molecular size and constitution of the heavy carbohydrates, like starch and glycogen, and the family of dextrins intermediate between these and the sugars, we have at present little more than guesses to go upon. To give, as the present author does, long lists of reactions with iodine and other reagents, and on the strength of differences in these to describe as separate substances amylose, amylosan, amylodextrin, and other forms of dextrin, and to add to the list amyloporphyrin and amylorubin, does not really advance matters much. Bütschli apologises at the start for his lack of chemical knowledge, and in the end admits that several of his preparations are mere mixtures; we therefore fear that, from the chemists, his work will meet with but scant courtesy. He has nevertheless succeeded in producing a very readable little brochure, and if his main contention is accepted, his labours will not have been useless.

Lessons on Country Life. By H. B. M. Buchanan and R. R. C. Gregory. Pp. xi+330. (London: Macmillan and Co., Ltd., 1903.) Price 3*s*. 6*d*.

ONE of the authors of the above book, Mr. H. B. M. Buchanan, produced a little time ago two small "Country Readers," most excellent books for the children of a rural elementary school, in which our common domestic animals were discussed from a full knowledge in an easy, pleasant style. We are sorry we cannot give the same praise to the "Lessons" before us; the educational value of the former book has disappeared, and the authors have allowed a craving for completeness to swamp their judgment, so that the result is a miniature and scrappy encyclopædia instead of a book.

Country life is a vast subject, so vast that no child can learn during his school life even a fraction of the information it may be desirable he should possess in his after life; the teacher, then, must abandon the attempt to impart information, but devote his energies to instilling into his pupils the right way of looking at things, the method which they can employ themselves when going about the world. The method consists in a training in observation and experiment. Here instead we have first a sort of abbreviated textbook on live stock, hints on breeding and feeding, twelve breeds of cattle described at lengths varying from a page down to two lines, horses, sheep and pigs to correspond, analyses of milk, rules for making butter and cheddar cheese; with such a programme what chance is there of observation or experiment for school children?

The latter portion of the book deals with common birds and mammals in a much better spirit; strike out the unnecessary Latin names for orders, families and species, and it forms a fair reading book. The last section, on insects, is again spoiled by a wholly unnecessary passion for classification; classification is only grammar, and the parts of τυπτω are just as good in this way as "Coleoptera, Euplexoptera, Orthoptera, Thysanoptera, &c." We know by sad experience how easy the schoolmaster finds it to write these things on the blackboard and make his class copy them with due attention to neatness and spelling; observation and experiment require both labour and thought. We grieve to speak unkindly of Mr. Buchanan, who has done such excellent work before; there are good things in the book, *e.g.* the section on poultry and the illustrations, but, like the curate's egg, it is only good "in parts." If the new teaching on country life is to succeed in our schools, it will be in virtue of the spirit, and not of the information which the teacher imparts to his pupil, and we consider that this book fatally misses the spirit.

LETTERS TO THE EDITOR.

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Radio-activity and the Age of the Sun.

IN the Appendix E of Thomson and Tait's "Natural Philosophy," Lord Kelvin has computed the energy lost in the concentration of the sun from a condition of infinite dispersion, and argues thence that it seems "on the whole probable that the sun has not illuminated the earth for 100,000,000 years, and almost certain that he has not done so for 500,000,000 years. As for the future, we may say, with equal certainty, that inhabitants of the earth cannot continue to enjoy the light and heat essential to their life for many million years longer, unless sources now unknown to us are prepared in the great storehouse of creation."

The object of the present note is to point out that we have recently learnt the existence of another source of energy, and that the amount of energy available is so great as to render it impossible to say how long the sun's heat has already existed, or how long it will last in the future.

The lost energy of concentration of the sun, supposed to be a homogeneous sphere of mass M and radius a, is $\frac{3}{5}\mu M^2/a$, where μ is the constant of gravitation. On introducing numerical values for the symbols in this formula I find the lost energy to be $2{\cdot}7\times10^7$ M calories, where M is expressed in grammes. If we adopt Langley's value of the solar constant this heat suffices to give a supply for 12 million years. Lord Kelvin used Pouillet's value for that constant, but if he had been able to use Langley's his 100 million would have been reduced to 60 million. The discrepancy between my result of 12 million and his of 60 million is explained by a conjectural augmentation of the lost energy to allow for the concentration of the solar mass towards its central parts. I should have thought the augmentation somewhat too liberal, but for the present argument it is immaterial whether it is so or not.

Now Prof. Rutherford has recently shown that a gramme of radium is capable of giving forth 10^9 calories. If, then, the sun were made of such a radio-active material it would be capable of emitting 10^9 M calories without reference to gravitation. This energy is nearly forty times as much as the gravitational lost energy of the homogeneous sun, and eight times as much as Lord Kelvin's conjecturally concentrated sun.

Knowing, as we now do, that an atom of matter is capable of containing an enormous store of energy in itself, I think we have no right to assume that the sun is incapable of liberating atomic energy to a degree at least comparable with that which it would do if made of radium. Accordingly, I see no reason for doubting the possibility of augmenting the estimate of solar heat as derived from the theory of gravitation by some such factor as ten or twenty.

In an address to Section A of the British Association in 1886 I discussed the various estimates which have been made of geological time, and I said, "Although speculations as to the future course of science are usually of little avail, yet it seems as likely that meteorology and geology will pass the word of command to cosmical physics as the converse." I think the recent extraordinary discoveries show that this forecast was reasonable.

It is probable that the bearing of radio-activity on the cosmical time-scale has occurred to others, but I do not happen to have seen any such statement.

Cambridge, September 20. G. H. DARWIN.

The Principle of Radium.

WOULD some of your readers inform me whether the case of the radium phenomena is quite unique? When a small magnet in my drawer has been ready to act on a compass at any time during the last twenty years, and has not