its danger-zone and be broken up in turn, just as the sun had previously been broken up by entering the danger-zone of the other star; the plane of their motion would be that containing the orbit of the planet round the sun. In this way we get a conjectural explanation of the satellite systems of the planets, of their general resemblance to the main system, and of the fact that their orbital planes lie mainly in the plane of the solar system.

In time the planets would cool, then liquefy, and then solidify; the largest would remain gaseous for longest. Now a theoretical investigation of the question shows that planets which remained gaseous until after the birth of their satellites would be likely to give birth to a large number of small satellites, whereas planets which had already liquefied or solidified would be likely to give birth to a smaller number of large satellites—or possibly to no satellites at all. This at once explains a further regularity in the arrangement of the solar system. The planets which have the greatest number of satellites are the two big central planets, Jupiter and Saturn. These have nine satellites each, and all are very small in comparison with the planets round which they revolve. Like the main solar system, the satellite systems of Jupiter and Saturn show the characteristics to be expected in systems born out of a gaseous body. As we proceed away from these giant planets in either direction we come to planets whose satellites are fewer in number, but larger in size relative to the sizes of their primaries—the characteristics to be expected in systems born out of a liquid, or liquefying, body. This is at once explained if we suppose that the great size of Jupiter and Saturn caused them to remain gaseous for a long time, while the smaller planets such as Mercury and Venus liquefied or solidified almost at once. The cases of transition appear to be provided by our own earth in the one direction and by Neptune in the other; each of these planets possesses a single satellite which is abnormally large in comparison with the size of its primary.

We can perhaps find confirmation of this in the fact that Mars and Uranus, the two planets which come next to these as we pass inwards towards Jupiter, are both abnormally small; we might have expected Mars to be intermediate in size between the earth and Jupiter, and Uranus to be intermediate in size between Neptune and Saturn. Now if we suppose that these two planets were the smallest of all the planets which retained their gaseous condition for long, they would suffer more than the others from the continued dissipation of their atmospheric layers into space. On this view Mars and Uranus must be regarded as mere relics of far larger masses, and we see at once why they are abnormally small for their positions in the planetary sequence.

There are so many conjectural elements in this theory that it would be rash to claim, or even to hope, that it can in any way prove final. The highest claim I would make for it is that it accounts for many of the observed facts, and has not yet been found to suffer from insuperable objections—and this can be said of few, if any, other hypotheses as to the origin of the solar system.

If we accept it we must accept also the consequences I stated at the outset. Stars are very rare objects in space, and so are spaced very far apart, so far apart that it is very hard to imagine the sparseness of stars in space. If we take three particles of dust and place them in a large cathedral, this would be incomparably more crowded with dust than space is with stars. As a consequence stars approach one another very rarely, and it is an almost inconceivably rare event for two stars to come so close that planets are born. Planets, and so presumably life also, must be exceedingly rare in the universe.

We can regard this with satisfaction or the reverse, as we choose. Some will feel overwhelmed with a great loneliness; they will feel that it adds to the terror which overcame Pascal when he contemplated the immense voids of space. Others will view it with satisfaction, because it adds to the relative importance of human and terrestrial life. When we thought of each star as the centre of a system which teemed with life, human life appeared as a very small thing; it formed an inconceivably small fraction of the total life of the universe. The new view compels us to think of life on earth as forming a comparatively large fraction of all life of the universe.

George Graham, F.R.S., 1673–1751.

On Nov. 24, 1751, at night, a funeral procession left a shop bearing the sign of the Dial and One Crown, in Fleet Street, for Westminster Abbey. The hearse was preceded by three coaches containing the pall-bearers Dr. Knight, Mr. Watson, Mr. Canton, Mr. Short, Mr. Catlyn, and Mr. Bird, and was followed by nine other coaches. Thus was borne to his last resting-place George Graham, widely known both at home and abroad as the finest mechanician of his day. Arrived at the Abbey, the coffin was carried into the nave and was then laid beside that of Thomas Tompion, who had died in 1713, recognised as "the father of English watchmaking". The grave is not far from that of Newton. It is covered by a stone with an inscription, a part of which refers to Graham, "whose curious inventions do honor to ye British genius whose accurate performances are ye standard of mechanical skill". In the middle of the eighteenth century burials in the Abbey were more frequent than they are to-day, and it was a fortunate decision which led to the interment within its walls of these two famous masters of horology.

Graham, who was a Quaker both by upbringing and by conviction, was cast in much the same mould as that other Quaker and man of science of a later day, John Dalton. Born in Cumberland in 1673, at the age of fifteen he came on foot to London and there began an apprenticeship of seven years with Henry Aske, a clockmaker. His apprenticeship ended, he entered the employ of Tompion, afterwards marrying his niece and succeeding to his business at the Dial and Three Crowns, Fleet Street. In 1720 Graham moved across the street to the Dial and One Crown to a shop which was destined to become famous, and it was there he died, Nov. 20, 1751. The friend of Newton, Halley, Molyneux, Hadley, Bradley, and many others, Graham lived for the advancement of science and the benefit of mankind, and though his business brought him ample means, so little account did he take of wealth that on principle he refused to accept interest on loans and never invested in Government securities. To his more intimate contemporaries he was known as honest George Graham.

Of the life of such a man we cannot know too much, and both horologists and astronomers will read with interest the pamphlet issued by the *Vassar Journal of Undergraduate Studies*, giving Miss C. D. Hellman's sketch of George Graham, maker of horological and astronomical instruments. Miss Hellman has taken the trouble to consult most of the original works which give information of Graham's scientific inventions and observations and her account is the fullest we have hitherto seen. Graham's position among his fellows can be judged from the facts that in 1720, when he took up his residence at the Dial and One Crown, he was elected a fellow of the Royal Society, and that two years later he was made Master of the Clockmakers' Company. He had already invented the 'dead beat' form of the anchor escapement for clocks and watches, and in 1721 had brought out his mercurial pendulum, an improvement which became of great importance.

With these inventions to his credit, Graham then proceeded to add to his reputation by observations on the magnetic needle, during which he discovered the diurnal variation and measured the magnetic intensity. In 1725 he made his well-known 8 ft. quadrant for Greenwich Observatory and at the same time constructed sectors for both Molyneux and Bradley. Much of Bradley's work at Kew was done with his assistance. Other instruments he made were those supplied to the French Academicians who in 1736 visited Lapland to measure an arc of the meridian. At his house in Fleet Street he observed comets, solar and lunar eclipses, sometimes by himself, sometimes with a fellow-observer. He also served on a committee connected with Greenwich Observatory, and carried out work in connexion with the standards of measurements. On all these matters Miss Hellman gives an account, and her pamphlet contains extracts from Graham's paper published in the *Philosophical Transactions*. Without an equal in his own line, Graham lived to see the rise of Mudge, Harrison, Dollond, Bird, Short, and others, in whose hands scientific instrument making reached a pitch of excellence surpassing even that of Graham. Most of these, however, owed something to Graham, and Bradley once wrote: "If my own Endeavours have, in any respect, been effectual to the advancement of astronomy, it has principally been owing to the advice and assistance given me by our worthy member, Mr. George Graham, whose great skill and judgment in mechanics, joined with a complete and practical knowledge of the uses of astronomical instruments, enable him to contrive and execute them in the most perfect manner". "No greater tribute than this", says Miss Hellman, "could be paid to George Graham."

Obituary.

DR. RICHARD WETTSTEIN.

THE death on Aug. 10, at the age of sixty-eight years, of Dr. Richard Wettstein, Ritter von Westersheim, Hofrat, professor of systematic botany and director of the Botanic Garden and Institute of the University of Vienna, removes a notable figure from the botanical world. His commanding presence, courteous demeanour, and powers of oratory give credence to the statement by the correspondent of the *Times* that on more than one occasion he was seriously considered as a possible president of the Republic.

Among botanists, Wettstein was known as a careful and painstaking investigator, a capable teacher, and an efficient organiser. He studied at Vienna under Anton Kerner von Marilaun, author of the well-known volumes on the natural history of plants, and, after a short period as a *privatdocent*, went in 1892 to Prague, where he followed Heinrich Willkomm as professor of botany in the German University. Seven years later he returned to Vienna to succeed Kerner, whose daughter he had married, as University professor and director of the Gardens. Shortly after his return, a commodious botanical institute was erected to replace the historic but meagre old buildings at the Gardens, and here Wettstein played the part of host to the delegates who met to formulate the Rules of Botanical Nomenclature at the International Botanical Congress in 1905, of which he and Prof. Julius Wiesner were joint presidents. More recently, as senior president of the International Horticultural Congress, in September 1927, Wettstein again welcomed botanists and horticulturists from all parts of the world at the University.

In 1889, while still *privatdocent* at Vienna, Wettstein succeeded Alexander Skofitz as editor of the *Oesterreiche Botanische Zeitung*, which he continued to edit, with some assistance in later years, until his death. The volumes of this journal contain numerous contributions from him relating to the Austrian flora, of which he was a careful student, to systematic botany, and to nomenclature. The journal took a leading part in preparation for the discussions on nomenclature at the Congress in 1905. In 1901, Wettstein led a botanical expedition to South Brazil under the auspices of the Austrian Academy of Sciences, the results