is only apparent in high velocities. For nearly all studies, it will suffice to consider the deflections as if produced on a sphere.

Ritter's speculations concerning the gaseous condition of the earth's interior are of especial importance, inasmuch as they may tend to counteract the very positive statements made by English physicists and geologists in recent years in regard to the age and contraction of the earth as determined by its cooling. The English school generally regards the earth as essentially solid, with a great central volume of dense matter at a high, and, roughly speaking, uniform temperature. On the basis of certain plausible assumptions concerning the original temperature and conductive power of the mass, it has been possible to approximate fairly well to the age for an earth of such characters, and to determine roughly the shortening of its radius, and consequent diminution of circumference since it has had a definite solid crust on which water might condense from the vaporous atmosphere into the oceans. The age of an earth thus limited has greatly reduced the estimates in vogue by the followers of Hutton and Lyell, even though its years are still to be counted by millions. Its contraction from cooling has also been pronounced insufficient to produce the observed structure of mountain ranges in the way that Élie de Beaumont had suggested. Strongly contrasted with these assumptions and their legitimate results are the conclusions reached by Ritter. His original papers were published in Poggendorff's 'Annalen,' and have received an approving review from so trustworthy a physicist as Zöppritz. Günther quotes largely from the latter. We cannot here do justice to the hypothesis, for it would need a somewhat deliberate statement to make it clear. Excessively dense vapors, probably dissociated from their ordinary combinations, and existing at temperatures high above their 'critical point,' are supposed to occupy the earth's centre; and from these there is a gradual transition to the solid superficial crust. The cooling of such a central mass follows a paradoxical law, — the more heat it loses, the hotter it becomes, — and so the supply of interior heat is long maintained, and the time allowed for geological processes is lengthened. Moreover, the contractional theory here finds a cause for all the diminution of interior volume demanded by the wrinkling of the crust in mountain ranges. Altogether, while the venturesome hypothesis is very far indeed from any thing like demonstration, its consideration is profitable if it prevent our settling down prematurely to a fixed belief concerning the condition of the earth's interior.

We shall wait impatiently for the second volume of the work, in which the physics of the air and sea will be discussed; and it will be particularly interesting to see what treatment so learned an author gives to the physical geography of the land.

ROMANES' RESEARCHES ON PRIMITIVE NERVOUS SYSTEMS.

ALL who are interested in the physiology of the nervous system in lower animals will find in this volume a most useful popular contribution to this subject. The book, as the author states, is restricted to experiments made in his own researches; but these are so numerous and varied that it will be found to contain a summary of the most important results in this line of investigation which are at present known.

'Do they feel?' and 'Have they senses?' are questions which are very naturally asked by any one who watches the varied movements of the jelly-fishes, star-fishes, and sea-urchins. A natural credulity prompts one to question whether the medusae, whose bodies contain over ninety-eight per cent of water, have a nervous system, and organs of special sensation. Twenty-five years ago, science would have given a very unsatisfactory answer to these questions; but to-day we have a very accurate knowledge of the anatomy of these structures. With this advance in anatomical knowledge, physiological research has kept pace; and certainly no one has done more than Romanes in this kind of research. Thanks to these advances, we can now reply to our questioner with more confidence than formerly. These animals not only feel, but also have special organs of sight, hearing, and probably smell.

The author puts the anti-vivisectionists in a receptive frame of mind for the work which follows by declaring, in the introduction, that his experiments on living animals involve no pain, and that the "consciousness which is present must be of a commensurately dim and unsuffering kind."

The work is mainly taken up by experiments in excising portions of the body, and noting the effects on the movements of the animal. Many very interesting experiments

Jelly-fish, star-fish, and sea-urchins: being a research on primitive nervous systems. By G. J. ROMANES. New York, *Appleton*, 1885. (International scientific series.) 12+323 p., illustr. 8°.

on the effects of the application of stimulants — mechanical, electrical, and chemical — are described. The action of poisons upon jelly-fishes shows a wonderful resemblance to that of the same on higher animals. Many conclusive experiments are given to prove that the fatal effects of transferring medusae from salt to fresh water is not due to a difference in density of the two media. A medusa artificially frozen into a solid block of ice, so that ice-crystals are formed in its body, is not killed by the operation.

The observations on the star-fishes and sea-urchins are recorded in a single chapter; yet they are in many respects as interesting as those on the jelly-fishes in the preceding nine chapters. The author points out the different methods adopted by star-fishes and sea-urchins in righting themselves when turned upon their backs. The 'geometrical regularity' of these animals, in their nervous system as in their form, leads to a "very pretty instance in physiology of the physical principle of the parallelogram of forces." If two stimuli are applied simultaneously at opposite extremities of an axis passing horizontally through a round sea-urchin, the Echinus moves off 'in a direction at right angles' to a line connecting these points.

The author finds, that, by cutting off the eye-spots from several star-fishes and sea-urchins, they do not seek the light thrown into the dish, as is invariably their habit when these organs are intact. He also finds that an excised ray of a star-fish makes its way to the beam of light as if it were an entire animal. A star-fish, with all the eye-spots but one removed, crawls to the light.

Romanes ascribes to the star-fish a sense of smell from the following experiments: a star-fish is kept fasting for several days. A piece of shell-fish is then placed in the tank with the animal. He immediately crawled toward it. "Moreover," says the author, "if a small piece of the food were held in a pair of forceps, and gently withdrawn as the star-fish approached it, the animal could be led about the floor of the tank in any direction, just as a hungry dog could be led about by continually withdrawing from his nose a piece of meat as he continually follows it up." To determine the region of the body where the supposed sense of smell is located, the experimenter removed the eye-spots, and the hungry star-fish moved in the direction of its food. He varnished the whole upper (aboral) surface of the body, and still the acuteness of the sense was not diminished. He concludes that the sense is not localized, except that it is "distributed over the whole of the ventral or lower surface of the animal."

These last-mentioned experiments can be easily tested by any one without elaborate apparatus. Certainly one great value of all the experiments is their great simplicity; and the book has this strong recommendation to contribute to make it, what the author expresses a wish that it should be, a "book of service to the working physiologist."

The work of Romanes is certainly one of the most valuable contributions to the physiology of the primitive nervous system which have been published, and it is the only book on this subject which has yet appeared in America. Yet, much as there is to praise in this book, there are several statements which an anatomist cannot accept; but these do not detract from the excellence of the work, as far as the main questions are concerned.

MINOR BOOK NOTICES.

PROFESSOR JOHNSON'S little book on curve-tracing is more clearly arranged than Frost's treatise, and seems much better suited to the wants of readers who need only a general knowledge of methods, and do not wish to go into refinements of approximation which they may seldom or never have occasion to use. Students rarely think it worth while to spend much time in curve-tracing after they have once acquired a little knowledge of analytic geometry; but every man who means to devote his attention specially to mathematics needs to have some facility in interpreting equations geometrically, and this he can best get by studying some such book as the present one. Professor Johnson treats the analytical triangle in a way which will recommend itself, we feel sure, to mathematicians, and introduces it so early that a person who has time for no more can read the first half of the book to advantage. In a few instances the addition of a short clause would make clear sentences which are now rather obscure.

Pettit's little book gives in a concise form a brief account of nearly all the more important

Curve-tracing in cartesian co-ordinates. By WILLIAM WOOLSEY JOHNSON, professor of mathematics at the U. S. naval academy. New York, *Wiley*, 1884. 6+86 p. 16°.

Modern reproductive graphic processes. JAMES S. PETTIT. New York, *Van Nostrand*, 1884. (Van Nostrand sc. ser., No. 76.) 4+127 p. 16°.

Comparative physiology and psychology. A discussion of the evolution and relations of the mind and body of man and animals. By S. V. CLEVENGER, M.D. Chicago, *Jansen, McClurg, & Co.*, 1885. 6+247+10 p. 8°.

Elements of zoölogy. By C. F. HOLDER and J. B. HOLDER, M.D. New York, *Appleton*, 1884. (Appleton's sc. text-books.) 10+385 p., illustr. 8°.