the question; and while some of the difficulties which present themselves upon detailed examination may be overcome, others are less easily surmounted. In the trunk of a tree it is only the cambium itself which can properly be regarded as consisting of living cells—if we use the expression in its usual sense. Besides protoplasm the cambium cell contains a nucleus, and splitting up to form the growing wood is evidently and unquestionably a living cell. The sap cannot, however, be considered as entirely rising through the cambium alone; while the medullary rays and wood-parenchyma, although they both contain protoplasm or such like organic substances, are in no other respects like living tissue. They may be regarded simply as store houses containing nutritive matter, or as actively engaged in the plant's circulation, or as acting in both capacities; but scarcely can they be described as centres of vitality.

The theory which most readily commends itself to our ideas of probability is that which regards osmosis as the primary and all potent cause of the sap's ascent in plants; not taking place in the root alone, as was supposed by those who advocated the earlier theory, but active throughout the whole height of every tree. Concerning osmosis itself it is well to remember that the phenomenon contains nothing transcendental or beyond the reach of ordinary molecular physics for its complete explanation. We know that the particles of a liquid, though far from possessing that mobility which in a gas is due to the great extent of free path enjoyed by its molecules, are constantly in a state of translational motion with regard to each other. The phenomenon of diffusion in inorganic solutions obviously suggests the conclusion that this capacity depends largely upon the relative simplicity which characterises the molecule's construction. Especially is this idea forced upon us when considering the relative diffusibility of various solutions. Here we find the rate of diffusion bearing a definite relation to the solution density; the square of the time of equal diffusion being in the case of such solutions equal to their solution density. It would appear, apart from all questions of chemical combination, that each molecule—or perhaps group of molecules—of the solvent becomes attached to a certain number of molecules of the dissolved substance; this complex group holding together so far as diffusion and osmosis are concerned. Under such circumstances it is only to be expected that the rate of diffusion, which means the passage through intermolecular fluid spaces, or of osmosis, which consists in the passage through interstitial spaces in a porous solid, should vary quite as much as is observed to be the case.

It is true the relatively small differences in the rate of passage through porous bodies observable when inorganic solutions are compared with each other, seem to depend principally upon chemical action between the solutions and the substance; but in the much more marked difference observed when we compare the dialysis of crystalloid and colloid bodies, this does not depend on any such action.

Now in a plant we have a system in which the process of nutrition is going on at both ends, the roots and the leaves of a tree; it is, however, the organic colloid substances which are manufactured in the leaves, while in most part inorganic or crystalloid compounds are absorbed by the roots. Both forms of nutriment are required at every point of the tree. The colloids have to descend, the crystalloids and water have to be raised. Constant evaporation from the leaves by maintaining "negative" pressure in the vessels greatly facilitates the rise of water from below; but the motive power is osmotic action taking place between any or every pair of cells in the chain. The "air bubbles" which form a *chapelet de Jamin* in the vessels and prevent the fall of any water previously raised by osmosis, at times when demand falls or moist air saturating the leaves supplies all water necessary from above, very possibly convert the fluid column itself into the equivalent of a porous body suitable for the action of osmosis to make itself felt between each pair of drops as they hang suspended in the vessels. The film of liquid surrounding each bubble is as a narrow space in a porous body through which the simpler and smaller groups of atoms can more readily pass than can that cumbrous collection which constitutes the physical molecule of any colloid solution. This action adapts itself exactly to the plant's requirements. Should any sap fall short at any point of water or crystalloid solution, osmotic action immediately supplies what is required from below; while the enormous pressures which dialysis can bring into play leave gravity *une quantité negligeable*. The details characterising this action as observable in conifers, as distinguished from dicotyledonous trees, will doubtless vary. The former suggest to most unbotanical minds the idea of an earlier and less highly developed type. The tracheides of a conifer act simultaneously as conducting vessels and as hollow cells in the structural framework of the trunk considered as a beam; while these purposes are more or less differentiated in the case of dicotyledonous plants. In this latter case the wood-parenchyma cells surrounding the "vessels"—filled as they are with colloid matter—appear to supplement the action of the medullary rays, not here in such close connection with conducting tracheides as they are in the case of conifers. The presence of all this colloid matter, scattered throughout the conducting mass and closely connected with the tracheides or with the fitted vessels, probably act as a reservoir and enlarge the sphere of the osmotic action, thus avoiding violent changes and preventing any very noticeable difference in sap density occurring throughout the tree's height. A gradient, however, marking difference in proportion between colloids and crystalloids must necessarily exist whenever water is rising, and this would naturally be expected to follow the introduction of these different forms of nutritive matter at opposite ends of a chain.

ELEMENTARY GEOLOGY.[1]

If a new elementary text-book of geology is really in request, no better author could be found than the president of the Geological Society of London for 1905. We venture to prefer this work to his somewhat similar "Agricultural Geology," and hope that candidates for a diploma in agriculture will now make use of both. The author, while engaged upon his task, appears to be absolutely devoid of the emotion which "nature-study" provokes in other men in various measure, and his introduction, if a little cold, should lead to accurate observation and understanding. The photographic illustrations are refreshingly large, and include successfully the forms of familiar fossils and even of flint implements. Four pins fixed in a dull white wall would, however, have served as a more satisfactory support for a helpless belemnite than the operating table and other apparatus displayed in Fig. 29. The striking relic of a Triassic land-surface, photographed by Prof. H. E. Armstrong (Fig. 27), is here reproduced, as an example of the admirable landscapes in this volume.

Our only question about the book is as to the class for whom it is intended. In the frequent absence of systematic scientific training in English schools—things are fortunately different now in Ireland—scholars may come up to our universities completely ignorant of chemistry and physics. They may also be ignorant of the animal and vegetable forms around them, and they are certain to believe that coral is a substance laboriously manufactured by an insect. We take it that, on contact with Dr. Marr and the well-known Woodwardian collections, such scholars may become attracted towards geology. Hence, in the present work, this complex subject, relying for its evidence on almost every other science, is treated as one to be laid before babes, who have never handled a blowpipe, or stroked the back of a cat to see that it possessed a spinal column. From these pages the reader may "proceed to the perusal of more advanced treatises." But what

[1] "An Introduction to Geology." By J. E. Marr, Sc.D., F.R.S. Pp. viii+230. (Cambridge: University Press, 1905.) Price 3s. net.

is to be his course of study in between? Before the advanced treatise, or at any rate, such a one as Dr. Marr would approve, can be really entered on and appreciated, the student must surely have some practical acquaintance with carbon dioxide and silica as chemical substances, with "boneless animals" and "those possessing bones," and with other matters that are here mentioned as if they were absolutely new to his intelligence. On pp. 224 and 225 the beginner is sent out into the open country as his "true museum." This is excellent advice for the true beginner in geology, but not for those beginners in science whom Dr. Marr, from his experience of English public schools, finds himself compelled to contemplate.

Among the excellent points in the present treatise we notice the early introduction of conceptions of crust-movement, which render descriptions of other phenomena far more easy of comprehension; the reference to what is often known as "plucking" in the action of glaciers (p. 57); and the concise account of plains of denudation (peneplains) on p. 99. Among the very few slips, we may note that Kimeridge (p. 179) is in Dorset, not in Wiltshire; that the insoluble part of felspar (p. 79) does not by itself form china-clay; and that the phrase "evaporation of water by the sun" (p. 67) is scarcely a happy one. The fan-structure on p. 93 is, we think, not that usually thought of in connection with the term.

On p. 65 we must invoke subsidence of the crust to enable the sea to perform all the work there claimed for it; and we should like more sympathy on p. 89 with the view that the earth is continually losing moisture from its interior. Lastly, the author (p. 181) should not, even by an accident of phraseology, encourage a belief in the existence of "fossil thunderbolts." But these small asperities only give an edge to our appreciation. GRENVILLE A. J. COLE.

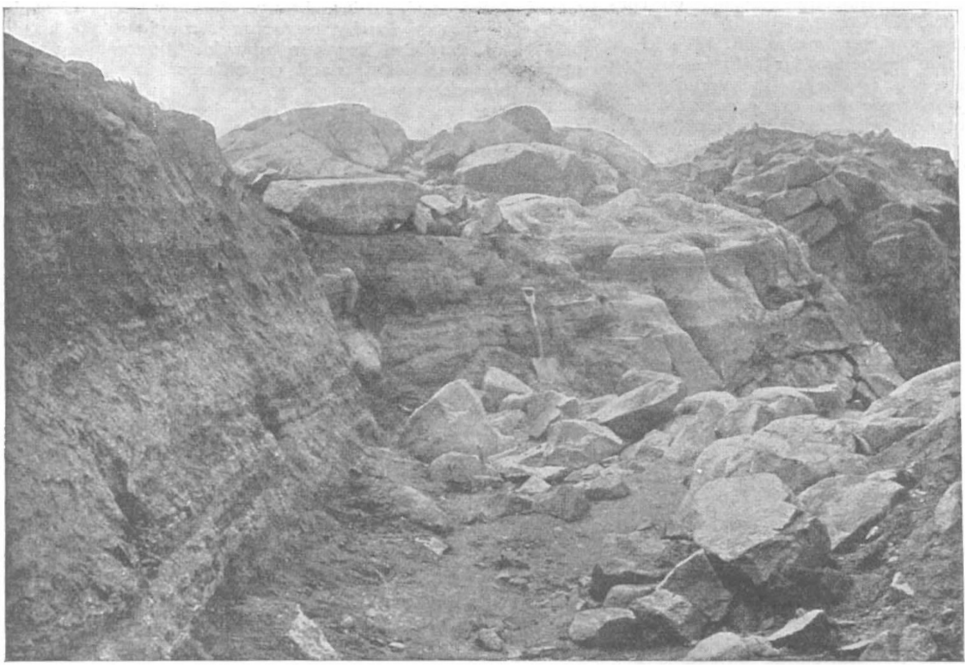

FIG. 1.—Wind-worn surface of older rocks (on right), revealed by removal of New Red Sandstone, Charnwood Forest. Landscape of Triassic times. (From Marr's "Introduction to Geology.")

TIDAL RESEARCHES.[1]

ONE of the crowning features of the enunciation by Newton of the law of universal gravitation consisted in the fact that herein the phenomena of the tides and their relationship with the moon could for the first time be coordinated with other well-known phenomena of the solar system. Though the principal phenomena of rise and fall and ebb and flood of the sea must have been recognised bv coast dwellers and navigators from the earliest times, the theory of the tides as it exists to-day may fairly be said to have originated with Newton, and its purpose has largely been to examine to what extent these phenomena are attributable solely to a gravitational cause or how far it may be necessary to invoke some other exciting or controlling influence.

It was early recognised that a theory which failed to take due account of the inertia of the water, of the earth's rotation, and of the curvature of its surface could but inadequately represent the phenomena actually existent in nature, and the reduction of the tidal problem to a mathematical form in which all these features were duly taken into account was first accomplished by Laplace; since his time the equations furnished by him have formed the basis of almost all attempts to further the study of the tides from its purely theoretical aspect. The theory of tides in narrow canals developed *in extenso* by Airy, though not directly based on Laplace's equations, consists largely in the discussion of a special type of solvable cases of the more general mathematical problem propounded by Laplace. In the memoirs under review the author emphasises the hopelessness of such attempts to realise their main purpose of providing a theory sufficiently exact and yet sufficiently general in character to allow of direct comparison with observations, as is the practice in the study of other gravitational phenomena such as the planetary motions, and proposes a new method of attacking the problem. An essential difference between this method and that of Laplace consists in the fact that in the former the influence of the earth's rotation is regarded as of secondary importance. Such solutions of Laplace's equations as have been obtained, which allow of an exact estimate of the

[1] "A Manual of Tides." Part iv. A, Outlines of Tidal Theory. Part iv. B, Cotidal Lines of the World. By Rollin A. Harris. Appendices to Reports of U.S. Coast and Geodetic Survey.