region, as well as the crossing of the Little Khingán, were made by Dr. Nansen, partly in horse carriages, partly in trolleys run along temporary rails, and partly in a motor-car, until he reached, on the Zéya plain, about 420 miles from Khabarósvk, a station where he could take the direct train to Petrográd. This station, from which Dr. Nansen could now travel by rail all the way to Petrográd, with but one or two interruptions at unfinished bridges, received from the local engineers the name of "Nansen's."

On October 18 Nansen was at Chitá, where he joined the Eastern Express. He passed Irkútsk at night, without stopping; six days later he was in the Urals, and on October 27 he reached Petrográd; and yet, notwithstanding the rapidity of the journey, his observations and remarks about Siberia, "the land of the future," "Russia in the East," and "The Yellow Question," and so on, are both valuable and interesting.

The book is richly produced, with numerous excellent reproductions of Dr. Nansen's photographs, and with three maps—one of the Kara Sea and adjoining lands, and two of Siberia. The transcription of Russian names, both in the text and on the maps, is quite correct, with the exception of a very few words, in which the German spelling has been followed (Tas, Seya, Syriansky, instead of Taz, Zeya, Zyriansky).

P. KROPOTKIN.

Men and women of the Yuraks and Yenisei Samoyedes. From "Through Siberia." By Dr. F. Nansen. (London: W. Heinemann.)

A BIOLOGICAL PUZZLE.[1]

DR. BRUN, of Zürich, has done a fine piece of work in devising an elaborate and ingenious series of experiments which enable us to come to a decision among the rival theories of way-finding among ants. Let us first illustrate the facts. If we pick up one of the higher ants from an ant-road, turn it about in a box, and then empty it out again near the place of its capture, it makes no mistake in hurrying homewards. When an ant goes off alone on an exploring adventure, it often keeps persistently in one general direction, in spite of many divagations to one side or the other, and when it turns its face homewards, it does not usually retrace its steps, but pursues a parallel course until it comes near the nest. If a higher ant, such as *Formica rufa,* be gently but firmly induced to travel on a path chosen for it and not by it, it makes straight for home when freed from coercion. It may run along a line which is the hypotenuse of the triangle the other two sides of which it was compelled to follow, or it may complete a polygonal figure and reach the nest. If members of such species as *Formica rufa* and *F. sanguinea* be lifted up and carried some distance and put down in hunting ground which they have

[1] "Die Raumorientierung der Ameisen und das Orientierungsproblem im allgemeinen. Eine kritisch-experimentelle Studie; zugleich ein Beitrag zur Theorie der Mneme." By Dr. Rudolf Brun. Pp. viii+234+51 figs. (Jena: Gustav Fischer, 1914.) Price 6 marks.

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not visited for a fortnight, they will return home, quickly, confidently, and by the shortest way.

These are four illustrative facts out of many, and the question is how they are to be interpreted. Some authorities still believe that there is no getting past the assumption of a non-analysable sense of direction, such as the Martian of Du Maurier's novel had of the North Pole. Others have swung to the opposite extreme of taking too simple a view, and maintain that it is altogether a question of scent: ants, like dogs, living in a smell-world. Others again lay too heavy a burden on muscle-memory, and others on visual impressions gathered by the way. Dr. Brun shows clearly, we think, that the power of way-finding is usually a composite product, and that there is no mysterious sense of direction.

Of course, there are ants and ants, and there is no doubt that the scent of the nest, of the food, and of the pupæ sometimes counts for much. If two adjacent sections of a pre-arranged ant-road be lifted and interchanged, the travellers go on just as they were doing; but if a section of the road—say a zinc plate—be lifted and replaced with its ends reversed, the ants seem to be perplexed at the boundaries, and there may be a temporary block. Facts of this sort have given rise to over-ingenious theories of polarised scent, of positive and negative scent, and so forth. This much seems clear, that the nest-smell gets fainter in proportion to the distance from home, and that the food-smell increases as the source of supply is approached; and it is very instructive to find that if an ant of one of the olfactory species be transported and placed in the middle of one of the ant-roads, it does not go home right away, but takes a tentative run first in the one direction and then in the other. In some genera, however, such as Formica, smell counts for little, and the obliteration of the scent by brushing the road or pegging down a spread-out newspaper does not disturb the homing. In connection with smell, it may be noted that the seat of the olfactory sense is in the tips of the mobile antennæ, where tactility is also located, so that tactile and olfactory impressions are closely combined.

To many ants the illumination is much more important than scent, as Lord Avebury proved long ago. He got his ants to make a path across a wooden disc, concentric segments of which could be rotated, and found that if he turned a ring so that an ant on its journey was made to face the wrong way, it righted itself and proceeded in the old direction. But this was not the case when he made the experiment in uniform shade, or when he shifted the light at the same time as he rotated a segment of disc. One of Brun's experiments with a species of Lasius is very instructive. It was marching with the sun directly in its eyes, when the experimenter put an extinguisher over it, and kept it prisoner from 3 to 5 p.m. When it was set free at five o'clock, it turned its back on the position which the sun had reached, moving through 30°, and set off in a straight line homewards, eventually turning sharply to the left to reach its original starting-point. Numerous experiments confirm the view that the direction of the light serves as a compass. When Santschi shut off the sun with a large shade and made a false sun by means of a mirror, he got the ants, even on one of their main roads, to march in a direction either at right angles to the original one, or opposite to it, according to the position of the mirror. If, in the absence of sunlight, there be equal bipolar illumination of a given area, there is in many species no orientation.

From waxing and waning scent and from differential illumination, ants seem to build up associations, but this is not all. There is evidence in some cases of a memory of muscular movements, especially of the distance traversed, as if the ant kept its eye on a pedometer. There is something very interesting, too, in the phenomenon technically known as Turner's curves. A solitary ant that has travelled successfully from a considerable distance reaches a point quite near the nest; but instead of going on confidently, it stops as if perplexed. In many instances—80 per cent. in *Cataglyphis bicolor*—it proceeds to describe concentric curves, it may be for 5–15 minutes, and gradually draws near to the door of its home. Is it seeking for a sign, which might be a shining stone among the sand, or a scent, or the faint stridulation of one of its kin? Is it pursuing a trial and error method, very willing to be helped by any hint or combination of hints?

In some cases, *e.g.*, *Formica rufa*, Brun has proved a baræsthesia, or feeling of gravity. A table was gently tilted, with the nest at the foot of the slope; a feast of honey was placed in the centre; the ants climbed straight up and straight down again. But if, while an ant was supping honey, the table was gently tilted in the opposite direction, so that the way to the nest was up-hill, the ant persisted in going down-hill as before—away from, not towards, home. Among the highest ants Brun finds distinct evidence of definite local memory, based on visual, topographical, and topochemical data, and lasting for two or three weeks at least. And only thus can we understand the confidence with which one of these creatures, transported to a distant part of its range, will make for home. There are ants which trust mostly to scent, and others which are largely guided by the direction of light, but for the higher ants the orientation is a complicated process, the outcome of the registration of manifold imprints received from the outer world—imprints relating to the quantity and quality of scents, the general direction of light, the illumination of particular objects, the slope of the ground, the feel of things, the distance travelled, the turns of the road, the direction of the wind, and even, perhaps, sounds. Individual ants hereditarily endowed with great sensitiveness, hereditarily attuned to receive certain kinds of tidings, serve an apprenticeship in the establishment of associations and reach a degree of perfection probably unsurpassed. Such is Dr. Brun's general position, which he defends

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with strong experimental evidence. There are still to be found old-fashioned fishermen who have attained within a certain range to a wonderful seamanship of an empirical sort; they have built up a body of associations from wind and from wave, from the sky and the "feel" of the sea, and they are seldom far out in finding their way home. And so it is with the higher ants, except that they work even more exclusively from an instinctive basis.

It must be remembered that the orientation power of ants does not stand magically alone. Even brainless animals adjust their body in a position of physiological equilibrium in relation to a stimulus of light or warmth or gravity—a static orientation. When there is direction of locomotion in relation to an external stimulus, we speak of dynamic orientation. This dynamic orientation may be direct or indirect. It is direct when the stimulus or goal is within the range of immediate sense-perception, and it must be noted that for ants this range is only about a yard. Of this locomotor orientation there are various grades—tropistic, reflex, instinctive, and acquired, the first three expressing a hereditary predisposition, the fourth expressing the results of the individual's own learning. On a higher level is indirect orientation, where the goal is beyond the range of direct sensory perception. A complex of imprints or memories, corresponding to the goal, functions in the animal's sensorium, and forms the unifying centre of a whole series of imprints of the environment of the goal. What leads the creature on from step to step—often quickly and, so to speak, unquestioningly, if no contradictory interruption occurs—is the recognition of localised stimuli corresponding to those of the unified reference series. The orientation implies a chain of recognitions, and the recognitions imply a registration of individual experiences. Without using Brun's somewhat forbidding mnemic terminology, we cannot do justice to his carefully worked-out theory, but we have indicated its general nature. It is essentially what may be called psycho-biological, for he thinks of the organism as a historic being that trades with time, that enregisters imprints, and that has its past living in its present, as Bergson has accustomed us to say. These imprints, which the individual ant selectively accumulates, are not like sheets filed in a portfolio of reference; they are interpenetrated with and kept alive by their meaning for the actual everyday life.

PROF. JAMES GEIKIE, F.R.S.

BY the death of Prof. James Geikie, Edinburgh and its university have been deprived of one of the most prominent of its men of science, and geology has lost a distinguished investigator and successful teacher. The son of J. S. Geikie, of Edinburgh, whose literary talent found expression in a number of popular Scottish songs, the subject of this notice was educated at the high school and university of his native city, and in 1861, when only twenty-two years of age, received an appointment upon the Geological Survey of Scotland, a service in which his elder brother, Archibald, had already been engaged for five years. James Geikie's work as a surveyor lay chiefly in the south-west of Scotland, and in 1869 he was promoted to be a district surveyor; his studies seem to have been more particularly attracted, from a very early date, to the post-tertiary deposits, and in various papers in the scientific journals, as well as in the official memoirs of the survey, he published the results of his observations and his conclusions based upon them. Early in his career, James Geikie had become a great admirer and warm friend of Andrew Ramsay, then director of the English Geological Survey, and Ramsay's theoretical views and speculative suggestions found a stout supporter in the young Edinburgh geologist. In 1876 the Colonial Office requested Ramsay to proceed to Gibraltar in order to report on the important question of its water-supply, and James Geikie was chosen to accompany and assist him. In addition to the valuable report made to the Government, the two geologists were able to contribute to scientific journals memoirs dealing with the geology of Gibraltar, and especially with the superficial and cavern-deposits, and their bearing on the history of the Mediterranean in post-tertiary times.

In 1874 James Geikie had already published his conclusions concerning the history of the Glacial period in Britain in his well-known work, "The Great Ice Age," which has passed through three editions; and in 1881, after devoting his vacations to travel on both sides of the Atlantic, he extended the bearings of his views on the subject by the publication of his "Prehistoric Europe."

In the following year, however, James Geikie entered upon a new field of labour. The appointment of his elder brother to the directorship of the Survey necessitated his vacation of the Murchison professorship of geology at Edinburgh, and James Geikie received the appointment, resigning his position on the Survey. During his energetic and successful work of teaching, carried on for more than thirty years, he published a number of very valuable educational books: "Outlines of Geology," of which four editions were called for; "Fragments of Earth Lore"; "Earth Sculpture," two editions; and "Structural and Field Geology," three editions. His labours were not by any means limited to the special subject of his studies; he was one of the founders of the Royal Scottish Geographical Society, acting as editor of its journal, and for a time as president of the society. He was also for many years dean of the faculty of science in Edinburgh University. In 1875 he was elected a fellow of the Royal Society, and in 1889 received the Murchison medal of the Geological Society, while he was a member and correspondent of many scientific societies at home and abroad.

It was not only in his numerous scientific writ-

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