distance from their base, by a mass of less hardened epithelium, secreted by the surface of the palatal membrane or matrix of the whalebone in the intervals of the lamellar processes. This is the "intermediate substance" of Hunter, the "gum" of the whalers.

The function of the whalebone is to strain the water from the small marine mollusks, crustaceans, or fish upon which the whales subsist. In feeding they fill the immense mouth with water containing shoals of these small creatures, and then, on their closing the jaws and raising the tongue, so as to diminish the cavity of the mouth, the water streams out through the narrow intervals between the hairy fringe of the whalebone blades, and escapes through the lips, leaving the living prey to be swallowed. Almost all the other structures to which I am specially directing your attention, are, as I have mentioned, in a more or less rudimentary state in the Cetacea; the baleen, on the other hand, is an example of an exactly contrary condition, but an equally instructive one, as illustrating the mode in which nature works in producing the infinite variety we see in animal structures. Although appearing at first sight an entirely distinct and special formation, it evidently consists of nothing more than the highly modified papillæ of the lining membrane of the mouth, with an excessive and cornified epithelial development.

The bony palate of all mammals is covered with a closely-adhering layer of fibrovascular tissue, the surface of which is protected by a coating of non-vascular epithelium, the former exactly corresponding to the derm or true skin, and the latter to the epiderm of the external surface of the body. Sometimes this membrane is perfectly smooth, but it is more often raised into ridges, which run in a direction transverse to the axis of the head, and are curved with the concavity backwards; the ridges moreover do not extend across the middle line, being interrupted by a median depression or *raphé*. Indications of these ridges are clearly seen in the human palate, but they attain their greatest development in the Ungulata. In oxen, and especially in the giraffe, they form distinct laminæ, and their free edges develope a row of papillæ, giving them a pectinated appearance. Their epithelium is thick, hard, and white, though not horny. Although the interval between the structure of the ridges in the giraffe's palate and the most rudimentary form of baleen at present known is great, there is no difficulty in seeing that the latter is essentially a modification of the former, just as the hoof of the horse, with its basis of highly developed vascular laminæ and papillæ, and the resultant complex arrangement of the epidermic cells, is a modification of the simple nail or claw of other mammals, or as the horn of the rhinoceros is only a modification of the ordinary derm and epiderm covering the animal's body differentiated by a local exuberance of growth.

(*To be continued.*)

THE PERAK TIN-MINES[1]

THIS interesting memoir, which forms part of the *Archives des Missions scientifiques et littéraires*, série iii. vol. ix., gives the result of a seven months' exploration of the Malay State of Perak, made by the author, who was sent by the French Government upon a mission of scientific inquiry into the Malay Archipelago in 1881. Perak, although an insignificant unit among even the smallest States of the world, its extreme dimensions being only 95×50 miles, or an area of less than 5000 square miles, has long been known as a tin-producing country, being mentioned in the narratives of Tavernier, and the Dutch and Portuguese navigators of the seventeenth century; but it is only since the large influx of Chinese miners, consequent upon the suppression of the Taeping rebellion, that it has become of first-rate importance.

[1] "Les Mines d'Étain de Perak." Par J. Errington de la Croix. 8vo. Paris, 1882.)

The success attained by the first-comers led to a rapid increase of the Chinese population, who arrived in such numbers as to be soon beyond the control of the feeble Malay Government, and the mining being carried on without any regulations as to boundaries, the miners became divided into two parties, who made war upon each other with varying success, the Sultan looking on impartially during the contest, but siding with the winners. The defeated party in 1872 having taken to piracy at sea, was suppressed by English gunboats, and a resident was appointed for the purpose of keeping order; but the Malays having revolted in 1875, when the resident was murdered, the country has since been placed under a British protectorate, with a native rajah, under the title of Regent. This has been attended with the happiest results, the country having made great progress during the last six years, under the vigorous and enlightened management of the resident, Hugh Low, Esq., C.M.G., and now bids fair, according to the author, to become the most considerable producer of tin in the world.

The mines worked up to the present are entirely alluvial or stream works, the watercourses being filled with sand and gravel deposits to a depth of 20 or 30 feet, resting upon a floor of pure china clay, apparently derived from the decomposition of the granitic rocks forming the numerous parallel ridges which traverse the country from north to south. The geological description is necessarily imperfect owing to the dense tropical vegetation which covers the entire county; but the author has been able to establish the presence of numerous quartz veins traversing the granites which are coarsely porphyritic in the centre and largely charged with tourmaline at the edges of the masses, in fact reproducing the phenomena observed in the north-western tin districts of Cornwall. No mines have as yet been opened in any of these veins, but the author speaks of blocks of tin ore weighing more than 1 cwt. as having been found in the immediate vicinity of the hills, which are evidently not far removed from their original position. The bulk of the production is, however, derived from smaller rounded crystalline masses and grains contained in the lower part of the alluvial gravel, the workable thickness ranging from 7 to 10 feet, and the proportion of clean ore or "black tin" from about 1 to 4½ per cent. by weight. This is remarkable for its purity, being almost entirely free from wolfram, arsenic, and other foreign substances, which are so troublesome to the Cornish tin-miner. The methods of working, mechanical preparations, and smelting of the ore are of the simplest possible kind, the work, with the exception of a few centrifugal steam-pumps, and of Chinese chain-pumps driven by water-wheels, being entirely carried out by manual labour, with furnaces and other appliances of the most primitive types. This simplicity adds considerably to the interest of the author's detailed and carefully illustrated description, which enables the reader to realise in imagination the conditions prevailing in our western districts in the days when the Phœnicians traded with the Cornish miners for tin at St. Michael's Mount. Under the new British rule, the country has made rapid progress, the output of tin having risen from 2059 tons in 1876 to 5994 tons in 1881, the whole of which is exported through Penang. As at the latter date the cost of production, including revenue charges of about 17*l*., was estimated at about 61*l*. per ton, while the local selling price was 88*l*., showing a profit of 45 per cent., the popularity of the business is sufficiently explained. It is not probable, however, that such large profits will continue to be realised after the more productive deposits have been exhausted. It does not appear from the narrative that European labour of any kind is employed, the workpeople belonging to three races, namely, Malay aborigines, Klings or coolies from Madras and the Malabar coast, and Chinese, the latter supplying the whole of the miners, smelters and other artisans directly employed in producing the metal. The author has a very high opinion of the Chinese miners, who are described as sober, regular in work, and accustomed to cooperative enterprises, against which, however, must be set the defects of being addicted to excess in opium and gambling, besides being very quarrelsome and exceedingly superstitious. The latter failing is, however, of interest as reproducing the old European legends of guardian genii of the mine, the "Kobads" of Germany and "Knockers" of Cornwall, who require to be propitiated by sacrifices and kept in good humour by orderly behaviour on the part of the miners. Infractions of the last rules are punished by the withdrawal of the guardian gnome, who takes all the unwrought ore in the mine away with him.

The execution of the work, both as regards illustration and typography, are exceedingly good, and reflect great credit upon the French National Printing Office.

H. B.

THE SIZE OF ATOMS[1]

FOUR lines of argument founded on observation have led to the conclusion that atoms or molecules are not inconceivably, not immeasurably small. I use the words "inconceivably" and "immeasurably" advisedly. That which is measurable is not inconceivable, and therefore the two words put together constitute a tautology. We leave inconceivableness in fact to metaphysicians. Nothing that we can measure is inconceivably large or inconceivably small in physical science. It may be difficult to understand the numbers expressing the magnitude, but whether it be very large or very small there is nothing inconceivable in the nature of the thing because of its greatness or smallness, or in our views and appreciation and numerical expression of the magnitude. The general result of the four lines of reasoning to which I have referred, founded respectively on the undulatory theory of light, on the phenomena of contact electricity, on capillary attraction, and on the kinetic theory of gases, agrees in showing that the atoms or molecules of ordinary matter must be something like the 1/10,000,000, or from the 1/10,000,000 to the 1/100,000,000 of a centimetre in diameter. I speak somewhat vaguely, and I do so, not inadvertently, when I speak of atoms and molecules. I must ask the chemists to forgive me if I even abuse the words and apply a misnomer occasionally. The chemists do not know what is to be the atom; for instance, whether hydrogen gas is to consist of two pieces of matter in union constituting one molecule, and these molecules flying about; or whether single molecules each indivisible, or at all events undivided in chemical action, constitute the structure. I shall not go into any such questions at all, but merely take the broad view that matter, although we may conceive it to be infinitely divisible, is not infinitely divisible without decomposition. Just as a building of brick may be divided into parts, into a part containing 1000 bricks, and another part containing 2500 bricks, and those parts viewed largely may be said to be similar or homogeneous; but if you divide the matter of a brick building into spaces of nine inches thick, and then think of subdividing it farther, you find you have come to something which is atomic, that is, indivisible without destroying the elements of the structure. The question of the molecular structure of a building does not necessarily involve the question, Can a brick be divided into parts, and can those parts be divided into much smaller parts? and so on. It used to be a favourite subject for metaphysical argument amongst the schoolmen whether matter is infinitely divisible, or whether *space* is infinitely divisible, which some maintained, whilst others maintained only that *matter* is not infinitely divisible, and demonstrated that there is nothing inconceivable in the infinite subdivision of space. Why, even time was divided into moments (time-atoms!), and the idea of continuity of time was involved in a halo of argument, and metaphysical—I will not say absurdity—but metaphysical word-fencing, which was no doubt very amusing for want of a more instructive subject of study. There is in sober earnest this very important thing to be attended to, however, that in chronometry as in geometry, we have absolute continuity, and it is simply an inconceivable absurdity to suppose a limit to smallness whether of time or of space. But on the other hand, whether we can divide a piece of glass into pieces smaller than the 1/100,000 of a centimetre in diameter, and so on without breaking it up, and making it cease to have the properties of glass, just as a brick has not the property of a brick wall, is a very practical question, and a question which we are quite disposed to enter upon.

[1] A lecture delivered by Sir William Thomson at the Royal Institution, on Friday, February 2. Revised by the Author.

I wish in the beginning to beg you not to run away from the subject by thinking of the exceeding smallness of atoms. Atoms are not so exceedingly small after all. The four lines of argument I have referred to make it perfectly certain that the molecules which constitute the air we breathe are not very much smaller, if smaller at all, than 1/10,000,000 of a centimetre in diameter. I was told by a friend just five minutes ago that if I give you results in centimetres you will not understand me. I do not admit this calumny on the Royal Institution of Great Britain; no doubt many of you as Englishmen are more familiar with the unhappy British inch; but you all surely understand the centimetre, at all events it was taught till a few years ago in the primary national schools. Look at that diagram (Fig. 1), as I want you all to understand an

One centimetre. One millimetre.

FIG. 1.

inch, a centimetre, a millimetre, the 1/10 of a millimetre, and the 1/100 of a millimetre, the 1/1,000 of a millimetre, and the 1/1,000,000 of a millimetre. The diagram on the wall represents the metre; below that the yard; next the decimetre, and a circle of a decimetre diameter, the centimetre and a circle of a centimetre, and the millimetre, which is 1/10 of a centimetre, or in round numbers 1/40 of an inch. We will adhere however to one simple system, for it is only because we are in England that the yard and inch are put before you at all, among the metres and centimetres. You see on the diagram then the metre, the centimetre, the millimetre, with circles of the same diameter. Somebody tells me the millimetre is not there; I cannot see it, but it certainly is there, and a circle whose diameter is a millimetre, both accurately painted in black. I say there is a millimetre and you cannot see it. And now imagine *there* is 1/10 of a millimetre, and *there* 1/100 of a millimetre and 1/1000 of a millimetre, and *there* is a round atom of oxygen 1/1,000,000 of a millimetre in diameter. You see them all.

Now we must have a practical means of measuring, and optics supply us with it for thousandths of a millimetre. One of our temporary standards of measurement shall be the wave-length of light; but the wave-length is a very indefinite measurement, because there are wave-lengths for different colours of light, visible and invisible, in the ratio of 1 to 16. We have, as it were—borrowing an analogy from sound—four octaves of light that we know of. How far the range in reality extends above and below the range hitherto measured, we cannot even guess in the present state of science. The table before you (Table I.) gives you an idea of magnitudes of length,