and the baleen whales or *Mysticetes*, and none of the known extinct forms present true transitional or intermediate characters; but it must be remembered that even such remains as have been already collected have not yet been thoroughly worked out. The Mysticetes appear, at first sight, the most specialised and aberrant, in the absence of teeth, in the presence of whalebone or baleen, in the form and size of the mouth; but as we see in other groups, dental characters and all such as relate to the prehension of food generally, are essentially adaptive, and consequently plastic or prone to variation, and hence cannot well be relied upon as tests of affinity. In another character, also adaptive, the laxity of the connection of the ribs with the vertebral column and with the sternum, and the reduction of that bone in size, allowing great freedom of expansion of the thoracic cavity, for prolonged immersion beneath the water, the Mysticetes have passed beyond the Odontocetes in specialisation. On the other hand, the great symmetry of the skull, the more anterior position of the nares, and their double external orifice, the form of the nasal bones, the presence of a distinctly developed olfactory organ, the mode of attachment of the periotic bone to the cranium, the presence of a cæcum, and the regular arrangement of the alimentary canal, the more normal characters of the manus and the better development of the muscles attached to it, and the presence (in many species at least) of parts representing a hind limb, all show less deviation from the general mammalian type than is presented by the Odontocetes. Taking all their structural characters into consideration, as well as what we know of their past history, it does not appear that we can consider either type to have been derived from the other, at all events in the form in which we see it now, but must rather view them as parallel groups.

Among the Mysticetes, in the especially distinguishing characters of the division, the *Balænopteræ* are less specialised than the *Balænæ*, which in the greater size of the head, the length and compression of the rostrum, the development of the baleen, and the shortness of the cervical region, are exaggerated types of the former, and yet they retain more fully some primitive characters, as the better development of the hind limb, the pentadactylous manus, and the absence of a dorsal fin. Both forms are found distinct in a fossil state as far back as the early Pliocene, but generally represented by smaller species than those now existing. The Mysticetes of the Miocene seas were, as far as we know at present, only *Balænopteræ*, some of which (*Cetotherium*, Brandt) were, in the elongated flattened form of the nasal bones, the greater distance between the occipital and frontal bones at the top of the head, and the greater length of the cervical vertebræ more generalised than those now existing. In the form of the mandible they are considered by Van Beneden to present more approximation to the Cetodonts.

Among the toothed whales, the earliest known form, the *Zeuglodon*, was far the most aberrant, approaching in the structure of its skull and teeth to a more generalised but very low carnivorous type. In smallness of cerebral cavity, compared to the mouth and other parts of the skull, it is as far below all other known cetaceans, as the singular *Arctocyon primævus* is below all carnivores. One could quite imagine that the skull of a very degraded seal would present many features in common with Zeuglodon, and this is the only near link we seem to possess between the Cetacea and the rest of the animal world. All the resemblances which some naturalists have seen between the skull of Zeuglodon and the Sirenia are purely superficial and imaginary. The forward position of the narial aperture and the length and flatness of the nasal bones which this animal possesses in common with (though to a greater extent than) the Mysticetes, we may suppose to be common primitive cetacean characters, though completely lost in all other known Odontocetes. Even the Squalodons, which in dental characters so much resemble the Zeuglodons as to have been placed in the same genus by some zoologists, agree in their essential cranial characters with the ordinary dolphins. They are, in fact, dolphins with double-rooted molar teeth, peculiar to the Miocene formations of Europe and America. Among existing dolphins, *Platanista* has been considered to conform most to the general type of mammalian structure. It is therefore interesting to find a similar form (*Champsodelphis*) well represented among the earliest fossil remains of Cetaceans in Europe, and others abundant in North America. Apart from these the greater number of toothed whales range themselves under the two principal heads of *Ziphioids* or *Physeteroids*, and *Delphinoids*. The former are an ancient group, of which the remains are exceedingly numerous in the Antwerp and Norwich crags, and of which the existing sperm whale is a highly modified and specialised form. Among the latter, *Delphinus* and its various modifications may be regarded as the dominating type of Cetaceans at the present day, abundant in slightly differentiated species, and abundant in individuals. They are in this respect to the rest of the order, much as the hollow-horned ruminants are to the Ungulates.

It seems in vain at present to speculate upon the origin of the Cetacea. They present no marks of closer affinity to the lower classes of Vertebrates than do the rest of their own class. Indeed, in all that characteristically distinguishes a Mammal from the oviparous Vertebrates, especially in the nervous and reproductive systems, they are far above many other groups of the class. There is no existing order of land mammals to which they can be said to be decidedly and unquestionably allied. Their agreement with the *Sirenia* is mainly in modifications of structure adapted for a somewhat similar mode of existence, while in many essentials the difference between them is as wide as that between any other two orders. Taking into consideration many of their habits, and their food, and bearing *Zeuglodon* in mind, a relationship to the Carnivora through the seals seems indicated; but if the mode of development has the weight many modern zoologists are disposed to assign to it, their affinities would be rather with the Ungulates, an order from which, on other grounds, they are far removed.

(*To be continued.*)

ON REPULSION RESULTING FROM RADIATION.—PART IV.[1]

IN this paper the author describes experiments on the repulsion produced by the different rays of the solar spectrum. The apparatus employed is a horizontal beam suspended by a glass fibre, and having square pieces of pith at each end coated with lampblack. The whole is fitted up and hermetically sealed in glass, and connected with an improved mercury-pump. In front of the square of pith at one end a quartz window is cemented to the apparatus; and the movements of the beam, when radiation falls on the pith, are observed by a reflected ray of light on a millimetre-scale. The apparatus was fitted up in a room specially devoted to it, and was protected on all sides, except where the rays of light had to pass, with cotton-wool and large bottles of water. A heliostat reflected in a constant direction a beam of sunlight, which was received on an appropriate arrangement of slit, lenses, and prisms for projecting a pure spectrum. Results were obtained in the months of July, August, and September; and they are given in the paper graphically as a curve, the maximum being in the ultra-red, and the minimum in the ultra-violet. Taking the maximum at

[1] Abstract of a paper read befor the Royal Society, Feb. 10, 1876, by William Crookes, F.R.S., &c.

100, the following are the mechanical values of the different colours of the spectrum :—

Ultra-red	100
Extreme red	85
Red	73
Orange	66
Yellow	57
Green	41
Blue	22
Indigo	$8\frac{1}{6}$
Violet	6
Ultra-violet	5

A comparison of these figures with those usually given in text-books to represent the distribution of heat in the spectrum is a sufficient proof that the mechanical action of radiation is as much a function of the luminous rays as it is of the dark heat-rays.

The author discusses the question, "Is the effect due to heat or to light?" There is no real difference between heat and light; all we can take account of is difference of wave-length; and a ray of a definite refrangibility cannot be split up into two rays, one being heat and one light. Take, for instance, a ray of definite refrangibility in the red. Falling on a thermometer it shows the action of heat, on a thermopile it produces an electric current, to the eye it appears as light and colour, on a photographic plate it causes chemical action, and on the suspended pith it causes motion. But all these actions are inseparable attributes of the ray of that particular wave-length, and are not evidence of separate identities.

The author enters into some theoretical explanations of the action of the different parts of the spectrum, but these cannot well be given in abstract.

An experiment is described by which sunlight was filtered through alum, glass, and water screens, so as to cut off the whole of the ultra-red or dark-heat rays. The ray of light which was thus freed from dark heat was allowed to fall on the pith surface of the torsion-apparatus, when it produced a deflection of 105°. On interposing a solution of iodine in disulphide of carbon the deflection fell to 2°, showing that the previous action was almost entirely due to *light*. With a candle tried under the same circumstances, the light filtered from dark heat produced a deflection of 37°, which was reduced to 5° by interposing the opaque solution of iodine.

In order to obtain comparative results among discs of pith coated with lampblack and with other substances, a torsion-apparatus was constructed in which two or more discs could be exposed one after the other to a standard light. One disc always being lampblacked pith, the other discs could be changed so as to get comparisons of action. If the action of radiation from a candle on the lampblacked disc be taken as 100, the following are the proportions obtained :—

On Lampblacked pith	100
Iodide of palladium	87·3
Precipitated silver	56
Amorphous phosphorus	40
Sulphate of baryta	37
Milk of sulphur	31
Red oxide of iron	28
Scarlet iodide of mercury and copper ...	22
Lampblacked silver	18
White pith	18
Carbonate of lead	13
Rock-salt	6·5
Glass	6·5

In consequence of some experiments tried by Professors Tait and Dewar, and published in NATURE, vol. xii. p. 217, the author fitted up a very sensitive apparatus for the purpose of carefully examining the action of radiation on alum, rock-salt, and glass. The source of radiation was a candle. Perfectly transparent and highly polished plates of the same size were used, and the deflection was made evident by an index ray of light. Taking the action on the alum at 100, that on the rock-salt in five successive experiments was 81, 77·3, 71, 62·5, 60·4. This increasing action on the alum was found to be caused by efflorescence, which took place rapidly in the vacuum, and rendered the crystal partially opaque. A fresh alum plate being taken, this and the rock salt were coated with lampblack and replaced in the apparatus, the black side away from the source of radiation, so that the radiation would pass through the crystal before reaching the lampblack. The action of radiation was in the proportion of blacked alum 100 to blacked rock-salt 73.

Rock-salt and glass were next tested against each other *in vacuo* in a torsion-balance. Professors Dewar and Tait say that rock-salt is inactive when the beam from a candle is thrown on it, while a glass disc is active. The author has failed to corroborate these results; he found the mean of several concordant observations to be—rock-salt 39, glass 40.

The Measurement of the Force.—The author describes a torsion-balance in which he is enabled to weigh the force of radiation from a candle, and give it in decimals of a grain. The principle of the instrument is that of W. Ritchie's torsion-balance, described in the Philosophical Transactions for 1830. The construction is somewhat complicated, and cannot be well described without reference to the diagrams which accompany the original paper. A light beam, having two square inches of pith at one end, is balanced on a very fine fibre of glass stretched horizontally in a tube, one end of the fibre being connected with a torsion-handle passing through the tube, and indicating angular movements on a graduated circle. The beam is cemented to the torsion-fibre, and the whole is enclosed in glass and connected with the mercury-pump and exhausted as perfectly as possible. A weight of 0·01 grain is so arranged that it can be placed on the pith or removed from it at pleasure. A ray of light from a lamp reflected from a mirror in the centre of the beam to a millimetre-scale 4 feet off shows the slightest movement. When the reflected ray points to zero, a turn of the torsion-handle in one or the other direction will raise or depress the pith end of the beam, and thus cause the index ray to travel along the scale to the right or to the left. If a small weight is placed on one end so as to depress it, and the torsion-handle is then turned, the tendency of the glass fibre to untwist itself will ultimately balance the downward pressure of the weight, and will again bring the index ray to zero. It was found that when the weight of the $\frac{1}{100}$ of a grain was placed on the pith surface, the torsion-handle had to be turned twenty-seven revolutions and 353°, or 10073° before the beam became horizontal. The downward pressure of the $\frac{1}{100}$ of a grain was therefore equivalent to the force of torsion of the glass thread when twisted through 10073°.

The author next ascertained what was the smallest amount of weight which the balance would indicate. He found that 1° of torsion gave a very decided movement of the index ray of light, a torsion of 10073° balancing the $\frac{1}{100}$ of a grain, while 10074° overbalanced it. The balance will therefore turn to the $\frac{99}{100000000}$ of a grain.

Divide a grain weight into a million parts, place one of them on the pan of the balance, and the beam will be instantly depressed.

Weighed in this balance the mechanical force of a candle 12 inches off was found to be 0·000444 grain; of a candle 6 inches off 0·001772 grain. At half the distance the weight of radiation should be four times, or 0·001776 grain; the difference between theory and experiment being only four millionths of a grain is a sufficient proof that the indications of this instrument, like those of the apparatus previously described by the author, follow rigidly the law of inverse squares. An examination of the differences between the separate observations and the mean shows that the author's estimate of the sensitiveness of his balance is not excessive, and that in practice it will safely indicate the millionth of a grain.

One observation of the weight of sunlight is given; it was taken on December 13; but the sun was so obscured by thin clouds and haze that it was only equal to 10·2 candles 6 inches off. Calculating from this datum, it is seen that the pressure of sunshine is 2·3 tons per square mile.

The author promises further observations with this instrument, not only in photometry and in the repulsion caused by radiation, but in other branches of science in which the possession of a balance of such incredible delicacy is likely to furnish valuable results.

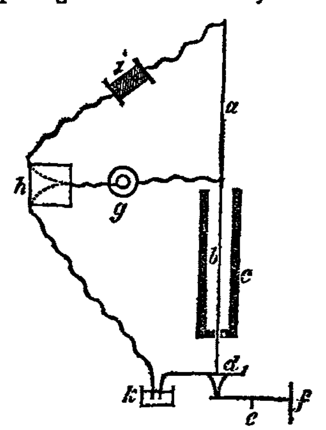
SCIENCE IN GERMANY

(*From a German Correspondent.*)

A FEW years ago Edlund attempted to decide the question whether the galvanic current is capable of directly altering the volume of a conductor through which it flows, or not, *i.e.*, whether changes of volume were demonstrable that were independent of the heat produced in the conducting wire? The results of his experiments appeared to furnish an affirmative answer to this question. More recently, Streintz published an investigation, the result of which was a confirmation of Edlund's view on the expanding power of the galvanic current. The expanding action found by Edlund was from 2·8 to 6·5 per cent. of the action of the heat simultaneously produced; that found by Streintz was considerably greater. In soft iron it amounted to 27 per cent. of the action of the heat.

From the fundamental importance which attaches to this question, in relation to the theory of galvanism, and from the difficulty of demonstrating the volume-changes referred to, apart from the actions of the heat simultaneously produced, it was desirable that the subject should be investigated by a method as free from error as possible. Such an investigation has lately been carried out by Herr Exner, in Vienna. The essential points of his method are as follows:—

Two pieces, *a* and *b*, of the same wire, about equally long, were suspended vertically one over the other, as indicated schematically in the figure. The lower piece, *b*, passed centrally through a glass tube, *c*, which was quite open above, but closed below with a cork, which merely gave passage to the wire *b* by a short glass tube



(2mm. wide) inserted in it. From the lower end of the wire *b* hung the plate *d* for holding weights. This was furnished at its base with a sharp iron point, meant to act on one arm of a lever which could be turned about *e*, while the other arm bore the mirror *f* at right-angles to its axis, and so in a vertical plane. If the image of a vertical scale were observed in this mirror with a telescope, the least change in length of the wires *a* and *b* could thereby be perceived. From the point of connection between *a* and *b* a wire was connected with the battery *g*. The other pole of the battery was connected with the commutator *h*, and thus the current could be sent either through the rheostat *i* to the suspending point of the wire *a* and through the latter back to the battery, or on the other side to the mercury cup *k*, in which is dipped the bent end of a short copper wire soldered to the plate, *d*, establishing thus a conductive connection between the commutator *h* and the wire *b*. Through the latter the current then went back to the battery. One could thus easily send the current successively through each of the two wire-pieces, *a* and *b*, separately, and so observe the elongation experienced by each. Since, as has been said, the two pieces *a* and *b* were not exactly equal in length, their elongations were also not exactly equal; to make them equal, the rheostat *i* was inserted, by which the resistance in the circuit *g h i a g* was so regulated, that with unchanged battery the successively observed elongations of *a* and *b* were the same. Water was now allowed to pass through the glass tube *c*, in order to take away as much as possible of the heat produced in the wire *b* by the galvanic current. If, now, the current passed through *b*, only the elongation which might occur independently of the heat action of the current would be observed, the heat produced being removed by the flowing water.[1] If, however, the current passed through *a*, both an elongation produced in *a* through direct action of the current, and the elongation through action of heat would be observed at the same time. [These experiments might of course also be made with only one piece of wire, *e.g.* *b*. The second piece *a*, serves only for making the obvervations more quickly in succession.]

It was found that the galvanic expansion expressed in percentage of the heat-expansion was only about 1·2 to 2·2 per cent.; and no connection was recognisable with the nature of the metal employed. If it be considered that these values, of course, can only be an upper limit, it will follow from the smallness of the effect obtained that there is no sufficient ground for the hypothesis of a special expansion-power of the galvanic current. There can hardly be any doubt that the slight expansion which the water-inclosed wire still shows is simply and alone due to the heat remaining in it. W.

THE INTERNATIONAL METRIC COMMISSION AT PARIS

IN previous numbers of NATURE[2] some information has been given of the proceedings of the International Metric Commission of Paris, and of the progress of their work in providing new international standards of the metric system. The construction of the new standard metres and kilogrammes of platinum-iridium, which was entrusted to the French section of the Commission, is now approaching completion, and their comparisons with the old standards of the Archives and with each other will probably be commenced early this spring.

It has been already explained that the definitive verification of the new standards was entrusted by the Commission to a permanent committee of twelve of their members, each representing one of the principal civilised countries interested. For the purposes of providing the committee with the necessary means of exercising their duties, and of giving an authoritative international character to the new standards, and to the regulations to be adopted for the custody and use of the new international metric prototypes, a diplomatic conference was held at Paris in March 1875, when a convention was entered into for effecting these objects.

Papers relating to the meeting and proceedings of this diplomatic conference, drawn up by Mr. Chisholm, the Warden of the Standards, who was the representative of

[1] It may happen that the heat of the wire is not entirely carried off by the flowing water.

[2] Vol. vii. pp. 197 and 237; vol. viii. p. 403; vol. x. p. 130.