the Protozoa, with which and the analysis of simple cell structure the author's course commences, the student, being told how to capture and mount his sample, is asked, "How many different shapes can you distinguish?" "What variations in size?" "In color?" and other questions of like order; but when there follow these (on p. 5 of the work), "How do these animals eat?" "Digest their food?" "Breathe?" (*sic*) we confess to a feeling of sympathy with the befuddled beginner. And when, further, after an altogether insufficient preamble and at the outset of his inquiry into the wide domain of biology, the tyro is asked, of the Amœba, "Is the process [of fission] preceded by sexual union?" "How is one sex distinguished from the other?" and, *à propos* of the cerebral hemispheres of the frog, "Why are they called hemispheres?" one's sympathy gives place to pity for the student thus led astray. We entirely disagree with the author's dictum that sooner or later the student will have to learn to use the microscope, and it matters little when he does so; and we further doubt the advisability of his interrogatory method, when "the questions usually apply equally well to several related forms," particular species being said to be "not required." A training in elementary biology is one in manipulation in a field beset with snares and pitfalls, rendering it a primary necessity to teach the beginner what to leave unconsidered. However, the experiment, while not altogether new, is an interesting one; the book is carefully compiled, and we await with interest the verdict of time upon the system which it advocates.

Notes on the Ventilation and Warming of Houses, Churches, Schools, and other Buildings. By the late Ernest H. Jacob, M.A., M.D. (London: S.P.C.K., 1894.)

A MELANCHOLY interest is attached to this little manual of health in the fact that its gifted author passed away on March 1. His posthumous work shows what a promising life was cut short, and will serve as a memorial to him. The idea that human beings confined in public buildings should have pure air at a suitable temperature supplied them, has only in recent years been taken seriously. It is notorious that in most churches there is no attempt at proper ventilation, and they are only excelled, as far as disregard for the laws of health go, by many Nonconformist chapels with galleries, and mission-rooms created by knocking two cottages into one. Dr. Jacob's manual should be consulted by those who are responsible for such buildings. Therein they will find described the general principles by which buildings are rendered healthy. The book should also be read by the householder, for he will learn from it how an ordinary dwelling-house ought to be ventilated and better, will find that it is an easy and not very costly business to make the average English house less stuffy and more healthy than it usually is. Indeed, all who desire in a popular form information on the subject of ventilation, should procure this book, while architects and builders would benefit the community by taking its lessons to mind.

LETTERS TO THE EDITOR.

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Rotating Shafts.

IN your account (NATURE, May 10, p. 43) of Dr. J. Hopkinson's "James Forrest" lecture at the Institution of Civil Engineers, appears the following statement: "Another example, having a certain degree of similarity with the case of struts, is that of a shaft running at a high number of revolutions per minute, and with a *substantial* distance between its bearings. . . . How will the shaft behave itself in regard to centrifrugal force as the speed increases? *In this case, so long as the shaft remains absolutely straight it will not tend to be in any way affected by the centrifugal force,* but suppose the shaft becomes slightly bent, it is obvious to anyone that if the speed be enormously high this bending will increase, and go on increasing until the shaft breaks. In this case also we may use mathematical treatment; we find that the condition of the shaft is expressed by a differential equation of the fourth order, and from consideration of the solution of this equation we can say that if the speed of any particular shaft be less than a certain critical speed, the shaft will tend to straighten itself if it be momentarily bent, but that, on the other hand, if the speed exceeds this critical value, the bending will tend to increase with the probable destruction of the shaft." (The italics are mine.)

The italicised statement seems to imply that a certain operating cause may have absolutely no effect, which cannot of course be the meaning Dr. Hopkinson intended to convey. Most engineers, it is to be hoped, are aware that the natural tendency of the material of the shaft is to retire from the axis of rotation, and that this is *necessarily* associated with a state of strain and stress throughout the shaft, whether straight or bent, for all speeds of rotation. Dr. Hopkinson must, I think, have had his mind so fully occupied with the idea of rupture through instability, worked out by Prof. Greenhill,[1] that he overlooked the fact that his language suggests the non-existence of the more commonplace and essential elastic phenomena.

So far even as rupture is concerned, Dr. Hopkinson's statements are, I believe, incomplete. The ordinary strain and stress developed by rotation in a shaft may, as I have shown elsewhere,[2] exceed the limits of safety before a velocity is attained at which, on the Greenhill theory, instability becomes possible. This is the more likely to happen the shorter the cylinder and the thinner its walls, if it be hollow; but even in a solid iron cylinder of length eight or nine times its diameter—a very substantial distance in a thick cylinder—the strain developed would be such as to merit an engineer's careful attention before a critical velocity was reached associated with instability.

I am somewhat doubtful whether Dr. Hopkinson's remarks on instability itself are altogether satisfactory. On the mathematical theory there appear in reality to be a series[3] of critical values, if any, at which instability *may* occur. Supposing the velocity gradually raised, it seems possible, *theoretically*, for the shaft to safely surmount the first crisis. It then would appear to remain unexposed to instability until the approach of the next higher critical velocity, and so on.

As Dr. Hopkinson says, Prof. Greenhill's instability theory leads to a differential equation of the fourth order. The solution of this equation is, however, dominated by the terminal conditions[4], at the ends or bearings of the shaft, and unless these be correctly assigned the numerical results deduced from the theory are untrustworthy. This is, I think, one of those points where the practical experience of the engineer is a most essential auxiliary to the analysis of the mathematician.

Kew Observatory, May 11. CHARLES CHREE.

IN order to shut out every possibility of ambiguity, I might have said, instead of "substantial distance between the bearings," "distance between the bearings very great in comparison with the diameter of the shaft," and in the next sentence quoted it would perhaps have been clearer if I had said "will not be broken by centrifugal force." But I do not think that in fact I could be misunderstood by anyone.

It was hardly desirable that I should touch upon the terminal conditions, or upon the possibility of stability between the critical values, in a paragraph introduced for illustration and not for detailed information.

But Mr. Chree's letter does remind me that I neglected to refer to Prof. Greenhill's name in this connection. This I should have done with the greatest pleasure, but, unfortunately, for the moment I forgot that it was he who had worked on the problem. I write this note in order to make the acknowledgment. J. HOPKINSON.

1 Institution of Mechanical Engineers, *Proceedings*, 1883, pp. 182-209.
2 Camb Phil. Soc. *Proceedings*, Feb. 8, 1892, pp. 283 *et seq.*
3 See *Phil. Mag.* August 1892, pp. 166-67.
4 See Camb. Phil. Soc. *Proceedings*, *l.c.* p. 300, and *Phil. Mag. l.c.* pp. 164-65.