Several points of great interest are touched upon by Prof. Holden, among which is a brief discussion of the dimensions of the smallest object on the moon which can be registered on the photographic plate by the 3-foot refractor. From this we learn that a crater on the moon which is less than one-tenth of a mile in diameter will form an image which is about the same size as the grains of silver in the photographic film, and cannot in general be distinguished. Craters not more than 0·3 and 0·15 English miles in diameter, however, have been detected already. Prof. Holden concludes that for further advances in lunar photography it will be necessary to employ plates of greater sensitiveness so as to shorten exposure, and also plates in which the grain is finer. Workers in all departments of celestial photography have felt the need of such improvements, and, as Prof. Holden remarks, "future improvements depend more upon the manufacturer of plates than upon the astronomer who uses them."

Prof. Weinek's concise descriptions of the lunar formations figured in the volume, and his account of the new features so far discovered, leave nothing to be desired. Observers of the lunar surface may take consolation in the fact that even yet they are not in danger of being entirely superseded by photographic methods, for, as Prof. Weinek points out, "both methods must be perfected, and each must support the other." It is worth remark here, however, that enlargements recently made of lunar photographs taken at the Paris Observatory seem to mark a clear step towards perfection. (See page 207.)

Prof. Keeler's work on the spectra of nebulæ during his connection with the Lick Observatory, may fairly be said to mark the commencement of a new era in the history of the spectroscope as an instrument of precision. The observations were undertaken in the first instance at the suggestion of Dr. Huggins, who appealed to the Lick astronomers in 1890 in connection with the discussion as to the origin of the chief nebular line. It was found possible to use the third and fourth order spectra of a grating spectroscope with advantage, and even then the spectra were "by no means extremely feeble." Former work left the wave-lengths of the nebular lines uncertain to at least two tenth-metres, but the uncertainties now amount to only a small fraction of a tenth-metre. Further, it is claimed that the observations of the nebulæ have shown the existence of errors in Angström's scale and in the wave-lengths of the reference lines, so that the observations did not become consistent until more reliable reference wave-lengths were determined by Prof. Rowland. As an example of the accuracy attainable, the velocity of Venus in the line of sight was found to be 6·4 miles per second at a time when the computed velocity was 7·69 miles.

It is not a part of our present purpose to discuss the origin of the chief line in the spectrum of the nebulæ, but we may say that Prof. Keeler does not favour the suggestion that it is due to magnesium; but, on the other hand, his measures definitely decide against the nitrogen origin of the line.

After all corrections have been applied, the normal positions of the first and second lines in the nebular spectrum are stated to be $5007·05 \pm 0·03$ and $4959·02 \pm 0·04$ respectively, and neither of the lines is represented among the Fraunhofer lines which appear in Rowland's photographic map. Indeed, we are not aware that either of these lines has ever been recorded as an absorption line in the spectrum of any celestial body whatever.

The observations have not been entirely limited to the determination of the position of the chief line. It has been found, for instance, that "the nebulæ are moving in space with velocities of the same order as those of the stars. Of the nebulæ observed, that having the greatest motion of approach, 40·2 miles per second, is G.C. 4373; that having the greatest motion of recession, 30·1 miles per second, is N.G.C. 6790. Most of the nebulæ have considerably smaller velocities than these."

It might well be imagined by anyone who has seen a photograph of the Orion nebula that the different parts would have a relative movement with regard to each other. Such, however, does not appear to be the case, according to Mr. Keeler; or, at least, there is no relative movement greater than four or five miles per second. Attempts to measure the velocity of rotation of the large planetary nebula G.C. 2102 showed that there was no radial motion greater than eight miles per second.

A study of the spectra of the nuclei of the planetary nebulæ has led Prof. Keeler, as it has independently led Prof. Pickering, to the conclusion that they are very closely connected with the bright-line stars, and thus the latest and most precise work goes to confirm one of the fundamental points of Mr. Lockyer's meteoritic hypothesis.

With reference to the discordant accounts of the spectrum of G.C. 826, to which attention was drawn by myself in 1889 (NATURE, vol. xli. p. 163), it is stated that Dr. Huggins's observation of a continuous spectrum in 1864 "was evidently a mistake," the spectrum being of the usual bright-line type.

Apparently in order to reconcile the presence of a continuous spectrum in such a nebula as that of Orion with the idea that masses of rarefied gas were alone in question, it has been suggested that this continuous spectrum may really be a large number of adjacent bright lines. The enormous dispersion employed by Prof. Keeler, however, fails to resolve it into lines, and thus Prof. Tait's suggestion as to the meteoritic constitution of nebulæ still stands as the best explanation of the spectrum.

Many other points of interest are raised by Prof. Keeler's admirable work, but sufficient has been said to indicate the progress which has been made in this branch of celestial physics and chemistry. Although Prof. Keeler has now removed to the Allegheny Observatory, his successor at the Lick Observatory—Prof. Campbell—has already shown himself to be fully capable of maintaining the spectroscopic department of the Observatory at the same high standard of efficiency.

A. FOWLER.

STUDIES OF A GROWING ATOLL.

THE researches of the surveying ships of the British Navy have from time to time rendered services to science no less important than those which it is their function to perform for navigation. It has become an established practice to encourage the surgeons of these vessels to undertake scientific investigations in the leisure which their professional duties frequently afford, and facilities are sometimes given for a competent man to continue such work by allowing his transference to another vessel when his own has to leave the place where he has been working. For this the Admiralty deserves credit and the thanks of those who desire to see her Majesty's ships maintaining the position they took up in the days of Cook, and continued through the voyage of the *Beagle*, and the long line of expeditions which followed it, to the voyage of the *Challenger*. While it may not be too much to hope for a renewal of special marine research by the Royal Navy before private enterprise reaps the waiting scientific harvest of the unknown Antarctic, we feel that too much prominence cannot be given to the good work done incidentally in the course of routine surveys.

The hydrographer, Captain Wharton, in his preface to the reports of Mr. Bassett-Smith on the Macclesfield

Bank,[1] expresses the general result of this piece of research very clearly and concisely, showing that its value is fully recognised by the authorities at the Admiralty.

The Macclesfield Bank is a shallow patch, rising abruptly from deep water in the middle of the China Sea, crossed by the parallel of 16° N. and frequently passed by vessels. It is of an oval shape, about 80 miles long and 30 wide, with a general depth of about 40 fathoms. Reports having been made of very shallow water on the edge of this bank, forming a possible danger to shipping, a complete survey was resolved upon, and as preliminary soundings had shown indications of a raised rim, instructions were given to pay special attention to the animal life upon what might turn out to be an atoll entirely beneath the surface of the sea. Half of the reef was surveyed by Captain Moore in the *Penguin* in 1892, and collections made by means of dredges and divers, under the superintendence of Mr. Bassett-Smith, several tons of specimens being subsequently despatched to the Natural History Museum for full study. The remainder of the bank was examined in 1893 by Captain Field in the *Egeria*, to which ship Mr. Bassett-Smith had exchanged in order to continue his work, and the result is such an investigation into the biological conditions of a submerged coral reef in mid-ocean as has never been made before.

The whole circumference of the bank rises as a ring of coral to within from 9 to 15 fathoms of the surface, being broken here and there by wide gaps of greater depth, but never so deep as the central depression, which varied generally from 40 to 48 fathoms. The minimum depth on the rim was 6½ fathoms, and an isolated shoal rising from the centre of the inner depression reached to within 5 fathoms of the surface.

The uniformity of the depth appears to Captain Wharton to be a strong argument against any movement of the bottom since the period when the atoll form was assumed; and he shows that the simple growth of coral on the rim will in time suffice to produce a perfect ring-shaped coral island without the aid of subsidence or upheaval. It appears, in fact, that here is an atoll in course of formation on a foundation sufficiently near the surface to allow coral to grow. Such a foundation Darwin admitted might allow a coral island to form without subsidence, and the recently discovered abundance of similar elevations in the tropical oceans is one of the main arguments for Murray's general theory of coral growth.

Mr. Bassett-Smith's first day's dredging convinced him that the Macclesfield Bank was by no means a "drowned atoll," but on the contrary that it was very much alive. The basis of the bank appeared certainly to be dead coral-rock, or in many places a calcareous rock composed of the consolidated vegetable organisms which seemed most common between the depths of 20 and 50 fathoms. Upon this ground corals grew in great patches, and other forms of life were very abundant, especially echinoderms, molluscs, crustaceans, and annelids; many very striking cases of mimetic resemblances were observed amongst them. Altogether forty-one genera of corals were dredged, excluding alcyonarian and hydroid corals; twenty-nine genera occurred between 25 and 35 fathoms, and twenty-seven genera in deeper water. It appears that reef-building corals can thrive at depths as great as 50 fathoms in the conditions of the Macclesfield Bank, where the water is very clear and warm. Concerning the genera represented, Mr. Bassett-Smith says:—

[1] "China Sea. Report on the Results of Dredgings obtained on the Macclesfield Bank, in H.M.S. *Rambler*, Commander W. U. Moore, R.N., April 1888, and H.M.S. *Penguin*, Commander W. U. Moore, R.N., April 1892, and H.M.S. *Egeria*, Commander A. M. Field, R.N., April 1893." By P. W. Bassett-Smith, Esq., Surgeon R.N. (London: Printed for Her Majesty's Stationery Office, 1894.)

"The most universally distributed were *Seriatopora*, *Pavonia* (especially a variety of forms very nearly allied to *Mycedium elegans* of Milne Edwards), *Leptoseris Montipora*, and *Stylophora Güntheri*, at all depths, but the sections 'Madreporaria Fungida' and 'Perforata' are undoubtedly most frequently met with in depths over 20 fathoms, and continued down to between 40 and 50 fathoms; the corallum being almost always light and delicate. *Agavicia*, *Phyllastræa*, *Pachyseris*, *Turbinaria*, and *Leptoseris*, in cups of varying size, from two inches to twenty inches across; *Oxypora*, *Pavonia*, *Hydrophora*, *Scaphophyllia*, and *Montipora*, in leaf-like expansions; *Cyphastræa*, *Galaxea*, *Turbinaria* and *Montipora*, in encrusting growths; or in branching forms, as *Seriatopora*, *Mussa*, *Madrepora*, *Psammocora*, *Napopora*, *Anacropora*, *Alveopora*, and *Rhodaræa;* the most massive forms found in deep water being *Pocillopora*, *Stylophora* and *Mussa*. On the sandy bottom of the lagoon, and near the rim, the corals that seemed to thrive best were small branching forms of *Psammocora*, and *Anacropora;* delicate frond-bearing clumps of *Pavonia; Leptoseris* cups, thick but light spreading branches of *Alveopora*, *Montipora;* and many simple corals as *Cycloseris*, *Fungia*, &c. Small fragments of more massive *Astræa* were brought up three times from deep water, twice from 30 to 40 fathoms, and once from 40 to 50 fathoms."

There was a strong current over the rim, even in calm weather, and the surface water, the temperature of which was sometimes as high as 88° F., swarmed with Plankton.

In addition to the chart of the bank showing its unmistakable atoll form, the blue-book contains two sections of the outer slope on a natural scale. The angles varied somewhat on different sides. On the north the slope was gradual, the 100-fathom line being one mile distant from the 20-fathom line, while 200 fathoms was only found ten miles farther out, beyond which the slope became more rapid to 1100 fathoms six miles beyond. On the east there was a much steeper slope, the 100-fathom soundings being found half a mile from the 20-fathom and 300 at the distance of a mile, while fifteen miles away the depth was 2100 fathoms. The wall-like spring of the bank from the ocean floor is still more striking on the south, where depths of 150 fathoms occur half a mile from the edge of the bank, 300 fathoms at the distance of one mile, and the oceanic depth of 1100 fathoms, only 3½ miles away, giving the remarkably high average slope of 1 in 3. The shoal at the north end of the future island is attributed to the strong current from the south-west sweeping the débris over the edge of the oceanic hill into the deep beyond.

The observations fully confirm Dr. Murray's preference for the term "organic" rather than "coral" as applied to the origin of atolls, for a very large part of the growing rock was shown to be due to calcareous algæ, to corals other than reef builders, and to the accumulation of the calcareous remains of crustacea, mollusca and annelids. Mr. Bassett-Smith suggests that the crust of algæ prevents the dissolved carbonic acid of the sea-water from touching the dead coral rock below, while the action of the growing algæ might decompose the carbonic anhydride. This we are inclined to doubt, as the decaying organisms would seem likely to produce far more carbonic acid than could be disposed of by the very feeble daylight which reaches depths approaching 40 fathoms; and from the continual dredging of "rotten rock" in the central depression, we feel inclined to think that active life and rock-growth are taking place there only in restricted patches. The observations seem to leave no doubt that the atoll is growing towards maturity and the air, not declining from a past existence as an island.

HUGH ROBERT MILL.