Formula for the Perimeter of an Ellipse.

WILL one of your mathematical readers kindly state whether the following empirical formula gives a nearer approximation to the perimeter of an ellipse than that usually given in pocket-books of formulæ?

x and y stand for axes.

$$\text{Perimeter} = \pi \left\{ \frac{x^{\frac{\log 2}{\log \pi - \log 2}} + y^{\frac{\log 2}{\log \pi - \log 2}}}{2} \right\}^{\frac{\log \pi - \log 2}{\log 2}}$$

Molesworth's book gives the following:—

T = semi-major axis; C = semi-minor axis.

$$\text{Perimeter} = \tfrac{1}{2}\pi[\sqrt{2(T^2 + C^2)} + T + C] + 0{\cdot}2078(T - C).$$

State School, Beaudesert, H. TOMKYS.
Nr. Brisbane, Queensland, Australia, February 26.

Sounds Associated with Low Temperatures.

THERE is one place where the sounds mentioned by Mr. Cave (p. 512) can be (or used to be) heard to perfection. This is at the lower end of Beaumont Street, Oxford, where the road widens out in approaching Worcester College. The pavement and the fence adjoining it take a crescent form, and while walking on the former quite a loud metallic musical note may always be heard. The fence consists, or consisted, of boards, in front of which are iron palings, the uprights of which had a square section. SPENCER PICKERING.
Woolacombe.

Sun Pillars.

THIS evening a sun-pillar was again visible at Swindon, not so brilliant or long-lived as that which recently attracted such widespread attention, but nevertheless quite definite. I first observed it about 6.15 p.m., when the sun was a few degrees above the horizon. It was of a clear yellow colour, and extended from the dull-red sun vertically upwards. The sun set behind a bank of murky haze, and shortly after—about 6.45—the pillar had faded from view. H. B. KNOWLES.
Swindon, April 7.

LUMINOUS BACTERIA.

LUMINOUS bacteria constitute a group of organisms which under certain conditions have the power of emitting light. They occur principally, if not entirely, in sea-water. It is, however, doubtful whether they give rise to any general luminosity of the sea, such as is caused by noctiluca and other relatively high forms of marine life, although it is possible that in the tropics, where the amount of non-living nutritive material is present in sufficient quantities, that bacteria do occasionally cause a general luminosity; but the opportunities of verifying this are rare. One organism in particular, the *Photobacterium Indicum*, from its forming a surface pellicle in artificial fluid cultures, which is very luminous, may at times cause luminosity of sea-water at the surface. It is remarkable that an unicellular organism such as a bacterium should have the power of emitting light. There is no evidence of any special structure in the cell itself, and in the present state of our knowledge it is difficult to regard it as other than a result of functional activity, exactly as heat is evolved by other forms of life, as an accompaniment of the metabolism of the cell. What is, however, the exact difference between the evolution of heat by some organisms and that of light by others it is at present impossible to say. Oxygen is absorbed in both instances and carbon dioxide evolved, but there is evidently some other factor of which at present we know nothing. The fact that light and heat are manifestations of the same form of energy may apparently simplify the matter; but further consideration shows that there is a different problem to be solved in each.

We are not acquainted with any artificial method of light production, in which chemical action takes place, where light is evolved except through the medium of heat, yet in nature, by a simple cell, light is produced which is apparently unaccompanied by any invisible radiations whatever.

These organisms are sometimes referred to as "phosphorescent," but the term is hardly a suitable one, as the phenomenon is likely to be regarded as analogous to the emission of light by inert chemicals and minerals, or to the continued glow of vacuum tubes after an electrical

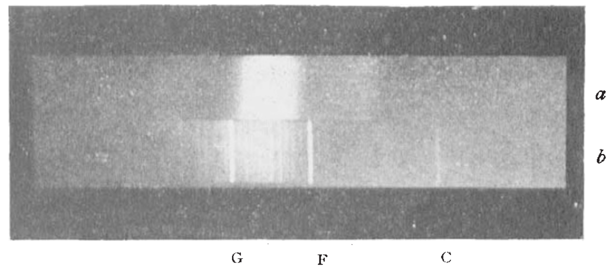

FIG. 1.—(*a*) Spectrum of luminous bacteria. (*b*) Spectrum of hydrogen for comparison.

current of high potential has been passed through them. In all marine light-producing animals, the light is not emitted continuously, but is given out at intervals in response to some stimulus or irritation. It is possible that bacteria act in the same way, but it is difficult to determine this point, as the individual organism is not sufficiently luminous to enable the observer to study it under the microscope by its own light. In fluid cultures they apparently respond to any agitation or excitation so

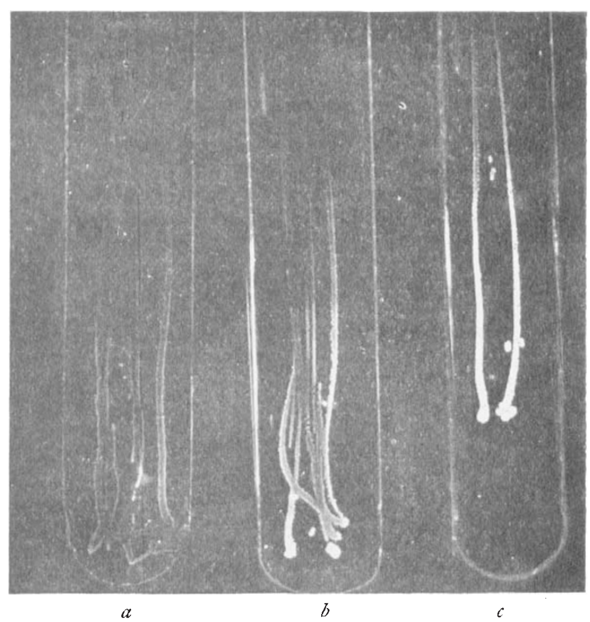

FIG. 2.—Cultures of different ages. (*a*) seven weeks; (*b*) three weeks; (*c*) young culture.

long as the supply of oxygen is maintained, but they can be kept in a luminous condition on fluid media if oxygen is continuously supplied in other ways, although they may remain at rest. This can be done, for instance, by allowing the wool plug, used to close the orifice of the glass vessel containing a fluid culture, to become saturated with the culture, when the plug will continue to glow for days, although the culture in the vessel may only become luminous when agitated. This points to the agitation only resulting in the introduction of fresh oxygen and not as being a direct exciting cause.

The number of species isolated up to the present is about twenty-five, but it is more than probable that some of these are identical, or at any rate closely related.

In artificial cultivations, these organisms grow best on a medium containing a considerable percentage of a soluble chloride in addition to the nutritive material. They will grow on an ordinary peptone-beef-broth gelatine medium, but they do not all emit light, and none of them emit the maximum amount they are capable of producing. The best results are to be obtained by adding to the culture medium 2·6 per cent. of sodic chloride, ·075 per cent. of magnesia chloride, and ·3 per cent. of potassic chloride.

Either of the chlorides which occur in sea-water, if added to a nutritive medium in suitable proportions, will cause some luminosity, but the results are not so good as on the medium mentioned.

In the case of fluid nutrient media, some means must be taken to replenish the oxygen, as the amount held in solution is speedily exhausted. Either free oxygen can

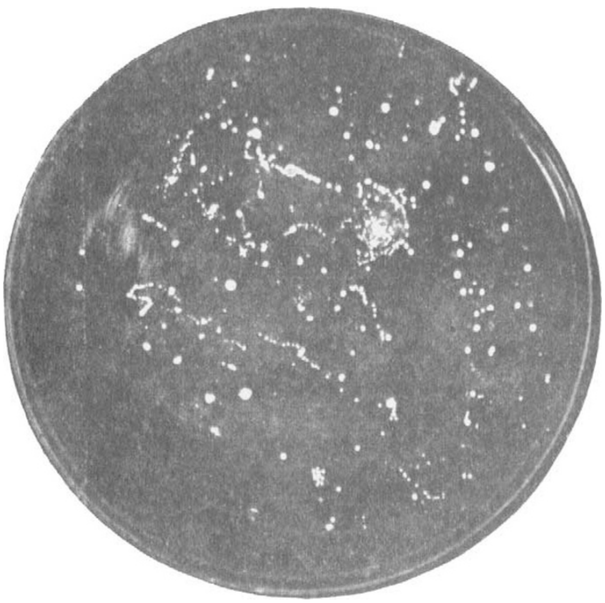

Fig. 3.—Plate culture of luminous bacteria.

be allowed to bubble through the medium, in which case very brilliant cultures can be obtained, or frequent agitation can be resorted to.

The temperature at which these organisms grow is variable. Those found in northern latitudes can grow and remain luminous at 0° C., the optimum temperature being about 15°, at which reproduction is very rapid and luminosity at its maximum. Some organisms found in the tropics grow, however, at a much higher temperature, but none of them have an optimum as high as blood-heat, 37° C. Spectroscopically, the light emitted by these organisms is confined to a small portion of the visible spectrum, never extending into the ultra-violet or infra-red. Visually it only includes the green and blue, and photographically it extends very slightly further towards the violet.

Fig. 1 shows a photograph of the spectrum of this organism (*a*), with the spectrum of hydrogen beneath for reference (*b*). It will be seen that the former is continuous, and the brightest portion lies between the lines F and G. There is some extension towards the D line, but it is not well marked, and it is only with very long exposure that this becomes evident. This result has been confirmed by using a spectroscope with a quartz system, but owing to its low dispersion, the photograph here shown was regarded as more suitable for purposes of illustration.

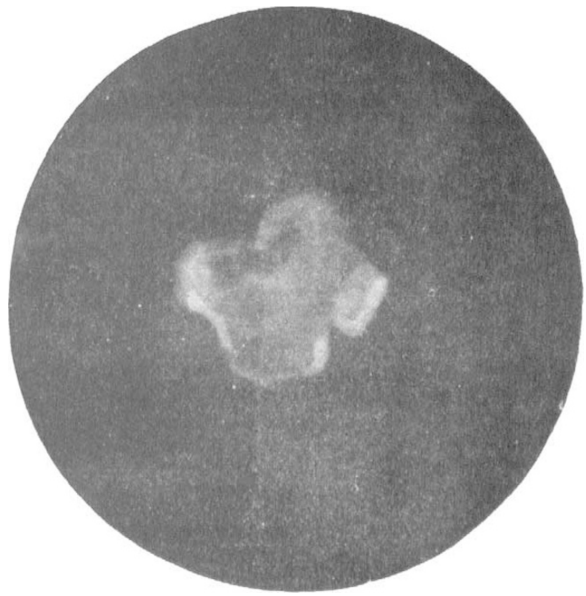

Fig. 4.—Single colony of luminous bacteria, magnified about forty-five diameters.

Figs. 2, 3, 4 and 5 are all cultures of luminous organisms, photographed entirely by their own light.

Fig. 2 is a photograph of three growths on gelatine to show the power of emitting light for long periods. The first one (*a*) is the oldest growth, some seven weeks old, in which, as always happens, the light has diminished at the centre of the streak, but is still bright at the edges, where reproduction of the organisms is still taking place. The next (*b*) is a three weeks' growth, while (*c*) is a young culture, showing that the streak is equally bright through-

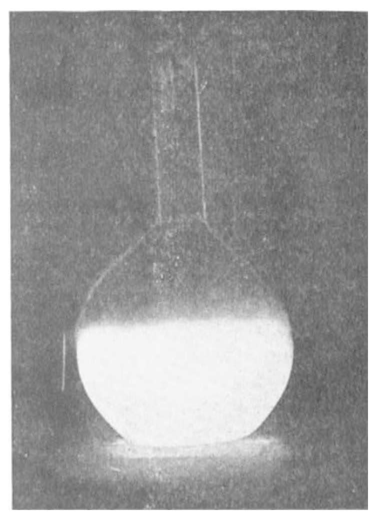

Fig. 5.—Fluid culture of luminous bacteria.

out. Fig. 3 is a plate cultivation one week old to show the individual colonies. Fig. 4 is a single colony magnified about forty-five diameters, showing that even in young bright growths the emission of light is greatest at the edges, where reproduction is proceeding most actively. Fig. 5 is a large flask containing a fluid culture through which air was passed continuously while the photograph was taken.

My investigations on these organisms have been carried out at the Jenner Institute of Preventive Medicine, and I am greatly indebted to Dr. Allan Macfadyen for help and advice during the progress of the work.

J. E. BARNARD.

INTERNATIONAL COMMITTEE OF WEIGHTS AND MEASURES.

THE International Committee of Weights and Measures at Paris has just issued an account of its business and proceedings for the past year.[1] It would appear from the report of the director of the International Bureau (at Sèvres, near Paris), made to the Committee at their session in October last, that the work of the Bureau has, under the directions of the Committee, included:—Research as to the mass of a cubic decimetre of water (giving for the specific mass of water at 4° C. a value equal to 0·9999707); the study of dividing engines; investigations as to the dilatation of metals, the precise measurement of temperature, &c. The ordinary verification work of the Bureau during the past year has included:—The re-verification of metric standards (metres and kilogrammes) for the High Contracting States who have given adhesion to the Metric Convention, 1875; the verification of standards (particularly thermometers, and decimetres) for a large number of scientific and official authorities; and the installation of new bases for geodetic measurements. We are glad to see that the Committee has now been able to extend and repair its laboratories at the Pavillon de Breteuil and to perfect its arrangements for undertaking electrical measurements.

We congratulate the new secretary of the Committee, Prof. P. Blazerna (Rome); who has succeeded the late secretary the lamented Dr. A. Hirsch; on the present issue of the *Proceedings* of the Committee. Four useful appendices are attached to the volume, including:—Annexe i., on the danger of introducing normal secondary standards in the definition of metric units; a *résumé* (annexe ii.) of legislation in different countries, derived from reports presented to both Houses of Parliament by the British Foreign Office in 1900 and 1901; and particularly annexe iv., which recapitulates the decisions of the Troisième Conférence Générale held at Paris last October, as to the definition of the metric units, metre, kilogramme and litre, and the true measurements of standards of those units. The Committee also was much engaged in the discussion of these definitions, which are now published in the *Compte rendus* des Séances de la Conférence (Paris, 1901).

The members of the Committee included MM. Arndsten, D'Arrillaga, Benoit, Blazerna, De Bodola, Chaney, Cornu, Egoroff, Gautier, Hasselberg, Hepites, Von Lang, De Macedo; and M. Mendeléeff, formerly an active member of the Committee, has now been named one of the honorary members of the Committee.

Last year the annual budget of the Committee was, as in previous years, fixed at 75,000 francs; but at the meeting at Paris in October 1901 of the General Conference it was proposed that the budget should be increased to 100,000 francs annually. This proposition did not, however, receive the support of the delegate from Great Britain, but we are now glad to see that the Treasury has given its sanction for the increase in the proportionate contribution payable by this country to the Committee, based on the annual budget of 100,000 francs.

1 "Comité International des Poids et Mesures." Procès Verbaux. Pp. 181. (Paris: Gauthier Villars, 1902.) 1 vol.

SIR JOHN DONNELLY, K.C.B.

SIR JOHN DONNELLY, whose death occurred on Saturday last after a painful illness of more than six weeks, will probably be best remembered for his unceasing and devoted service in developing and administering Governmental schemes for the promotion of scientific education in this country. Soon after the end of the Crimean War, through which he served with distinction as a Lieutenant of Royal Engineers, being twice mentioned in despatches and recommended for the Victoria Cross—an honour, however, rather unjustly withheld from him—he was appointed to the charge of a detachment of Royal Engineers quartered at the South Kensington Museum. At that time this institution was but newly born, under the fostering care of the Department of Science and Art, the principal permanent chief being Sir Henry Cole, who formed the highest opinion of Donnelly's marked abilities as a clear-sighted, shrewd and wholly trustworthy young officer. About 1858–1859, Captain Donnelly succeeded the late Lord (then Dr.) Playfair as inspector for science, and a general scheme of grants applicable to the whole country was formulated and set in operation. The subjects of science towards which instruction in aid was obtainable were at first few. Among the examiners was Huxley, with whom Donnelly came to be closely associated. This close association ripened into an intimate and affectionate friendship. It is probable that to few, if any, other men did Donnelly turn with equal confidence for counsel and advice more frequently than he did to Huxley.

From a beginning of thirty-eight local science classes and schools with 1330 students in 1860 were developed the existing 2000 classes and schools attended by at least 160,000 students. Grants for practical work in laboratories at such schools were made by the Government in 1870. As early as 1867 Donnelly had a large share in putting forward a scheme for aiding local efforts to establish local scholarships and exhibitions to assist the higher instruction of students in science.

Besides the management and care of these wide-reaching operations, he assisted in reorganising the old Royal College of Chemistry in Oxford Street and the School of Mines in Jermyn Street which became in 1890 the Royal College of Science, of which the first dean was the late Prof. Huxley. In 1868 Donnelly was appointed on a commission to consider what steps should be taken to constitute a separate Department of Science and Art for Ireland, and, acting also as secretary of the commission, he drafted its report. The commission could not see its way to reporting in favour of establishing a separate Department, and up to Donnelly's retirement in July 1899 various State-aided institutions in Ireland were subject generally to his control as Secretary of the Science and Art Department, to which office he was appointed in 1884, having held the office of Director for Science from 1873.

To develop the Museum of Science as a worthy companion to the Museum of Art at South Kensington, Donnelly pressed upon the notice of his chiefs the desirability of holding a very important and successful loan exhibition of scientific instruments and apparatus, which was opened in 1874 by Her Majesty Queen Victoria in person. This led to the formation of a museum of scientific apparatus for teaching and research. For many years after the retirement of Sir Henry Cole in 1873, Donnelly was untiring in his exertions to secure Parliamentary grants for the completion and erection of properly devised permanent buildings to house the Museums of Art and Science, the component sections of which were dispersed throughout in temporary and straggling makeshift galleries and sheds. The obvious scandal that a Government could permit the existence of such a