royal Swedish Academy of Sciences. Loudon was a prolific horticultural and landscape design writer and his first published work was *An Encyclopædia of Gardening* (Loudon, 1824), an immediate success. In his book Loudon suggested that fish might be added:

"It is almost needless to add, that exotic aquatic fowls and fishes might be kept in such an aquarium, and either of the sea or fresh water rivers, according as salt water or fresh was used."

In a later gardening book (M'Intosh, 1853) the author quotes from the *Liverpool Chronicle* that chronicles the miniaturization and exportation of the aquarium to the home:

"Few, perhaps, are aware of the great beauty which the tropical aquatic tribes present under good cultivation. They are not well adapted for small houses, but look best in houses having a

Figure 11: John Claudius Loudon (1783-1843)



vestibule, or circular centre. They may be made in various forms, according to the taste of the proprietor: if in a square or oblong vestibule, the aquarium should be of the same shape; if in a circular house, or part of the house, the form may be varied and much ornamented; a vase-shaped basin, circular cistern, or any other form suitable to the style of the building: a jet-de-eau in the centre is a great improvement. The interior must be of various depths, to suit the plants of various sizes, for which reason steps are usually formed from the circumference to the centre, the water being thus made shallower at the edge, to suit the smaller plants. Upon these steps or shelves pebbles and soil are laid, in which the roots are planted; and gold and silver fishes may be made to add to the interest of this group."

It is odd that M'Intosh made no mention of the "Parlour Aquarium," a term that entered the vocabulary of gardening magazines and other journals the previous year, but once again there is the suggestion that gardeners might combine fishes with the plants in their aquaria.

The earliest reference I have found to the word aquarium in the sense of a fish tank is in the article, "The Aquatic Plant Case, or Parlour Aquarium (*The Garden Companion, and Florists' Guide*, January, 1852). If we define the aquarium as a vessel consisting of at least one transparent side in which water-dwelling plants and animals are kept, then here is perhaps the first reference to the word "aquarium" in the literature. I say "perhaps" since one can never be sure that an earlier reference won't be discovered.

Although it is likely that either Arthur Henfrey, Thomas Moore or William P. Ayres (the regular authors of the publication) was responsible for the title of the article, on page 7 Warington himself uses the term, and since his submission to the journal preceded the use of the term in the title, Warington must be given credit for its first recorded use.

The Garden Companion, and Florists' Guide was preceded by *The Gardeners' Magazine of Botany, Horticulture, Floriculture, and Natural Science*, edited by Thomas Moore and William P. Ayres (Arthur Henley was listed as an Assistant). This magazine, however, was dedicated more to the professional than to the amateur gardener and so was experiencing subscription problems, hence the change of name and favoring of a different audience. I thought it wise, therefore, to examine *The Gardeners' Magazine of Botany, Horticulture, Floriculture, and Natural Science* for 1851 to see if the word aquarium had been used. Indeed it had, in an article by Mr. George Lawson titled "Contributions to the Aquarium." However, its use was in the traditional gardener's sense, not in the sense of a fish tank.

In another article, this one titled "Visits to Remarkable Gardens," the author (Thomas Moore) visited the suburban residence of Nathaniel Bagshaw Ward at Clapham. The Wardian case was mentioned in this article, and included quotes from Ward himself. The author ends with the following:

"We have left ourselves but little space to notice the many interesting plants crowded into Mr. Ward's small house. Passion-flowers, Manettias, Aristolochias, and such like, cover the pillars and festoon the roof, from which also Orchids are suspended. The raised rocky mounds on either side give pasturage to various small Palms, Ferns, Bamboos, Musas, Cannas, Colocasias, Clerodendrons, Achimenes, and hosts of smaller plants. The Cuphea ignea here grew, and flowered from year's end to year's end, until it became too large for the space. Fuchsias, too, which grew luxuriantly and flowered profusely, became too large, and had to be rooted out. A tank at the end affords accommodation for gold fish, and some of the smaller aquatic plants. The whole forms a beautiful miniature tropical forest scene."

It seems safe, therefore, to conclude that Warington was the first to use the word "aquarium" in the sense of a vessel to hold fish.

In any event, the modifier "parlour" is easily understood. If gardeners are going to bring the aquarium into their homes, they need a new descriptor to distinguish it from the external greenhouse concept and what better one than "parlour," since that is the best room in the house (indeed, the parlour was often colloquially called just that) and where parlour aquaria were usually sited (although if there was room, as mentioned previously, the entryway was also popular). In any event, it is during the remainder of the year 1852 that we find an increasing use of the term (Chambers, 1852):

"An interesting companion to the Wardian Case has lately been presented in the Aquatic Plant Case, or Parlour Aquarium, due to the ingenuity of Mr. Warington, and which has for its object, as its name indicates, the cultivation of aquatic or water , plants. It may be described as a combination of the Wardian Case and the gold-fish globe, the object being to illustrate the mutual dependence of animal and vegetable life.

"The Parlour Aquarium affords valuable, we might say invaluable, facilities to the naturalist in the prosecution of his researches. The botanist can now conveniently watch the development of aquatic plants under conditions *not* unnatural, throughout the entire period of their existence, from their germination to the production of flowers and the perfection of seeds; and we are in hopes that much of the obscurity that invests many aquatic vegetables will in consequence be cleared up. The zoologist is perhaps even more indebted to the invention. The habits, not only of the fishes, but of the mollusca, can be accurately studied under natural conditions, and many important facts of their history ascertained and illustrated. The water-beetles and other aquatic insects will also come in for a share of attention."

Warington uses the word "aquarium" with an interesting modifier (Warington, 1852, p.7):

"Since the reading of my paper before the Chemical Society, on March 4, 1850, respecting the Miniature Aquarium (Quarterly Journal of the Chemical Society, iii 62), I have continued the investigations, introducing other water plants, and also three other varieties of water snail. But the principal alteration has been the

Figure 12: Warington's sketch of his idea of what became to be known as the "Warington Case" and later the "Warington Aquarium."

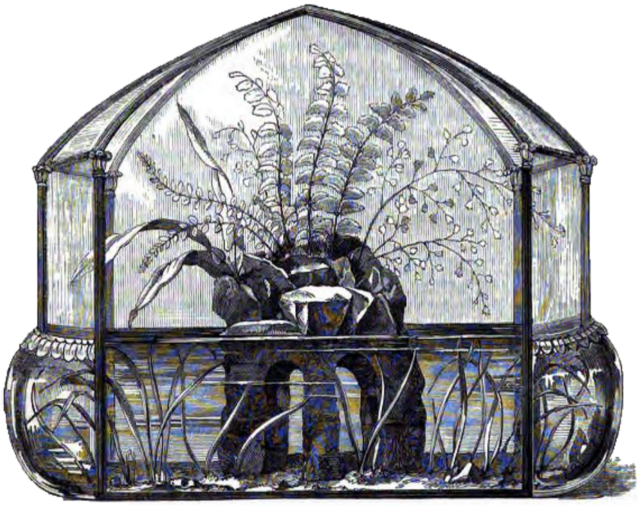


Figure 13: The "Warington's Plant Case" designed by A. Aglio

construction of a better form of vessel for holding the water, as I found that the globular form of the glass receiver, produced a distortion in the vision of the fish, besides being very inconvenient for observation. I have therefore adopted the form of vessel, of which a sketch is appended, having flat surfaces of plate-glass at the back and front, the bottom and ends being formed of slate, and supplied with a loose plate of glass at the top to keep out dust and soot To render the whole more ornamental, as it was to stand in a sitting room, some pieces of tufa, or sandstone, were attached to the ends by means of Roman cement, so as to form ledges and slopes rising from the water line, on which mosses and ferns, such as luxuriate in an atmosphere loaded with moisture, could be grown. These materials are set in a stout angular zinc framework, and connected with a mixture of white-lead ground in oil, to which about an equal quantity of red-lead is added. This arrangement I have found to answer all my expectations, as it has been going on most flourishingly since January 1851. The plants consist chiefly of Hymenophyllum tunbridgense, and H. Wilsoni, Trichomanes speciosum, Blechnum boreale, Adiantum Capillus-Veneris, and several mosses. The whole of the interior can be viewed with the greatest ease, so that the natural habits of its living inhabitants can be watched and accurately noted in every particular."

Note that Warington was also one who needed to modify the gardener's "aquarium." Using the term "miniature aquarium" made sense since Warington was comparing the parlour aquarium to its forebears, in general rather large constructions. Warington followed the use of the word "aquarium" in print by using the plural in his 1854 article, "Memoranda of observations made in small aquaria..." (Warington, 1854b).

Although Warington provided the editors with a drawing showing the basic idea of his aquarium (see Figure 12), in another article in this issue the editors show the result of a commission they gave to A. Aglio, a teacher of drawing and civic engineering:

"We have already given a view of the parlour aquarium, contrived by Mr. Warington, and which may well bear his name; and have also explained in his own words the principles on which success depends. These principles, it must be obvious, admit of various modes of application so that our former illustration is to be regarded rather as an exemplification of the principle than as a model. We now subjoin another design for an aquarium, or Warington case, with the view to indicate, to some extent, the variety which may be attained, by combining this with the Wardian case. It will be obvious that this combination will afford scope for a much greater variety of form than would have been brought out by confining them chiefly to the growth of aquatic plants, and this amount of variety will afford opportunity for the display of a greater amount of ornamentation.

"The design now submitted (Figure 13), from the pencil of A. Aglio, Esq., jun., is intended to consist of an ornamental zinc frame-work, a slate bottom, and the whole of the sides to consist of glass, used in plates, as large as the fittings will allow. The front and back will thus each consist of a single plate, and the absence of frame-work of every kind will admit of the whole interior being viewed without obstruction. The convex ends of the basin portion are also intended to be of glass formed into the exact shape and size required."

"The mass of imitation rock in the centre must be formed expressly for the reception of the plants, good drainage being an essential feature, so that the soil may not become soddened. The whole is supposed to be supported by an appropriate and elegant stand.

It is interesting to mention that the Zoological Society intend to fit up a case on Mr. Warington's principle in their garden in the Regent's Park."

As I have shown, although the term aquarium was used for the vessel to hold aquatic animals before Gosse's book "The Aquarium" (Gosse, 1854a) appeared on the scene, there was no general agreement on the matter. The moment the book was published, however, it became the name that everyone used. Although Gosse had discussed the true origin of the term, the public thought he was its architect; thus it might be said that he invented it de facto. Indeed, it forced the Regent's Park Aquarium, established a year earlier, to discard aqua-vivarium in favor of aquarium. Many authors (but not the London Zoo itself) claim that the word aquarium originated there, but this clearly is not true.

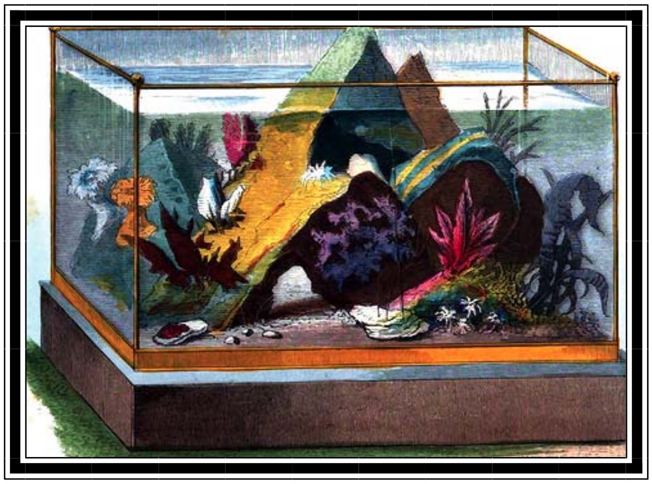
It may seem strange that the origin of the word "aquarium" rests with the gardening community. However, gardeners needed a word that denoted a container for aquatic plants and if the Romans could use "aquarium" for a vessel to supply water to cattle, why not use it for a vessel to supply water to aquatic plants? As Gosse argued (Gosse, 1854a), "The term had already been in use among the botanists, to designate the tanks in which aquatic plants were reared; and the employment of the same term for our tanks is not forbidden by the character of the service to which they are put, since this is not an alteration, but only an extension. The growth of aquatic plants is still a most important and pleasing feature of our pursuit, and the addition of aquatic animals does not at all detract from the appropriateness of the appellation." Gosse had it right.

EPILOGUE

As David Allen writes in his *The Naturalist in Britain, a Social History* (1976),
"Gosse was already well known for his immensely successful book, *The Ocean,* published in 1843. Ten years later he now repeated his success with *A Naturalist's Rambles on the Devonshire Coast*, in which he described the marine aquarium and forecast that it would soon be in mass-production for the parlour. A great rush of books promptly followed - and a general advance on the beaches by a large section of the British middle classes. The aquarium, almost overnight, turned into a national craze. Ladies of fashion, it is credibly recorded, had palatial plate-glass tanks erected in their drawing-rooms; the odd corners of most of the newspapers were filled with notes for the would-be aquarist; a multitude of shops opened for the single purpose of supplying aquaria and their contents."

"Then, at length, the enthusiasms faded. Nine out often aquaria were thrown out or abandoned; many of the shops folded up their shutters; 'to all appearances,' in the words of the Rev. J. G. Wood, 'the aquarium fever had run its course, never again to recur, like hundreds of similar epidemics.'"

An amusing alternate explanation of the hobby's decline comes to us from France (Kete, 1995):
"Although the introduction of tropical fish into fin-de-siécle Europe and American permanently reinvigorated interest in aquarium keeping - the aquarium still has a place in Western culture - its precipitous decline by around 1880 elicited comment. In France, *La Grande Encyclopédie* explained in 1886, medical warnings about pernicious miasmas accounted for this decline. It was '…above all after the doctors had suggested that effluvia released by evaporation could well pro-



duce intermittent fevers" that aquarium keeping fell into disfavor.'"

The saltwater phase of the hobby laid dormant until the years after World War II when it was rescued by technology. The freshwater hobby, however, soldiered on and slowly grew over the next 175 years. I think that any one of the pioneers mentioned in this monograph would be absolutely astounded and amazed by the worldwide aquarium hobby as it exists today.

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