bility by itself, afterwards made by B. Stewart; and so I failed to perceive that a soda flame which emits bright D must *on that very account* absorb light of the same refrangibility.

"When Foucault, whom I met at dinner at Dr. Neil Arnott's, when he came to receive the Copley Medal in 1855, told me of his discovery of the absorption and emission of D by a voltaic arc, I was greatly struck with it. But though I had pictured to my mind the possibility of emitting and absorbing light of the same refrangibility by the mechanism of a system of piano strings tuned to the same pitch, which would, if struck, give out a particular note, or would take it up from the air at the expense of the aërial vibrations, I did not think of the extension of Prevost's theory, afterwards discovered by Stewart, nor perceive that the emission of light of definite refrangibility *necessitated* (and not merely *permitted*) absorption of light of the same refrangibility.

"Reviewing my then thoughts by the light of our present knowledge, I see that my error lay in the erroneous chemical assumption that sodium could not be free in the flame of a spirit-lamp; I failed to perceive the extension of Prevost's theory, which would have come in conflict with that error.—Yours sincerely,

(Signed) "G. G. STOKES

"To Chas. Whitmell, Esq."

"P.S., Dec. 31.—As Sir Wm. Thomson has referred in print to a conversation I had long ago with him on the subject, I take the opportunity of describing my recollection of the matter.

"I mentioned to him the perfect coincidence of bright and dark D, and a part at least of the reasons I had for attributing the latter to the vapour of sodium, using I think the dynamical illustration of the piano strings. I mentioned also, on the authority of Sir David Brewster, another case of coincidence (as was then supposed, though it has since been shown to be only a casual near agreement) of a series of bright lines in an artificial source of light with dark lines in the solar spectrum, from which it appeared to follow that potassium was present in the sun's atmosphere. On hearing this Thomson said something to this effect: 'Oh then, the way to find what substances are present in the sun and stars is to find what substances give bright lines coincident with the dark lines of those bodies.' I thought he was generalising too fast; for though *some* dark lines might thus be accounted for, I was disposed to think that the greater part of the non-terrestrial lines of the solar spectrum were due to the vapours of *compound* bodies existing in the higher and comparatively cool regions of the sun's atmosphere, and having (as we know is the case with peroxide of nitrogen and other coloured gases) the power of selective absorption changing rapidly and apparently capriciously with the refrangibility of the light.

"If (as I take for granted) Sir William Thomson is right as to the date [1852] when he began to introduce the subject into his lectures at Glasgow (Address at the Edinburgh Meeting of the British Association [1871], page xcv.), he must be mistaken as to the time when I talked with him about Foucault's discovery, for I feel sure I did not know it till 1855. Besides, when I heard it from Foucault's mouth, it fell in completely with my previous thoughts.

"I have never attempted to claim for myself any part of Kirchhoff's admirable discovery, and cannot help thinking that some of my friends have been over zealous in my cause. As, however, my name has frequently appeared in print in connection with it, I have been induced to put on paper a statement of the views I entertained and talked about, though without publishing.

"In ascribing to Stewart the discovery of the extension of Prevost's law of exchanges, I do not forget that it was re-discovered by Kirchhoff, who, indeed, was the first to *publish* it in relation to light, though the transition from radiant heat to light is so obvious that it could hardly fail to have been made, as in fact it was made, by Stewart himself (see 'Proceedings of the Royal Society,' vol. x. p. 385). Nor do I forget that it is to Kirchhoff that we owe the admirable application of this extended law to the lines of the solar spectrum."

SCIENCE IN THE ARGENTINE REPUBLIC *

THE fourth part of the Bulletin of the National Academy of Sciences recently founded at Cordova, in the Argentine Republic, completes the first volume of this remarkable work, of which we have previously given some account to our readers.† The present part is mainly occupied by the conclusion of a long article upon the vegetation of the little known province of Tucuman, in the interior of the Republic, by Dr. Hieronymus, commenced in a former number. This is based upon the observations made by the author during a long and extensive scientific journey in that province, and upon the collections amassed by Dr. Lorentz in the same districts in 1871 and 1872, which have been mainly determined by Prof. Grisebach, of Göttingen. A second important article is by Dr. D. A. Döring, and treats of the land and freshwater Molluscs of the Argentine Republic, amongst which are a considerable number of new species, and several interesting novel forms discovered by the author. A third memoir, from the pen of Dr. Burmeister, treats of the abnormal Hymenopterous insects of the Linnean genus *Mutilla*, and forms a complete monograph of the native species of this group, which will be very acceptable to entomologists. By the chronicle appended to the number, we learn that the strife which has prevailed between the Director of the Academy and the six German professors originally imported for its constitution has terminated in the signal defeat of the latter. After the expulsion of about half the number, the remainder resigned, and their places have been filled by other professors from the same country, whom we trust Dr. Burmeister will find more tractable. That they are full of work is evident by the contributions to science already published in the present volume, upon the successful completion of which we heartily congratulate the energetic and illustrious Director of the Academy of Natural Sciences of the Argentine Republic.

SOME UNSOLVED PROBLEMS IN THE MANAGEMENT OF THE MARINE AQUARIUM

IT would be fatal to further progress in that direction in which so much has been achieved during the last ten years, if the zoological conditions of even the most successful of existing marine aquaria were to be blindly accepted as incapable of improvement, and especially if further experiment in reference to the vexed question of aëration were to be barred by the assumption that any one of those rival systems which are typified in the practice of Brighton, Sydenham, or any other similar establishment, is necessarily the best which can be attained.

More discussion than it has yet received is due to the broad question whether the total or almost total exclusion of vegetation from public aquaria is based on necessity or philosophy; whether artificial may not be advantageously supplemented by this most natural and automatic mode of aëration; and the further question remains, to what extent must the conditions of the aquarium be modified, as regards circulation and introduction of air, in order to render practicable the establishment and maintenance of a healthy vegetation, if the propriety of its introduction

* "Boletin de la Academia Nacional de Ciencias exactas existente en la Universidad de Cordova." Entrega iv. (Buenos Ayres, 1875.)

† See NATURE, vol. xi. p. 253.

be once conceded as a result of theoretical considerations?

Before briefly discussing these questions, let us refer for a moment to one or two other minor points which deserve a passing consideration as bearing upon the state of the marine aquarium as a miniature sea, the health of whose inhabitants is ensured in proportion as its actual conditions approach to those of its natural prototype.

It has been suggested that the proportion of carbonic acid held in solution in the water is a matter of more importance than has been recognised, and that the effect of the constant influx of a copious and finely comminuted stream of air passing night and day through the tanks is, after pretty completely oxidising the organic matter with which their contents are charged, to displace the resulting carbonic acid, and so reduce its percentage below the normal amount present in the ocean; and a parallel has been drawn between the condition of the inhabitants under these circumstances and that of human beings breathing an atmosphere containing an abnormal proportion of oxygen.

In confirmation of this opinion, it has been pointed out that one of the prominent results of the *Challenger* researches is that animal life is abundant at the bottom of the sea, while the amount of carbonic acid held in solution in its lowest strata exceeds that of the surface layer by six or seven per cent.

Now, it is certain that, supposing all sources of further or continuous supply of carbonic acid to be excluded, the exposure to the air of any given bulk of water containing the maximum quantity of that gas which it is capable of holding in solution (or any less quantity) will finally result in its total elimination; for Dalton long ago established laws from which it follows that when water saturated with a gas, *e.g.* carbonic acid, is placed in contact with the open air, the whole of such gas is set free, while the water absorbs the constituents of the air.

Hence the small quantity of carbonic acid always present in sea-water is not due to absorption from the air, but to the incessantly renewed supply afforded by the oxidation of organic matter in the sea itself.

If this supply were not constantly maintained, this constituent would vanish from the ocean. Its higher percentage in the lower strata of the sea is doubtless due to three causes: 1, to the comparative stillness of the water, whereby the diffusion of the solution is retarded; 2, to the absence of direct contact with the air and exposure to the wind; 3, and chiefly, to the increased pressure, whereby solution of the gas is greatly facilitated; for under pressure of 1 atmosphere and at ordinary temperatures, 1 cubic centimetre of water dissolves in round numbers 1 cubic centimetre, or 1·529 milligrammes, of carbonic acid, while under double that pressure the absorption is double, and so forth, varying directly as the pressure, *approximately.*

It can hardly be doubted that this presence of a larger proportion of carbonic acid in the lowest depths of the ocean has a distinct correlation to the character of their special inhabitants.

Prof. Wyville Thomson writes: "In the 'warm area,' and wherever the bottom is covered with ooze, calcareous forms predominate, and large sandy cristellarians, with their sand-grains bound together by calcareous cement, so that the sand-grains show out, dark and conspicuous, scattered on the surface of the white shell." And again: "The dredging at 2,435 fathoms at the mouth of the Bay of Biscay gave a very fair idea of the condition of the bottom of the sea over an enormous area. . . . The surface layer was found to consist chiefly of entire shells of Globigerina bulloides, large and small, and fragments of such shells mixed with a quantity of amorphous calcareous matter in fine particles;" and he proceeds to trace how the gradual subsidence of this ooze is forming, under the pressure of superincumbent water, vast geological strata, just as they have been formed for countless ages in the past.

Now, carbonate of lime is much more freely soluble in water containing carbonic acid than in pure water. Hence the abundant supply of this substance in the bed of the ocean is doubtless freely taken up into solution, to be in turn abstracted and secreted by fresh generations of living animals; and thus the carbonic acid forms, as it were, a carrier or circulating medium, if not essential to, at any rate vastly facilitating the ever-alternating processes of life and death, by which the surface of the submarine globe is being constantly and profoundly modified.

But, on the other hand, the animals kept in aquaria are essentially surface-dwellers; the tubicolous Annelids, Actiniadæ, Echinoderms, Crustacea, Nudibranchs, Mollusca, and fishes, which can be successfully kept in confinement all belong to this category, and are captured either between tide-marks or within a few fathoms of the surface. Coral-building Anthozoa perish as the subsidence of the areas in which they dwell plunges them into depths exceeding fifteen or twenty fathoms, a fact which is the basis of Mr. Darwin's simple and elegant theory of the formation of circular reefs and "atolls."

It appears that the amount of carbonic acid present in the tanks of a marine aquarium must represent the balance between the quantity evolved from decaying animal matter, exuviæ, excreta, remnants of food, and the like, and that eliminated from the water by the absorption of air. It has probably never been determined, and its accurate estimation would be a problem both easy and interesting.

But in comparing or contrasting the conditions under which animals live in the confinement of the tanks with those which prevail in the open sea, it must not be forgotten that there is present in an artificial collection of animals an element wholly different from those which exist in the ocean.

In the upper layers of the sea, at any rate, the bulk of water passing over any given animal is tens of thousands of times greater than if the whole contents of the largest aquarium were circulated over it daily. In comparison, the animals are far more sparsely distributed, and dead organisms, together with rejectamenta of all sorts, are swept away by the first tide, and practically got rid of once and for all, so far as their effect on the living individual is concerned.

In the aquarium, animals are disposed in groups artificially brought into comparatively close juxtaposition, and direct oxidation is the only means of removing the various organic impurities of which they are the source.

The observations of the *Challenger* naturalists show that the amount of organic matter in surface and bottom waters is about the same, being about 2½ times as great as in intermediate strata. It corresponds, therefore, to the more abundant distribution of animal life; yet no one can doubt that the percentage of organic matter present in the aquarium vastly exceeds that in the sea, owing to the non-dilution of decomposing animal matter by any such enormous influx of pure water as is supplied by the tides and currents of the ocean.

Hence there is an evident necessity for much more direct aëration in order to prevent the accumulation of organic matter either dissolved or suspended.

Pari passu with aëration, the formation of carbonic acid increases, but as this substance is in turn eliminated by excess of air, experiment alone can determine whether the amount present in the aquarium, as now worked, is greater or less than that contained in either the upper or lower strata of the ocean.

We may, at any rate, safely conclude that it is of the utmost importance to have command at all times of a superabundant *power* of aëration.

The possibility of increasing it to meet the emergency of some sudden temporary pollution arising from the death of some of the inhabitants, the careless introduction of excess of food, or some other casualty coming into the category of possible accidents, may be invaluable. The influx of air can always be regulated, or even stopped, while an insufficient supply might be fatal, at least to the more delicate animals.

Let us now consider briefly the larger question, whether vegetation ought to be admitted at all, and if so, under what limitations and with what precautions.

It is a proposition requiring no proof that the more nearly the actual conditions of nature can be approached in our tanks, the more likely is success to ensue, and the more varied will be both the classes and species of animals which it will be possible to domesticate and maintain in health.

An aquarium without seaweeds does indeed seem a wide departure from this standard, and inasmuch as vegetation fulfils the double function of naturally aërating the water by absorbing carbonic acid and evolving oxygen, and of affording wholesome and palatable food to fishes and molluscs, its introduction would appear highly desirable if not attended with dangers more than sufficient to counterbalance its advantages. On this point my friend Mr. Hughes writes to me as follows in a recent letter:—"I can no more see how fishes and molluscs can do without vegetation than the higher primates without cabbages. I feel certain that the mortality of fishes is due to its absence in public aquaria. In my own tanks I have seen a Blenny tugging at a mere rag of Ulva, black almost with age, for half an hour, to get a mouthful of 'green meat.'

"Our most beautiful family of British fishes, the Wrasses, haunt the banks of Zostera and Fucus; and they do this for more than mere play!"

The lovely tribe of Nudibranchs is practically excluded at present by reason of the absence of their natural food, the one or two species now admitted being animal feeders, and by no means the most beautiful of their class.

Why, then, are not seaweeds seen in the aquaria at Brighton, Sydenham, or Paris?

I believe the answer to be this. For some reason they do not appear spontaneously in the tanks of public aquaria; possibly because the water is deprived of all germs of vegetation by the process of filtration or purification to which it is subjected before use; more probably because, in order to secure purity, it is generally taken from deep water, where such germs are likely to be absent.

Certain it is that in water taken from near shore and not filtered, vegetation very speedily makes its appearance; and it is impossible to suppose that the gentle flow of water in the aquarium could present any obstacle to the development of germs which are not prevented from finding a resting-place and reproducing their species in every rock-pool on shores washed by the tides and lashed by the storms of the open Atlantic.

As vegetation does not spring up spontaneously in the tanks, and as the possibility of doing without it has been practically demonstrated, its introduction has been avoided because the growth of Algæ is so rapid that they are apt to become uncontrollable, to overgrow and hide the animals from view, and at certain seasons by their rapid decay to introduce into the tanks a large amount of decomposing matter of the most objectionable kind—difficult to remove by oxidation, and likely to be fatal to many of their delicate inmates.

It cannot be doubted that the careless or indiscriminate admission of vegetation into the marine aquarium is open to all these objections; but, on the other hand, it seems probable that its careful and judicious introduction would be productive of excellent results to the health of the animals, while there cannot be two opinions as to its adding vastly to the charm of the whole scene. To clothe, or partly to clothe, the bare and monotonous grey and yellow surfaces of rock which now form the regulation background of our tanks with tufts of green and red seaweeds waving their delicate tresses in the gently-flowing water, would add the one thing now wanting to make the aquarium in practice what it is in theory, a miniature reproduction of rock-pools and sea-caves.

Now, the larger part of our British seaweeds are annual, and perish rapidly in autumn and winter, after producing countless zoospores from which a fresh generation of plants is to be born in due time.

These annual Algæ would be dangerous inmates of an aquarium, but in all three sections of the class (Rhodospermeæ, Melanospermeæ, and Chlorospermeæ) there are perennial as well as annual species, and in the first division the plants are usually of a more delicate nature than in the two latter, of slower growth, and therefore more manageable.

We should therefore choose from among the Chlorospermeæ the one or two species which alone are perennial or biennial, such as *Cladophora arcta* and *Codium tomentosum*.

Unfortunately all the other species of Cladophora are annual, as also are those of Enteromorpha and the lovely *Bryopsis plumosa*, which, however, might be tentatively admitted by reason of its small size, slow growth, and singular beauty.

Ulva latissima, *lactusa* and *linza* are also all annual, and should certainly be introduced very sparingly, if at all, and with precautions designed to control and curtail their growth, to which reference will presently be made.

Among the Melanosperms scarcely any would be available. It is among the Rhodosperms that the ornaments of the aquarium might be chiefly sought; and although experience would doubtless prove that some species of this charming group would not flourish in confinement, probably a sufficient number would be found, whose graceful forms and attractive colouring would add immensely to the beauty of the tanks, and which would yet be sufficiently slow in growth to be under the necessary control.

What could exceed in elegance the waving fronds of *Ptilota plumosa* or the plaited tresses of *Plocamium coccineum*?

What more delightful contrast could be imagined than that of the white and pink somewhat rigid tufts of *Corallina officinalis* mingling with the bronze-coloured leaves of *Chondrus crispus*?

What more charming juxtaposition than that of *Gelidium cornutum*, with its purple-black branches, the regularity of whose sub-division almost suggests a metallic crystallisation, with the crimson ribbons of *Delesseria sanguinea*, filmy almost to transparency?

Unfortunately the elegant Ceramiums are all annual, but among such species as *Rhodomela subfusca*, *Polyides rotundus*, *Polysiphonia fastigiata*, *Dasya coccinea*, and a score of others, all perennial and of moderate growth, there is an abundant choice of variety in form, habit, and colour, which would certainly justify the experiment of setting apart one or two tanks in some public aquarium for their trial.

Were such an experiment to be tried, it would be desirable to use every precaution first of all to ensure a clear field by the elimination, as far as possible, of all pre-existing germs of other species than those which it is proposed to cultivate; a precaution, however, the *necessity* of which the appearance of existing aquaria scarcely suggests.

Freshly gathered plants might then be introduced, in all cases attached to pieces of rock or other base, which would make it easy to remove them immediately if they proved unsuitable for the purpose in question.

If a large number of young plants made their appearance on the sides or front of the tank, it would not be a serious matter to run out the contents, scrub the surfaces clean, refill it, and replace the original plants.

By using the perennial species exclusively or mainly, it would be possible to depend solely or essentially upon specimens thus attached, and having these always in reserve, ruthlessly to exterminate any young individuals which might spring up at inconvenient times and places or in superabundant numbers, although it is more probable that our marine friends would in most cases save all trouble upon this point by anticipating the process.

Whoever among the managers of our public institutions will have the enterprise to try this experiment will probably set at rest one of the unsolved problems of aquarian management, and open up a new field of public interest and of scientific research by largely extending the list of animals which it is possible to keep in a state of health in the marine aquarium.

A. W. WILLS

THE NEW OBSERVATORY AT VIENNA

IN the *Monthly Notices* for November is an interesting paper by Dr. De la Rue on the preparations which are being made on the Continent for promoting physico-astronomical observations. The paper refers mainly to the new observatory which is being erected at Vienna, and the illustrations which we are able to give will enable our readers to form some idea of the plan of the building.

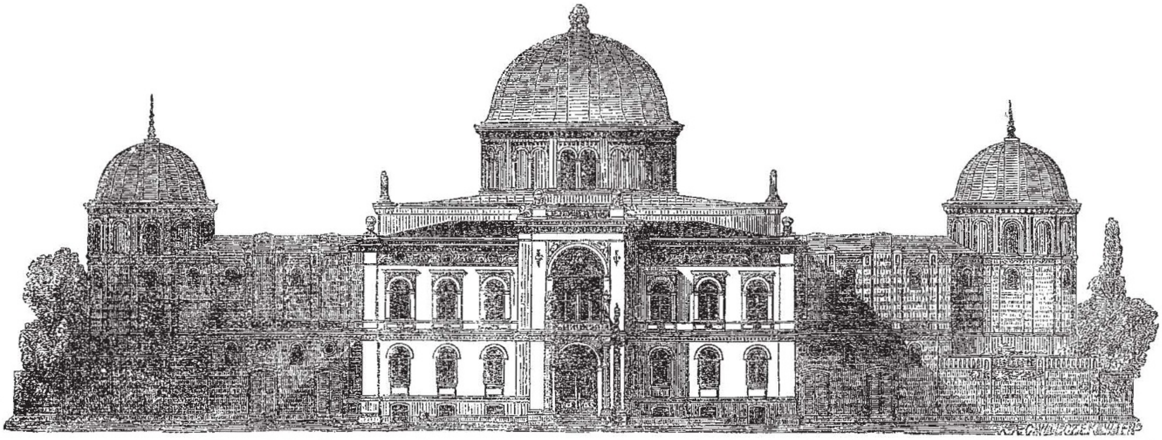

FIG. 1 represents the south front of the observatory, the central entrance opening into the dwelling of the director, which is to the south of the large dome.

"It is scarcely necessary for me to tell the Fellows of the Royal Astronomical Society," Dr. De la Rue says, "that their favourite branch of our science, namely, the physics of astronomy, is now engaging the earnest attention of foreign professional astronomers to a greater extent than obtained only a few years ago, and that grand preparations are now being made at several Continental State-observatories to grapple with the important truths which can only be revealed by adequate instrumental appliances such, indeed, as are far beyond the reach of most private fortunes. It was a matter of satisfaction to me to learn that photographic observatories are to be

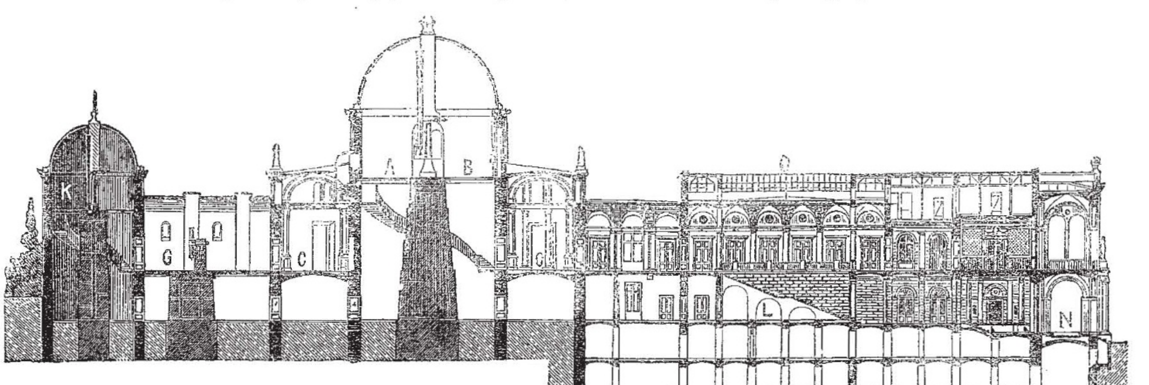

FIG 2, drawn on a smaller scale than Fig. 1, shows the general arrangement of the establishment in plan. A B is the great dome, 42 feet in diameter; this dome is surrounded at its lower portion by the central hall C C, which will contain all the portable instruments. From this central hall access is obtained to the terraces D, adapted for observations with portable instruments or the naked eye. The rooms E and F will receive the meridian instruments, and in G is to be placed the prime vertical. The smaller domes, H, I, and K are each 25 feet in diameter; besides the instruments spoken of in the text, one of these domes will most probably be equipped with an altazimuth or a heliometer.

included in at least two of those observatories, namely, in Paris and Vienna."

Dr. De la Rue refers to the old Vienna Observatory, which was founded in the year 1753, and rebuilt in 1826-27, but has been long so crowded round by other buildings as seriously to interfere with the satisfactory performance of astronomical work. After repeated representations to the Austrian Government, the present Director, M. C. von Littrow, obtained in 1873 the sanction of the Minister of Public Instruction, K. von Stremayer, for the erection of the building which is now approaching completion. The new observatory is about three miles to the north of the centre of the city, and was not commenced before Prof. Weiss, First Assistant at the Obser-