find its service increase in importance as he makes his way into the highest parts of the subject.

Of course no attempt is here made to attack D-ism, but to state that it and Dot-ism have their proper spheres, the latter generally, with more or less appropriateness, throughout the whole realm of functions, the former in the realm of motion, where the functions are functions of t—the sway over which realm was originally given to it by Newton, and acknowledged, as I have been told, by the D-ist Lagrange.

Glasgow College THOMAS MUIR

Occurrence of the Eagle Ray

A DOUBLE-SPINED specimen of the eagle ray (*Myliobatis aquila*), taken in Torbay on the 1st Nov., has been presented to this museum by Mr. Frank Gosden, fish dealer, High Street, Exeter. Its dimensions are as follows:—Breadth across the fins, 2ft. 3½in.; length from snout to the base of the spines, 1ft. 7¾in.; total length from snout to extremity of the tail, 3ft. 6½in. W. S. M. D'URBAN, Curator

Albert Memorial Museum, Exeter

Deep Sea Dredging

WHILE winter allows of time for complete arrangements to be made in anticipation of dredging weather, will you permit me to raise the question of the conditions under which our knowledge of the natural history of the sea may be most readily extended?

As a rule, yacht owners object to the fatigue and dirt of dredging, but as we have the successful example of the *Norna*, may we not hope that other yachts may further the cause of science, if assistance in the way of instruction or apparatus be afforded to them by those having the necessary experience and means?

The idea of now urging the question is not mine alone, but is entertained by many ardent naturalists who are much in favour of a skilful search of our seas at home, as well as of the Mediterranean and other distant and almost untried seas.

Your pages have often borne witness to the interest and importance attaching to marine zoology, and if men of practical experience, such as Carpenter, W. Thomson, Marshall Hall, &c., will indicate the best localities for search and the best measures to adopt, we may hope that others may follow in their steps, and that the large aquaria now built and building will be supplied, as only private zeal and enterprise can compass, with new and rare specimens from deep waters.

T. H. HENNAH

Milton House, Clarence Street, Brighton, Dec. 5

The Solar Halo

THE solar halo of the morning of the 13th ult. described in your last number as seen near, and at about thirty miles from, Durham, and which Prof. A. S. Herschel conjectures may have been seen from more distant stations, was visible here.

I first saw it at about 8 A.M., when it appeared as the arc of a circle, with a very short portion of an inverted arc touching it at the vertex—the sun itself being hidden by a bank of cloud, from behind which issued several radiating spikes. Shortly after half-past nine this halo had disappeared, except a small portion at the point of contact of the two arcs, vertically over the sun, which appeared like a bright elongated patch, forked at each end, and projected not on mist, but on blue sky, and tinged with dull prismatic colours, which were most strongly marked in the inverted arc, in which the red or orange was downwards, or on the outside of the circle. I then suddenly caught sight of a second halo, of much greater radius than the first—visible through perhaps 130° or 140° of arc, above, and to the right of, the sun, projected on the clear blue sky, but so faintly that it might easily have been missed. This outer circle exhibited the prismatic colours with a purity and delicacy that I have never before seen in halos, and which was quite different to the ordinary dull, muddy colours. In fact, it had just the appearance of a very faint and *narrow* rainbow, the red being inside, and the blue outside the circle. I was shortly after able to borrow a sextant, and measured the distance from the sun to the bright patch and the outer circle, which appeared respectively 21° 40′ and 43° 20′; but they were already growing so faint that I was unable to do this with much precision. Except the bright patch before named, I did not observe any appearance of "mock-sun."

Cardiff, Dec. 4 GEO. C. THOMPSON

ON THE ZIPHIOID WHALES

THE peculiar division of Cetaceans to which the term "Ziphioid" is now commonly applied, from one of the earliest known forms, *Ziphius* of Cuvier,* is in many respects one of the most interesting of the order. They form a very compact group, united closely together by the common possession of very definite structural characters, and as distinctly separated from all other groups by equally definite characters.

With the singular exception of *Hyperoodon rostratus* (the structure and habits of which species are as well known, perhaps, as those of any other cetacean), no specimen of the group had ever come under the notice of any naturalist up to the commencement of the present century. Since that time, however, at irregular intervals, in various and most distant parts of the world, solitary individuals have been caught or stranded, now amounting to nearly thirty, these being by some naturalists referred to upwards of a dozen distinct species and to very nearly as many genera. No case is recorded of more than one of these animals having been observed at one place at a time, and their habits are almost absolutely unknown. Their very presence in the ocean seems to pass unnoticed and unsuspected by voyagers, and even by those whose special occupation is the pursuit and capture of various better known and more abundant cetaceans, until one of the accidental occurrences just alluded to reveals the existence of forms of animal life of considerable magnitude, and at least sufficiently numerous to maintain the continuity of the race.

This comparative rarity at the present epoch contrasts greatly with what at one time obtained on the earth, especially in the period of the crag formations, and leads to the belief that the existing ziphioids are the survivors of an ancient family which once played a far more important part than now among the cetacean inhabitants of the ocean, but which have been gradually replaced by other forms, and are themselves probably destined ere long to share the fate of their once numerous allies or progenitors.

The Ziphioid whales belong to the great primary division or sub-order of the Odontocetes or Toothed whales, as distinguished from the Whalebone whales. They are allied on the one hand to the Cachalots or Sperm whales, and on the other to the true Dolphins and Porpoises, but more nearly to the former than the latter. They are animals varying between fifteen and thirty feet in length, and in external characters very closely resemble each other, all having small pointed snouts or "beaks," small rounded or oval pectoral fins or "flippers," a comparatively small triangular dorsal fin, situated considerably behind the middle of the back, and a single "blowhole" of concentric form, situated in the middle of the top of the head. One of their most obvious characteristics, distinguishing them from the true dolphin, is the complete absence of teeth (except occasionally a few mere rudiments concealed in the gum) in the upper jaw, while in the lower jaw there is usually but a single pair, which in some species may be greatly developed and project like tusks from the mouth, though sometimes even these are rudimentary and covered up by the gum, so that the animal is practically toothless. In addition to these external and easily-recognised characters, there are others connected with the skeleton and internal organs which separate them still more trenchantly from the other members of the order. Their food appears

* "J'appliquerai au genre dont elle (a skull found on the shore of the Mediterranean) devient le premier type, le nom de Ziphius, employé par quelques auteurs du moyen age (Voyez Gesner I., p. 209) pour un cétacé qu'ils n ont point déterminé" (Cuvier, "Ossemens fossiles"). According to strict rules of priority "Hyperodontoid" would be the more correct term, as Hyperoodon was the first genus of the group distinctly characterised; but as the name is erroneous in its signification, it will be better to keep to the more generally adopted and less objectionable term of "Ziphioid," first applied by Gervais. The group is equivalent to Eschricht's "Rhynchoceti."

to consist almost exclusively of cephalopods, or cuttlefish-like animals.

One of the greatest obstacles to acquiring a more accurate knowledge of this group is the excessively confused state of the nomenclature of the different animals of which it is composed. Nearly every single specimen that has been met with has been described under a different name, and before their characters and affinities were understood they were bandied about from one genus to another, even different individuals of the same species having been placed by systematists in different genera, until it has become almost impossible to write or speak of any of them, without the fear of inadvertently adding to the perplexity of those that come after, by adopting and perpetuating some ill-chosen or incorrect term.

In a valuable recent memoir on the subject by Prof. Owen,* the difficulty is disposed of in a very summary manner by uniting all the known forms, both recent and extinct (with the exception of *Hyperoodon*), under the generic name of *Ziphius*. This proceeding, at all events, has the merit of running no risk of adding to the confusion of nomenclature, caused by hasty or ill-defined generic subdivisions, founded on imperfect or fragmentary knowledge of the animal described. But, however great our admiration may be for this strong-handed resistance to the passion for name-coining, which is fast rendering the study of zoology almost an impossibility, it must not lead us to overlook well-marked structural characteristics by which certain small groups of species are allied together, and differentiated from others, whether we call them genera or by any other term.

In a paper recently presented to the Zoological Society (read Nov. 7), I have given reasons for my belief that the species of ziphioids at present known (I refer only to those now existing, not to the extinct forms), may be naturally arranged by certain structural characters, especially the conformation of the skull and teeth, into four groups; and as, so far as is yet known, these are not united by intermediate forms, they may, I think, be considered as generic, though of course this is a subject upon which the judgment of different zoologists may differ. This arrangement does not differ from that adopted by several other zoologists, who have specially studied the animals of this group, but the characteristics of each section or genus have not hitherto been clearly defined.

It is not my present purpose to enter into the details of these characteristics, for which I must refer to the above-mentioned communication, but to give a short summary of the known zoological facts relating to the different animals of which each is composed, so that a general idea may be gained of our present state of knowledge of the whole group.

I. Genus *Hyperoodon*, Lacépède.—This genus differs from the rest in having a very prominent convex "forehead" as it appears externally, though really corresponding to the lower part of the face of other animals, supported by strong bony crests on the maxilla, and below which the small pointed snout projects, something like the neck of a bottle from its shoulder, hence the name "Bottle-nose" often applied to these animals, in common with various other cetaceans. The common Hyperoodon (*H. rostratus*) is, as before mentioned, one of the best known of cetaceans, being a regular visitor to our coasts, and having been frequently described and figured by naturalists who have had opportunities of observing it in a fresh state. Skeletons, moreover, are to be seen in nearly every considerable osteological museum. The first really good description and figure is that of John Hunter, founded on an individual which was caught in the Thames near London Bridge, in the year 1783, and the skeleton of which still hangs in the great hall of the Museum of the Royal College of Surgeons. The figure of the animal appears in the Philosophical Transactions for 1787. Among the numerous subsequent contributions to the knowledge of the structure and natural history of this species, the monographs of Vrolik and of Eschricht are of especial importance.

The common Hyperoodon attains the length of twenty to twenty-five feet. It has no functional teeth, the only two which it possesses are quite small and buried in the gum at the front end of the lower jaw, but the palate is beset with numerous minute horny points. As in many other whales in which the teeth are either absent or very rudimentary when adult, it possesses a complete set at a very early period of its growth, but the majority of these disappear even before birth. Judging by the contents of the stomach of the captured specimens, their food consists of several kinds of squid and cuttlefish, and not of true fish; they are, therefore, not the enemies to fishermen that some have supposed them, but rather the reverse, for the cuttles, of which they destroy great quantities, are themselves voracious fish-eaters. In geographical range this species is limited to the North Atlantic, having been found both on the American and European coasts, extending as far north as Greenland, but its southern limit has not been accurately determined; it has, however, never been known to enter the Mediterranean. Within this range it is migratory, spending the summer in the Polar seas and the winter in the Atlantic, and it is chiefly on its passage northwards in the spring and southwards in the autumn that it visits our shores. It happens almost every year that in the last-named season one or more are stranded on some part of the extensive coast-line of the British Isles; usually a female accompanied by a young one, seeking probably for food in too shallow water, are cut off by the retreating tide from their chance of regaining the open sea. In these cases it appears that it is the less experienced younger animal which gets into danger, and is then rarely abandoned by the old one, who thus falls a victim to the strength of the maternal instinct so largely developed in the cetacea. The old males are apparently more wary, and rarely approach the shore near enough to be taken. They are never seen in herds or "schools" like so many of their congeners, but always either singly or in pairs.

Another animal, allied to *Hyperoodon rostratus* but of larger size, being fully thirty feet in length, and of heavier proportions, has been occasionally met with in the North Seas, and is generally supposed to be another species of the same genus (*H. latifrons*), though some naturalists have maintained that it is nothing more than the old male of the former.

II. Genus *Ziphius*.—The type of this genus is *Z. cavirostris* of Cuvier, founded on an imperfect skull picked up in 1804 on the Mediterranean coast of France, near Fos, Bouches-du-Rhône, and described and figured in the "Ossemens Fossiles." It was at first supposed to be a fossil, but has since been proved to belong to a species still living in the Mediterranean, and there is no evidence that the skull is of ancient date.

2. An animal of the same species was afterwards taken on the coast of Corsica; its external characters are described and figured by Doumet in the *Revue Zoologique*, v. 1842, p. 208, and its skeleton is preserved at Cette. 3. A third specimen was stranded near Aresquiers, Hérault, South France, in 1850; the skull, which is now in the Museum at Paris, has been described by Gervais and Duvernoy (*Annales des Sciences Naturelles*, 3 series, 1850 and 1851). 4. In the Museum of Arcachon is a skull found on the beach at Lanton, Gironde, West France, in 1864, and described and figured by Fischer, in the *Nouvelles Archives du Muséum*, tome 3, 1867. 5. A complete skeleton of an adult animal is mounted in the Anatomical Museum of the University of Jena. This was obtained at Villa Franca in 1867 by Prof. Haeckel, but has not yet been described. 6. In the Museum of

* British Fossil Cetacea from the Crag. Palæontological Society, vol. xxiii., 1870.

the University of Louvain is a skull of an animal of this genus, brought from the Cape of Good Hope, of which a description has been published by Prof. Van Beneden, under the name of *Ziphius indicus* (Mem. de l'Acad. Roy. de Belgique, coll. in 8vo, 1863). 7. A very similar skull in the British Museum, also from the Cape of Good Hope, has been described by Gray (Proc. Zool. Soc. 1865, p. 524) by the name of *Petrorhyncus capensis*. 8. A complete specimen of a young male, thirteen feet long, was taken near Buenos Ayres in 1865, and is the subject of an elaborate memoir by Burmeister (Annales de Museo Publico de Buenos Aires, Vol. i. p. 312, 1869), accompanied by detailed figures of external characters, skeleton, and some of the viscera. The specimen was first named in a preliminary notice *Ziphiorhynchus cryptodon*, but subsequently described as *Epiodon australis*.

Such are the materials upon which our knowledge of the genus *Ziphius* is based. For the present it is impossible to determine whether the differences that have been noticed in the above-mentioned specimens are the result of age, sex, or individual peculiarity, or whether they denote specific distinctions. The remains that are preserved indicate in every case an animal of rather smaller size than the Hyperoodon.

III.—Genus *Mesoplodon*, Gervais. It is not without some hesitation that I assign this designation to the present well-marked section, as it is extremely difficult to determine which of the numerous names which have been given to it by various authors should have the preference. The type-species of the group, Sowerby's whale, has had no less than eleven generic appellations given to it since its discovery in 1804, viz., *Physeter*, *Delphinus*, *Heterodon*, *Diodon*, *Aodon*, *Nodus*, *Delphinorhynchus*, *Micropteron*, *Mesoplodon*, *Mesodiodon*, and *Ziphius!* Many of these names had to be abandoned almost as soon as they were bestowed, as their authors had overlooked the fact that they had been previously appropriated to other members of the animal kingdom. To give a full account of the entangled literary history of the genus would occupy too much space for the present communication, so I will content myself with enumerating the specimens which are referable to it, as far as they are known to me, existing in various museums, from which some idea of the frequency of occurrence and of the geographical distribution of the animals will be obtained. They are rather more numerous than those of *Ziphius*.

1. An imperfect skull in the University Museum, Oxford, from an animal (a male) sixteen feet long, obtained on the coast of Elginshire, figured and described by Sowerby (*British Miscellany*, p. 1, 1804) under the name of *Physeter bidens*, but to which the specific name of *Sowerbyi* has since been generally attached. (This is *Delphinus* (*Heterodon*) *Sowerbensis* of De Blainville, Nouv. Dict. d'Hist. Nat., t. ix., 1817, Second edition; *D. Sowerbyi* Desmarest, Mammalogie, 1822.) 2. A skull in the Paris Museum from a female specimen fifteen feet long, stranded at Havre, Sept. 9, 1825, described by De Blainville (Nouv. Bulletin. Sc. t. iv., 1825) as the "Dauphin du Dale," by Cuvier as *Delphinus* (*Delphinorhynchus*) *micropterus*, and afterwards by a variety of other names, but now generally considered to be specifically identical with the first mentioned. 3. A complete skeleton in the Brussels Museum from a young specimen stranded at Ostend, August 31, 1835. 4. A skull and part of skeleton in the Museum at Caen from Sallenelles, Calvados, North France, 1825. 5. Mutilated skull in the Museum of the Royal Dublin Society, from an animal fifteen feet long, stranded in 1864 in Bandon Bay, Kerry, Ireland. 6. Another skull and some bones in the same museum from a second specimen from the same locality, in 1770. 7. A lower jaw in the Christiana Museum, from the Coast of Norway. 8. A skull in the University Museum, Edinburgh, of unknown origin. (I am indebted to Prof. Van Beneden for information about this specimen, which has not hitherto been recorded.) All these appear to belong to one species. The adult males have a single triangular compressed tooth on each side, rather in front of the middle of the lower jaw, which projects beyond the lip like a tusk, working against a hard callous pad in the upper jaw. In the specimen from Calvados, a group of barnacles had attached themselves to the outer surface of the tooth. 9. In the British Museum is a skull received from the Cape of Good Hope, with teeth in a similar situation, but developed to such an extent as to pass (curving upwards, backwards, and finally inwards) all round the upper jaw, and actually to meet above, preventing the mouth from opening beyond a very few inches at most. It is very difficult to imagine how the animal could have lived and obtained food in this condition, and it might well be supposed to be an individual deformity, but Mr. E. Layard has shown me a tooth of another individual having exactly the same conformation, and being upwards of a foot in length. To this species the name of *Layardii* has been applied by Dr. Gray. 10. An animal probably of the same species, but with the tooth much less developed (? a female), was very lately stranded at Little Bay, about six miles from Sydney, and its skeleton is now in the Australian Museum. 10. In the Museum at Caen there is another skull, from an animal caught in the entrance of the Channel about 1840, which appears to belong to a different species from those ordinarily found on our coasts, as the compressed tooth is placed nearer the apex of the jaw. 12. A skull in the Museum at Paris, remarkable for the peculiar form of the lower jaw, and of the heavy massive tooth which it supports, obtained from the Seychelle Islands, has received the specific name of *densirostris*, and very recently a complete skeleton of the same (13), obtained by Mr. Krefft from Lord Howe's Island, has been added to the Sydney Museum, already rich in skeletons of rare Cetaceans. Lastly (14), in the Museum at Wellington, New Zealand, is a skull and some bones of an animal, nine feet long, which was killed in Titai Bay, Cook's Strait, January 1866, and figured by Dr. Hector in the "Transactions of the New Zealand Institute," vol. iii., part XV., of which the conformation of the skull shows that it is a member of this group; but the single compressed tooth in the lower jaw is situated farther forwards than in any other known species, thus completing the series of different positions in the side of the ramus occupied by the developed teeth, and proving its small value as a generic character.

IV.—*Berardius*, Duvernoy. This genus was founded by Duvernoy upon a skull received at the Museum of Paris in 1846, having been obtained from an animal stranded in Akaroa Harbour, New Zealand. In the name of *Berardius Arnuxii* conferred upon it by Duvernoy, the captain of the French corvette, *Le Rhin*, Bérard, and the surgeon, Arnoux, who jointly presented the specimen, with some others of considerable interest to the Museum, are commemorated in zoological literature.

Only three other specimens of this animal have since been seen, and all on the coasts of New Zealand:—One in 1862, embayed in Porirua Harbour, was converted into oil, and can only be conjectured to have been a Berardius by its dimensions, and a slight description published by Mr. Knox. In January 1870 another was taken in Worser's Bay near the entrance to Port Nicholson, and its skull and some bones were preserved for the Wellington Museum; and, lastly, a specimen of this fine animal, which is thirty feet long, and, after *Hyperoodon latifrons*, the largest of the group, ran aground on the beach near New Brighton, Canterbury, on the 16th of December, 1868, where it fortunately came under the notice of Dr. Julius Haast, F.R.S., the energetic and able geologist, and Curator of the Museum at Christ Church. The details of its capture are given by Dr. Haast in the Proceedings of the Philosophical Institute of Canterbury,

New Zealand, May 5, 1869, and also in the "Annals and Mag. Nat. Hist." October 1870.

The skeleton of this animal has been lately placed among the fine series of Cetaceans in the Museum of the Royal College of Surgeons, thanks to the extremely liberal desire of Dr. Haast that it should be made as available as possible for scientific examination, comparison, and description, and to the generosity of Mr. Erasmus Wilson, F.R.S., a member of the Council of the College, in providing the means of adding it to the collection without expense to the Institution. A detailed and fully illustrated description of this skeleton formed part of the communication to the Zoological Society alluded to above, and will appear shortly in the "Transactions." All the characters of the skeleton agree generally with those of the other Ziphioids, but it appears in some respects to be a less specialised form, approaching somewhat nearer to the true dolphins, while *Hyperoodon* is at the other extremity of the series, being modified in the direction of the sperm whales. It has two teeth on each side of the lower jaw, situated near the front end or symphysis, which show nearly the same characteristic and peculiar structure as that described by Mr. Ray Lankester in the teeth of *Mesoplodon Sowerbyi*. The skull is far more symmetrical than in any other member of the group, and wants the great maxillary crests of *Hyperoodon*, and the dense ossification of the rostrum found in so many of the others. The cervical region is comparatively long, with the majority of its vertebræ free, the dorsals and ribs are ten in number, the lumber and caudals thirty-one, making forty-eight in all. Viewing the skeleton as a whole, the most striking feature is the small size of the head compared with the great length of the vertebral column, and the massiveness of the individual bones, especially of the lumbar and anterior caudal vertebræ. It presents in this respect a remarkable contrast to the sperm whale, which hangs near it in the museum, though agreeing generally with the other Ziphioids. As before mentioned, it is thirty feet in length, and, as Dr. Haast was able to observe, it agrees with its congeners in the nature of its food, for its stomach was found to contain about half a bushel of the horny beaks of cephalopods. The colour of the whole animal when fresh was of a deep velvety black, with the exception of the lower portion of the belly, which was greyish.

Extinct Ziphioids.—To the circumstance of the extreme density of the rostral portion of the skull of certain Ziphioids, owing to the firm ossification of the mesethmoid cartilage and its coalescence with the surrounding bones (the maxilla, premaxilla, and vomer) our knowledge of many of the ancient members of this group of whales is due. When all other portions of the skeleton have yielded to the destructive influence of time, these rostra, generally in the form of elongated and somewhat flattened cylinders, worn and eroded by the action of water, gravel, and sand, occasionally come to light to attest the presence of a former world of oceanic life. A few teeth also have been found which would appear to be referable to these same animals. The localities in which these occur in England are the Red Crag deposits of Suffolk. They are still more abundant, and in a much more perfect condition in the beds of corresponding age in the neighbourhood of Antwerp, which have fortunately been laid bare by the excavations made in the defensive works of that city. A magnificent series of these fossils containing many new forms has recently been added to the Brussels Museum, but until M. le Vicomte Du Bus, the accomplished late Director of the Museum, has completed the great task he has undertaken of determining and describing them, they are as little available for zoological science as if they still lay

> In the bottom of the deep
> Where fathom line could never touch the ground.

W. H. FLOWER

CONTINUITY OF THE FLUID AND GASEOUS STATES OF MATTER *

WHEN we find a substance capable of existing in two fluid states different in density and other properties, while the temperature and pressure are the same in both; and when we find also that an introduction or abstraction of heat without change of temperature or of pressure will effect the change from the one state to the other; and also find that the change either way is perfectly reversible, we speak of the one state as being an ordinary gaseous and the other as being an ordinary liquid state of the same matter; and the ordinary transition from the one to the other we would designate by the terms boiling, or condensing; or occasionally by other terms nearly equivalent, such as evaporation, gasification, liquefaction from the gaseous state, &c. Cases of gasification from liquids, or of condensation from gases, when any chemical alteration accompanies the abrupt change of density, are not among the subjects proposed to be brought under consideration in the present paper. In such cases I presume there would be no perfect reversibility in the process; and if so, this would of itself be a criterion sufficing to separate them from the proper cases of boiling or condensing at present intended to be considered. If now the fluid substance, in the rarer of the two states—that is, in what is commonly called the gaseous state—be still further rarefied, by increase of temperature or diminution of pressure, or be changed considerably in other ways by alterations of temperature and pressure jointly, without its receiving any abrupt collapse in volume, it will still, in ordinary language and ordinary mode of thought, be regarded as being in a gaseous state. Remarks of quite a corresponding kind may be made in describing various conditions of the fluid (as to temperature, pressure, and volume), which would in ordinary language be regarded as belonging to the liquid state.

Dr. Andrews (Phil. Trans. 1869) has shown that the ordinary gaseous and ordinary liquid states are only widely separated forms of the same condition of matter, and may be made to pass into one another by a course of continuous physical changes presenting nowhere any interruption or breach of continuity. If we denote geometrically all possible points of pressure and temperature jointly by points spread continuously in a plane surface, each point in the plane being referred to two axes of rectangular co-ordinates, so that one of its ordinates shall represent the temperature, and the other the pressure denoted by that point; and if we mark all the successive boiling- or condensing-points of temperature and pressure as a continuous line on this plane; this line, which may be called the boiling line, will be a separating boundary between the regions of the plane corresponding to the ordinary liquid state and those corresponding to the ordinary gaseous state. But, by consideration of Dr. Andrews's experimental results, we may see that this separating boundary comes to an end at a point of pressure and temperature, which, in conformity with his language, may be called the critical point of pressure and temperature jointly; and we may see that, from any ordinary liquid state to any ordinary gaseous state, the transition may be effected gradually by an infinite variety of courses passing round outside the extreme end of the boiling line.

Now it will be my chief object in the present paper to state and support a view which has occurred to me, according to which it appears probable that, although there be a practical breach of continuity in crossing the line of boiling-points from liquid to gas or from gas to liquid, there may exist in the nature of things a theoretical continuity across this breach, having some real and true significance. This theoretical continuity, from the ordinary liquid state to the ordinary gaseous state, must be supposed to be such as to have its various courses passing through conditions of pressure, temperature, and volume in unstable equilibrium for any fluid matter theoretically conceived as homogeneously distributed while passing through the intermediate conditions. Such courses of transition, passing through unstable conditions, must be regarded as being impossible to be brought about throughout entire masses of fluids dealt with in any physical operations. Whether in an extremely thin lamina of gradual transition from a liquid to its own gas, in which it is to be noticed the substance would not be homogeneously distributed, conditions may exist in a stable state, having some kind of correspondence with the unstable conditions here theoretically conceived,

* "Considerations on the abrupt change at boiling or condensing in reference to the Continuity of the Fluid State of Matter," by Professor James Thomson, LL.D., Queen's College, Belfast, read before the Royal Society, Nov. 16, 1871.