Letters to the Editor.

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Calculation of the Ages of Radioactive Minerals.

IT is now well known that, granted certain conditions of suitability, the age of a primary radioactive mineral is given to a first approximation in millions of years by the formula $\text{Pb} . C / (\text{U} + k . \text{Th})$, where k is the amount of uranium which is equivalent in lead-producing capacity to 1 gm. of thorium, and $1/C$ is the amount of lead produced by 1 gm. of uranium in a million years. Unfortunately, there has been a serious divergence in the values adopted for these constants by different authors, as a consequence of which the calculated ages are not always directly comparable. It is greatly to be desired that uniformity should be attained in this respect, and we feel that the time is now ripe for the adoption of agreed values of k and C by the various workers in this field of research, at least until unequivocably better data are available.

In a recent paper by one of us (A. Holmes: Estimates of Geological Time with Special Reference to Thorium Minerals and Uranium Haloes, *Phil. Mag.*, May, 1926, p. 1055) the value 6600 was accepted for C. This value was given by Dr. H. Jeffreys in his book, "The Earth," as "the revised value obtained by Lawson and Hess." We have now found, however, that it involves errors both in interpretation of the data and in arithmetic, and that, on the experimental data of Hess and Lawson, the value should have been 7400. On the other hand, H. V. Ellsworth and C. W. Davis in recent papers in the *Amer. Jour. Sci.* have used $C = 7900$, a value suggested by Lawson in 1917; and still more recently in the same journal L. A. Cotton uses $C = 8000$, while O. Hahn in a German publication adopts $C = 8200$.

Probably the most accurate determination of the number of α-particles emitted per second by 1 gm. of radium is that made by Hess and Lawson, using the electrical method of counting. Their value, $3{\cdot}72 \times 10^{10}$, almost exactly corresponds with the measured heat production by radium (NATURE, **116**, 897, 1925), and for this and other reasons we believe it to be the most trustworthy at present available. Accepting it, and combining it with the ratio of radium to uranium in uranium minerals, $3{\cdot}40 \times 10^{-7}$, we find $C = 7400$, which we propose as the most trustworthy value on current data.

The values adopted for k have varied between 0·3 and 0·4. Rutherford and Geiger's scintillation experiments on uranium and thorium indicate that per annum 1 gm. uranium gives $1{\cdot}26 \times 10^{-10}$ gm. uranium-lead, and 1 gm. thorium gives $0{\cdot}485 \times 10^{-10}$ gm. thorium-lead. Whence it follows that 1 gm. of thorium produces lead at the same rate as 0·38 gm. of uranium. Judged by later experience, the individual results for uranium and thorium are both probably rather low, but they were reached by the same method in either case, and are thus directly comparable. A slight correction to each of the results makes no appreciable difference to the ratio between them, as in each case it is in the same direction and of the same relative order. We therefore propose $k = 0{\cdot}38$ as the most reliable value at present attainable.

The approximate age of a mineral (omitting the time-average correction) is, therefore, on present data, given most reliably by the formula:

$$\text{Approximate Age} = \frac{\text{Pb}}{\text{U} + 0{\cdot}38\ \text{Th}} \times 7400 \text{ million years.}$$

The application of the time-correction has the effect of reducing the value of the age so obtained. The corrected age can be most conveniently obtained by means of the formula:

$$\text{Corrected Age} = \text{Approximate Age} . \left(1 - \frac{x}{2} + \frac{x^2}{3}\right);$$

where $x = 1{\cdot}155 . \dfrac{\text{Pb}}{\text{U} + 0{\cdot}38\ \text{Th}}$.

Adopting the factors here advocated, the Middle Pre-Cambrian pegmatites of Ontario, Texas, Colorado, Sweden, and India have an age of about 1000 to 1100 million years.

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Protoplasmic Viscosity as determined by a Temperature Coefficient of Biological Reactions.

IN a previous note [1] I have shown that the majority of biological processes depend on temperature according to the formula:

$$y = \frac{a}{x^b},$$

when x is temperature in degrees centigrade, y time, a and b constants. I have given some examples which seem to indicate that this equation is very general. I have also mentioned that the constant b, which is a real temperature coefficient (because it does not change with temperature), probably has a wider biological interest.

Let us compare the values of b for one and the same reaction in different species:

Reaction.	Species.	Author.	b.
Amœboid movement .	Marine amœbæ	Pantin [2]	0·90
" " .	Human leucocytes	McCutcheon [3]	2·14
Embryonic development .	*Cyclops fuscus*	Ziegelmayer [5]	1·16
" " .	Drosophila	Loeb and Northrop [4]	2·10
" " .	*Rana virescens*	Lillie and Knowlton [6]	2·36
" " .	Chick	cf. Morgan [7]	4·10
Heart-beat . . .	Anodonta	Koch [8]	1·10
" . . .	*Rana temporaria*	Clark [9]	1·06–1·48
" . . .	*Emys europaea*	Galeotti and Piccinini [10]	1·44
" . . .	*Hynobius lichen.* larva	Inukai [11]	1·15
" . . .	Duck embryo	"	2·92
" . . .	Dog	Frank [12]	2·06
" . . .	Rabbit	"	3·00
" . . .	Cat	Langendorff [13]	2·38

As may be observed from these data, b is generally higher in homoiothermic than in poikilothermic forms. But this is evidently not an exclusive feature of homoiothermy, since b is relatively high also in poikilothermic forms living at high temperatures:

[1] Bělehrádek, NATURE, 118, p. 117, 1926.
[2] Pantin, *Brit. Journ. Exp. Biol.*, 1, 1924.
[3] McCutcheon, *Amer. Journ. Physiol.*, 66, 1923.
[4] J. Loeb and Northrop, *Journ. Biol. Chem.*, 32, 1917.
[5] Ziegelmayer, *Zeits. wiss. Zool.*, 126, 1925.
[6] Lillie and Knowlton, cf. Morgan (7).
[7] Morgan, "Experimental Zoology," New York, 1907.
[8] Koch, *Pflüger's Archiv f. d. ges. Physiol.*, 166, 1917.
[9] Clark, *Journ. of Physiol.*, 54, 1921.
[10] Galeotti and Piccinini, *Archivio di fisiol.*, 8, 1910.
[11] Inukai, *Japanese Journ. of Zool.*, 1, 1925.
[12] Frank, *Zeits. f. Biologie*, 31, 1907.
[13] Langendorff, *Pflüger's Arch. f. d. ges. Physiol.*, 46, 1897.