BEQUEST.

"No being into naught can fall,
The eternal liveth in them all;
In being, therefore, be thou blessed,
Being is eternal, for fixed measures
Preserve its ever-living treasures,
In which the world is nobly dressed.

"The Truth of yore has been decried,
And noble spirits has allied.
To dear old Truth we must adhere!
'Tis to the Wise One Truth we owe:
To Him who did their orbits show
To earth and to her brother-sphere.

"First, friend, within thyself thou enter,
For 'tis within that lies the center;
No noble thinker will gainsay.
No rule there's missing. So rejoice,
That conscience' independent voice
Serves duty as its solar ray.

"We on our senses must rely,
And if our reason we apply,
Sensation never error yields;
With open eyes do all observing,
And roam with confidence unswerving
Through this world's rich and wondrous fields.

"Temper your joys with moderation,
With reason keep in consultation,
When life is beaming with life's glee.
The past will thus become enduring,
E'en now the future life-securing;
The moment gains eternity.

"Born, as of old, of patient love,
Whenever may the spirit move,
Are bard's and thinker's great creations;
With highest favors they are fraught.
Forefeel of noble souls the thought;
'Tis the most enviable of vocations."

THE DISCOVERY OF NEPTUNE.

The appearance of a new edition of Miss Clerke's well-known *Popular History of Astronomy*[1] affords us a welcome opportunity of calling to the attention

[1] Fourth Edition, Revised and Corrected. New York: The Macmillan Co.; London: Adam and Charles Black. 1902. Pp., 489. Cloth, $4.00.

of our readers a work of sterling merit in perhaps the most delightful province of natural inquiry. The story of the heavens is of entrancing interest, and in the present case it has been told with an authority and self-restraint that the natural flights of fancy and pietism in which writers on these topics are tempted to indulge have only in rare instances transcended. Miss Clerke, it may be mentioned in passing, is the author of astronomical articles in the *Encyclopædia Britannica* as well as of independent works on the history of astronomy. We quote below from her *Popular History*, as a specimen of the reading Miss Clerke offers, the story of the discovery of Neptune,—one of the greatest achievements in the annals of astronomical science. The English side of the discovery naturally receives here strong emphasis.

THE STORY OF NEPTUNE.

"We have now to recount an event unique in scientific history. The discovery of Neptune has been characterised as the result of a 'movement of the age,' and with some justice. It had become necessary to the integrity of planetary theory. Until it was accomplished, the phantom of an unexplained anomaly in the orderly movements of the solar system must have continued to haunt astronomical consciousness. Moreover, it was prepared by many, suggested as possible by not a few, and actually achieved, simultaneously, independently, and completely, by two investigators.

"The position of the planet Uranus was recorded as that of a fixed star no less than twenty times between 1690 and the epoch of its final detection by Herschel. But these early observations, far from affording the expected facilities for the calculation of its orbit, proved a source of grievous perplexity. The utmost ingenuity of geometers failed to combine them satisfactorily with the later Uranian places, and it became evident, either that they were widely erroneous, or that the revolving body was wandering from its ancient track. The simplest course was to reject them altogether, and this was done in the new Tables published in 1821 by Alexis Bouvard, the indefatigable computating partner of Laplace. But the trouble was not thus to be got rid of. After a few years fresh irregularities began to appear, and continued to increase until absolutely 'intolerable.' It may be stated as illustrative of the perfection to which astronomy had been brought, that divergencies regarded as menacing the very foundation of its theories never entered the range of unaided vision. In other words, if the theoretical and the real Uranus had been placed side by side in the sky, they would have seemed, to the sharpest eye, to form a single body.

"The idea that these enigmatical disturbances were due to the attraction of an unknown exterior body was a tolerably obvious one; and we accordingly find it suggested in many different quarters. Bouvard himself was perhaps the first to conceive it. He kept the possibility continually in view, and bequeathed to his nephew's diligence the inquiry into its reality when he felt that his own span was drawing to a close; but before any progress had been made with it, he had already (June 7, 1843) 'ceased to breathe and to calculate.' The Rev. T. J. Hussey actually entertained in 1834 the notion, but found his powers inadequate to the task, of assigning an approximate place to the disturbing body; and Bessel, in 1840, laid his plains for an assault in form upon the Uranian difficulty, the triumphant exit from which fatal illness frustrated his hopes of effecting or even witnessing.

"The problem was practically untouched when, in 1841, an undergraduate of St. John's College, Cambridge, formed the resolution of grappling with it. The

projected task was an arduous one. There were no guiding precedents for its conduct. Analytical obstacles had to be encountered so formidable as to appear invincible even to such a mathematician as Airy. John Couch Adams, however, had no sooner taken his degree, which he did as senior wrangler in January, 1843, than he set resolutely to work, and on October 21, 1845, was able to communicate to the Astronomer Royal numerical estimates of the elements and mass of the unknown planet, together with an indication of its actual place in the heavens. These results, it has been well said, gave 'the final and inexorable proof' of the validity of Newton's Law. The date Ocober 21, 1845, 'may therefore be regarded as marking a distinct epoch in the history of gravitational astronomy.'

"Sir George Biddell Airy had begun in 1835 his long and energetic administration of the Royal Observatory, and was already in possession of data vitally important to the momentous inquiry then on foot. At his suggestion, and under his superintendence, the reduction of all the planetary observations made at Greenwich from 1750 onwards had been undertaken in 1833. The results, pnblished in 1846, constituted a permanent and universal stock of materials for the correction of planetary theory. But in the meantime, investigators, both native and foreign, were freely supplied with the 'places and errors,' which, clearly exhibiting the discrepancies between observation and calculation—between what *was* and what was *expected*—formed the very groundwork of future improvements.

"Mr. Adams had no reason to complain of official discourtesy. His labors received due and indispensable aid; but their purpose was regarded as chimerical. 'I have always,' Sir George Airy wrote, 'considered the correctness of a distant mathematical result to be a subject rather of moral than of mathematical evidence.' And that actually before him seemed, from its very novelty, to incur a suspicion of unlikelihood. No problem in planetary disturbance had heretofore been attacked, so to speak, from the rear. The inverse method was untried, and might well be deemed impracticable. For the difficulty of determining the perturbations produced by a given planet is small compared with the difficulty of finding a planet by its resulting perturbations. Laplace might have quailed before it; yet it was now grappled with as a first essay in celestial dynamics. Moreover, Adams unaccountably neglected to answer until too late a question regarded by Airy in the light of an *experimentum crucis* as to the soundness of the new theory. Nor did he himself take any steps to obtain a publicity which he was more anxious to merit than to secure. The investigation consequently remained buried in obscurity. It is now known that had a search been instituted in the autumn of 1845 for the remote body whose existence had been so marvellously foretold, it would have been found within *three and a half lunar diameters* (1° 49′) of the spot assigned to it by Adams.

"A competitor, however, equally daring and more fortunate—*audax fortunâ adjutus*, as Gauss said of him—was even then entering the field. Urbain Jean Joseph Leverrier, the son of a small Government employé in Normandy, was born at Saint-Lô, March 11, 1811. He studied with brilliant success at the École Polytechnique, accepted the post of astronomical teacher there in 1837, and, 'docile to circumstance,' immediately concentrated the whole of his vast, though as yet undeveloped powers upon the formidable problems of celestial mechanics. He lost no time in proving to the mathematical world that the race of giants was not extinct. Two papers on the stability of the solar system, presented to the Academy of Sciences, September 16 and October 14, 1839, showed him to be the worthy successor of Lagrange and Laplace, and encouraged hopes destined to be abun-

dantly realised. His attention was directed by Arago to the Uranian difficulty in 1845, when he cheerfully put aside certain intricate cometary researches upon which he happened to be engaged, in order to obey with dutiful promptitude the summons of the astronomical chief of France. In his first memoir on the subject (communicated to the Academy, November 10, 1845), he proved the inadequacy of all known causes of disturbance to account for the vagaries of Uranus; in a second (June 1, 1848), he demonstrated that only an exterior body, occupying at a certain date a determinate position in the zodiac, could produce the observed effects; in a third (August 31, 1846), he assigned the orbit of the disturbing body, and announced its visibility as an object with a sensible disc about as bright as a star of the eighth magnitude.

"The question was now visibly approaching an issue. On September 10, Sir John Herschel declared to the British Association respecting the hypothetical new planet: 'We see it as Columbus saw America from the coast of Spain. Its movements have been felt, trembling along the far-reaching line of our analysis with a certainty hardly inferior to that of ocular demonstration.' Less than a fortnight later, September 23, Professor Galle, of the Berlin Observatory, received a letter from Leverrier requesting his aid in the telescopic part of the inquiry already analytically completed. He directed his refractor to the heavens that same night, and perceived, within less than a degree of the spot indicated, an object with a measurable disc, nearly three seconds in diameter. Its absence from Bremiker's recently-completed map of that region of the sky showed it to be no star, and its movement in the predicted direction confirmed without delay the strong persuasion of its planetary nature.

"In this remarkable manner the existence of the remote member of our system known as 'Neptune' was ascertained. But the discovery, which faithfully reflected the duplicate character of the investigation which led to it, had been already secured at Cambridge before it was announced from Berlin. Sir George Airy's incredulity vanished in the face of the striking coincidence between the position assigned by Leverrier to the unknown planet in June, and that laid down by Adams in the previous October; and on the 9th of July he wrote to Professor Challis, director of the Cambridge Observatory, recommending a search with the great Northumberland equatoreal. Had a good star-map been at hand, the process would have been a simple one; but of Bremiker's 'Hora XXI.' no news had yet reached England, and there was no other sufficiently comprehensive to be available for an inquiry which, in the absence of such aid, promised to be both long and laborious. As the event proved, it might have been neither. 'After four days of observing,' Challis wrote, October 12, 1846, to Airy, 'the planet was in my grasp if only I had examined or mapped the observations.' Had he done so, the first honors in the discovery, both theoretical and optical, would have fallen to the University of Cambridge. But Professor Challis had other astronomical avocations to attend to, and, moreover, his faith in the precision of the indications furnished to him was, by his own confession, a very feeble one. For both reasons he postponed to a later stage of the proceedings the discussion and comparison of the data nightly furnished to him by his telescope, and thus allowed to lie, as it were, latent in his observations the momentous result which his diligence had insured, but which his delay suffered to be anticipated.

"Nevertheless, it should not be forgotten that the Berlin astronomer had two circumstances in his favor apart from which his swift success could hardly have been achieved. The first was the possession of a good star-map; the second was

the clear and confident nature of Leverrier's instructions. 'Look where I tell you,' he seemed authoritatively to say, 'and you will see an object such as I describe.' And in fact, not only Galle on the 23d of September, but also Challis on the 29th, immediately after reading the French geometer's lucid and impressive treatise, picked out from among the stellar points strewing the zodiac, a small planetary disc, which eventually proved to be that of the precise body he had been in search of during two months.

"The controversy that ensued had its ignominious side; but it was entered into by neither of the parties principally concerned. Adams bore the disappointment, which the dilatory proceedings at Greenwich and Cambridge had inflicted upon him, with quiet heroism. His silence on the subject of what another man would have called his wrongs remained unbroken to the end of his life; and he took every opportunity of testifying his admiration for the genius of Leverrier.

"Personal questions, however, vanish in the magnitude of the event they relate to. By it the last lingering doubts as to the absolute exactness of the Newtonian Law were dissipated. Recondite analytical methods received a confirmation brilliant and intelligible even to the minds of the vulgar, and emerged from the patient solitude of the study to enjoy an hour of clamorous triumph. For ever invisible to the unaided eye of man, a sister-globe to our earth was shown to circulate, in perpetual frozen exile, at thirty times its distance from the sun. Nay, the possibility was made apparent that the limits of our system were not even thus reached, but that yet profounder abysses of space might shelter obedient, though little favored, members of the solar family, by future astronomers to be recognised through the sympathetic thrillings of Neptune, even as Neptune himself was recognised through the tell-tale deviations of Uranus.

"It is curious to find that the fruit of Adams's and Leverrier's laborious investigations had been accidentally all but snatched half a century before it was ripe to be gathered. On the 8th, and again on the 10th of May, 1795, Lalande noted the position of Neptune as that of a fixed star, but perceiving that the two observations did not agree, he suppressed the first as erroneous, and pursued the inquiry no further. An immortality which he would have been the last to despise hung in the balance; the feather-weight of his carelessness, however, kicked the beam, and the discovery was reserved to be more hardly won by later comers." μ.

BOOK REVIEWS.

THE CHILDREN OF THE NATIONS; A Study of Colonisation and Its Problems. By *Poultney Bigelow*, M. A., F. R. G. S. New York: McClure, Philips & Co. 1901. Pages, xiii, 365.

Poultney Bigelow, well-known as the author of a book on *The German Emperor and His Neighbors*, a man of broad education acquired both at home (viz., at Harvard) and abroad in France and Germany, has published an instructive book under the title: *The Children of the Nations*. The book discusses in thirty-five chapters the several methods of colonisation among the different civilised peoples. First the Spanish colonies and their final doom in South America, Cuba, the Philippines, etc. (Chapters I–VII). Here follows (Chapter VIII) a discussion of the Negro as an element in colonial expansion both in America and South Africa. Then the author descants on official German civilisation in Kiao Chow and East Africa (Chapter IX), which ought to be very instructive to the German Emperor,