$$\frac{\pi m\sqrt{\mu a}}{2\pi\sqrt{\frac{a^3}{\mu}}}=m\frac{\mu}{2a}.$$

If we take the time-integral of both sides of the energy equation once round the path we get the theorem of elliptic motion stated above.

It may be remarked that $2m\pi\sqrt{\mu a}$ is the *action* for one revolution of the particle in its orbit, and thus we have the curious result (already known) that the action (and therefore the mean kinetic energy) for one complete revolution in an elliptic orbit is independent of the eccentricity. If the centre of force be shifted along the major axis, so that for different orbits about the centre of force the length of the major axis remains unaltered, the period and the action remain also unchanged.

It may be noticed that the process used above shows very clearly that the area traced out by the radius vector from the "empty focus" is proportional to the *action*, for the time given by the corresponding area traced out by the radius vector from the centre of force. I observed this fact some years ago, but found that it had previously been put on record by Tait.

For a hyperbolic path round the centre of attraction the energy equation is

$$\tfrac{1}{2}mv^2=m\mu\left(\frac{1}{r}+\frac{1}{2a}\right),$$

where $2a$ is the distance between the vertices of the two branches of the hyperbola; and we see that in this case the kinetic energy at distance r *exceeds* the potential energy exhausted in the transference from infinity to that distance by the mean kinetic energy of the motion in an ellipse of semi-major axis a. Thus if a planet formed in the course of the condensation of a nebula is to have a hyperbolic orbit, it must, by an explosion of chemical energy, or by some other convulsion or process, have a quantity of kinetic energy given to it, in excess of that produced by the transference of the matter from infinite dispersion in space. In the evolution of planets according to the nebular hypothesis hyperbolic orbits would thus be exceptional cases.

It may be noted that in a certain sense $m\mu/2a$ is also the mean kinetic energy in the hyperbolic orbit. For, when r has become considerable, $\frac{1}{2}mv^2$ is sensibly equal to $m\mu/2a$, and the time for this sensibly constant value is infinite. A. GRAY.

Boat of Garten, July 23.

"Phosphorescence" of Pennatulida.

PROF. NEWSTEAD and I have had two of the few British Pennatulida—*Pennatula phosphorea* and *Funiculina quadrangularis*—"phosphorescing" to-day before our eyes, so it may be worth recording the impressions while they are fresh. *Pennatula phosphorea*, as its name indicates, has long been known to emit light, and, writing from memory, I think Sir Wyville Thomson, in his "Depths of the Sea," refers to the "lilac phosphorescence of Pavonaria" (=Funiculina). Prof. Newstead and I have just seen the colour and distribution of the light very clearly in a makeshift dark-room (the lazarette of the yacht), and also on the deck at midnight. In Funiculina the distribution of the luminosity is very curious and quite different from that of Pennatula. There are many distinct sparkles over the polype-bearing part of the colony (corresponding, no doubt, to the individual polypes), but the long, bare lower part of the stem, 9 in. to a foot in length, when gently stroked in the dark glows with a continuous sheet of light of (it seems to me) a pale-green colour which flickers or pulsates like a lambent flame. The light on this bare part of the colony is certainly more intense than that of the polypes, and is the most brilliant "phosphorescence" I have seen in any marine animal. I have not seen Pyrosoma alive, but I imagine from the descriptions it may be even more brilliant than Funiculina.

In Pennatula, on the other hand, the light appears to be restricted to the polypes. I have not been able to excite any luminosity in the stem portion of the colony, but the illumination of the polypes is very general and beautiful—more general and more lasting than the sparkles that the polypes give in Funiculina.

Prof. Hickson, in a letter just received, asks me, if possible, to observe the phosphorescence of the other British Pennatulid, *Virgularia mirabilis*. I have not yet succeeded in dredging Virgularia here, but it ought to be found in these waters, and probably when examined alive in the dark will show some degree of phosphorescence like its two relations referred to above.

We have been able to get detailed colour notes of the living Funiculina, and some photographs of polypes extended to nearly an inch in length, which we hope may be useful. W. A. HERDMAN.

S.Y. *Runa*, Loch Sunart, N.B., July 26.

A Red-water Phenomenon due to Euglena.

A VERY remarkable red-water phenomenon is at present observable in a small pond in Broad Oak Park, Worsley, near Manchester, just in front of the seventh tee on the golf course. The surface of the pond—at any rate at times—is covered in places with an almost blood-red scum, which seems to float on the surface film like fine dust. The scum sometimes assumes a greenish hue. Microscopical examination shows that it is due to the presence of immense numbers of a large species of Euglena, the green chlorophyll of which, as in the case of Hæmatococcus, is more or less replaced by red hæmatochrome.

On keeping some of the water and scum under observation in a soup-plate, it is seen that the organism occurs chiefly in two conditions—crawling on the bottom in an elongated form, and resting on the surface in a spherical form. It does not seem to swim freely about in the intermediate zone of water, so that the red colour is confined to the bottom and the surface, and not, as in the case of the active form of Hæmatococcus, dispersed through the water itself. Crawling seems to be effected by typical "Euglenoid" contractions, but a very long flagellum is sometimes visible at the anterior end, while the posterior extremity is formed by a sharp projection free from pigment.

Since writing the above I have been able to observe how the Euglenæ reach the surface of the water. They evidently secrete some sort of slime in which they become entangled. Bubbles of oxygen gas, given off by the Euglenæ in presence of sunlight, are also caught in this slime, and when these reach a certain size they rise to the surface, trailing strings of slime, with numerous entangled Euglenæ, after them.

ARTHUR DENDY.

University of London, King's College, July 30.

The Terrestrial Distribution of the Radio-elements.

IN my letter of June 19 I briefly outlined three arguments which consistently point to a concentration of the radio-active elements in the earth's crust, such concentration having been accomplished at the expense of the material of the interior. The first of these