Sowerbiensis, yet it is with some reason considered that *Ziphius Sowerbiensis,* the only male specimen that had at the time been discovered, was the male species of that genus, and that the species micropterus was the female; the difference in the great development of the teeth in the male specimen, and the non-existence or rudimentary state of the teeth in the other, being viewed as sexual.

The subject of the discovery now recorded was obtained stranded on the shore of Brandon Bay, coast of Kerry, Ireland, on the 9th of March, 1864.

The skull and jaws, with the teeth, are identical in every respect with the specimen in the Museum at Oxford; it is remarkable as being only the second male specimen known to the European Fauna. The most valuable points in the details given of this discovery are the photographs that were taken of the head of the animal in the recent state, and which have enabled many most important and unrecorded observations to have been made and confirmed, with regard to the peculiar characteristics of the formation of the jaws, and action of the teeth, of this very rare Cetacean.

Thus, of six of these animals that have been recorded as European, four were females, and two were males; the two latter having only been met with on the shores of Scotland and Ireland.

X.—On the Formation of Ground Ice in the Bed of the River Dodder. By Professor Hennessy, F. R. S.

[Read April 8, 1867.]

The formation of ice under flowing water seems to have been long known to boatmen engaged in navigating the rivers of northern and central Europe. At first it was regarded with doubt by many physical inquirers, and its universal recognition as a well-established natural phenomenon has taken place only within a comparatively recent period. Among the properties of water, it would be impossible to name one more remarkable or better known than its loss of density in passing from the liquid to the solid state. The precise determination of the maximum density of water at nearly eight degrees (Fahrenheit) above the freezing point appears still further to interpose a difficulty with regard to the growth of true subaqueous ice; but, when all the circumstances under which such ice is stated to have been formed are fully taken into consideration, this difficulty disappears, and ground ice is seen to be the result of general physical laws.

At the beginning of January in the present year, an instance of the formation of ground ice in the bed of the Dodder* came under my ob-

* For the information of readers who are not acquainted with the neighbourhood of Dublin, it may be necessary to state that the Dodder is a stream which rises among the mountains, at a distance, measured in a straight line, of about twelve miles S. S. W. from the city; and that, after sweeping round the south suburban villages for three miles of its course, it falls into the bay, close to the mouth of the Liffey.

servation, which, not only on account of the rarely recorded occurrence of such ice in our island, but from the manner in which all the accompanying circumstances combine to throw a clear light upon the real causes of the phenomenon, induces me to communicate to the Academy the facts which I observed, and the conclusions to which I have been led. It is important to distinguish two well-defined periods of cold weather which occurred in the month of January, 1867: the earliest was continued from the first to the fifth; the second occupied the interval from the tenth to the nineteenth. The ice formed on ponds during the longer period having been more permanent, this period was popularly considered as that of the greatest frost. Thermometrical results show that the lowest temperature was attained during the first period.

Observations taken within the city of Dublin, or at a station close to the sea, would not furnish results from which we could draw any just conclusions as to the lowest temperature to which the Dodder was exposed. Observations taken at a station situated about the same distance from the sea, and at nearly the same height as the middle portion of the course of the river, would give the nearest approximation to the information required. In the "Transactions of the Association for Promoting Social Science," for 1860, p. 662, I have shown that the winter temperature of a large town must sensibly increase in going from the outskirts towards the centre. This conclusion was first established by observations made in London; and it seems to be fully confirmed with regard to Dublin by a comparison of observations, recorded at Trinity College, and the Phœnix Park, and especially from those made by Mr. Yates, in Grafton-street, with similar results obtained in the suburbs.* The observations on the low temperature of January by Mr. Arthur Pim, at Monkstown, which he has kindly communicated to me, fully establish the correctness of the remark as to the influence of the sea on winter temperature; and the Monkstown results seem also to show that the minima temperatures decrease very rapidly in going from the sea inland.† About seven miles and a quarter measured along the course of the river above the point where I observed the ground ice, the level of the water in the Dodder is 474 above the sea; and the station which from its position most nearly realizes our requirements is the Ordnance Meteorological Observatory at the west end of the Phœnix Park. This is 159 feet above the sea level—a height which corresponds to a part of the Dodder near Bushy Park, about one mile and three quarters above the place where the ground ice was observed. It also seems that the observations on minima temperatures at the Phœnix Park were made under circumstances approaching more closely to the actual conditions of a thermometer over an open stream, than those made at other stations in Dublin and its environs.

* I find that the same general law has been long since distinctly recognised by Dr. Lamont at Munich. See his essay "Ueber die Temperatur-Verhältnisse in Bayern," "Annalen der k. Sternwarte bei München," vol. iii.

† See "On the Distribution of Heat over Islands," "Atlantis," vol. i., p. 396.

The results which I have selected are taken from the weekly records furnished by Captain Wilkinson, R. E., and published by the Registrar-General, and I have also ventured to append a column of mean temperatures calculated by the formula,

$$\text{Mean} = \text{min} + 0.48\ (\text{max.} - \text{min.}).*$$

The results in this Table differ very little from the means of maxima and minima, otherwise I should give them with much more diffidence, as I am not yet perfectly satisfied as to the general applicability of the above formula to the determination of mean temperatures.

TEMPERATURE TABLE AT THE PHŒNIX PARK.

Date.	Minimum.	Maximum.	Mean of Max. and Minimum.	Mean by Formula.	Remarks.
	°	°	°	°	
Dec. 26,	38·7	49·7	44·2	44·0	
„ 27,	42·5	47·7	45·1	45·0	
„ 28,	44·0	49·3	46·6	46·5	
„ 29,	32·5	49·9	41·2	39·9	
„ 30,	29·5	38·7	34·1	33·9	
„ 31,	21·5	39·0	30·2	29·9	Heavy fall of snow, which remained unmelted until the 5th and 6th.
Jan. 1,	24·5	33·4	28·9	28·8	
„ 2,	12·2	29·4	20·8	20·5	Prevailing wind during the first period of frost, N. E.
„ 3,	2·8	20·2	11·5	11·1	Ground ice observed on weir, and close to bank of river.
„ 4,	9·5	36·3	22·9	22·4	
„ 5,	32·5	45·9	39·2	38·9	·712 inch of melted snow since January 1.
„ 6,	43·8	50·5	47·1	47·0	Rain ·230 inch, and rapid thaw.
„ 7,	43·8	51·9	45·9	45·7	
„ 8,	36·5	44·7	40·6	40·4	
„ 9,	32·5	43·3	37·9	37·7	
„ 10,	26·5	37·5	32·0	31·8	Prevailing wind during the second period of frost, N.W.
„ 11,	24 0	32·0	28·0	27·8	
„ 12,	19·2	28·5	23·8	23·6	
„ 13,	24·2	31 2	27·7	27·6	
„ 14,	13·0	33·2	23·1	22·7	
„ 15,	21 8	31·2	26·5	26·3	
„ 16,	12·5	32·5	22·5	21·1	
„ 17,	15·8	26·5	21·1	20·9	
„ 18,	13·2	33·8	23·5	23·1	
„ 19,	30·5	36·5	33·5	33·4	
„ 20,	30·0	37·2	33·6	33·5	
„ 21,	29·5	39·0	34·2	34·1	
„ 22,	29·5	50·0	39·7	39·1	
„ 23,	43·4	53·2	48·3	48·1	
„ 24,	37·8	54·5	46·1	45·8	

* For a discussion of formulæ suitable to the observations in question, see the folio volume of "Ordnance Meteorological Observations :" Dublin, 1856, p. 473.

In order to make the connexion between the results recorded in this Table and the formation of the ground ice more clearly manifest, I append a graphical representation, in which the dotted broken line represents the march of mean temperature, and the undotted line the march of minimum temperature. The two cold periods are well defined by the rising and falling of the curves above or below the line of frost. A remarkable feature in the first period is the sudden great rise of temperature from the 3rd of January to the 6th; whence resulted a sudden thaw, which had an important influence in bringing very significant phenomena distinctly under observation.

Towards the close of the first week in January, I frequently walked on the right bank of the Dodder between Rathgar and Rathfarnham bridges. The greater part of this portion of the stream remained unfrozen; and wherever the current was extremely rapid, the ice was restricted to a thin edging along the banks. On breaking a portion of this edging where there was a swift current, I found rough pieces of ice, with long needle-shaped crystals, jutting beneath the water. Water was flowing over some of these pieces, but they were easily hooked up with a stick. On a weir situated farther up stream I noticed many icicles attached to the stones over which the water was dashing. Still more decisive proofs of the existence of true ground ice under the stream were furnished soon after the commencement of the thaw.

On the morning of Sunday, the 6th, when the thaw was fully developed, I took a position a little above one of the weirs, and watched the breaking up and removal of the ice which overspread the river at this point. After a short interval I noticed, in addition to the smooth angular and uniformly thick slabs resulting from the breaking of the surface ice, several rough spongy pieces, more or less discoloured by mud, and having in some instances sand or small gravel attached to them. I could not at first discover whence these singular-looking pieces of ice had come; but after another short interval I saw similar fragments rise in succession to the surface of the water from below. This occurrence was repeated more than once, and it attracted the attention of other observers. I recently verified my impression of the facts by asking gentlemen* who were present as to what they had seen, and their reply completely accords with what I relate. Whenever a large sheet of surface ice was burst by the rapidly rising waters of the stream, rough lumps of the spongy ice were generally disclosed beneath. These could not have arrived at their position by drifting down the river; for the drifted fragments were heaped over the upper edge of the yet unbroken sheets of ice. The rough pieces must have floated up from the bed to the under side of the surface ice, and they were disclosed to view on the removal of the latter from the position it had held anterior to the thaw. The mud with which most of these fragments were

* Among these I may especially refer to Messrs. Joseph and John Hanley, both of whom reside close to the right bank of the Dodder.

discoloured indicated, moreover, that they must have come from a comparatively tranquil portion of the river bed—a condition which is found precisely at the place where they were observed. Mud can deposit in the Dodder only for a short distance at the backs of weirs and dams; at all other portions of its middle and upper course, the bed is coated with gravel or rock. As the rising of the spongy-looking fragments of ice took place about the middle of the stream, and as the pieces were afterwards rapidly carried over the weir, I made no attempt to obtain a specimen. It was, however, easy to see that their structure approached as closely to the rough pieces with projecting crystals which I had broken from the edge of the stream under water, as it deviated from that of the slabs of ice belonging to the surface.

The true cause of the formation of ground ice could not be more clearly illustrated than by the phenomena here adduced. The conditions which promote freezing, cited in the order of their relative importance, are—(1) low temperature; (2) stillness of the liquid; and (3) contact of rough solid substances. On the surface of a pond or lake, when the temperature falls below 32° F., the first two and most important conditions are both perfectly fulfilled. In a deep lake the two last conditions can in general alone prevail near the bottom, while the first and indispensable condition will not be sufficiently intense. In the middle of rapidly running water the first condition may exist; but, as it must then be alone, we never see ice formed in the axis of a swiftly flowing stream. Ice may be found in a shallow and rapid river along the banks, and on stones at the bottom, because in these positions the velocity of the cold current becomes sufficiently reduced to allow of the operation of condition (2), while the growth of ice crystals is directly promoted by the existence of condition (3), at the points of contact between the river and its bed. Condition (3) is in general most likely to exist in perfection in short rivers descending from an elevated source into the plains; and, as such rivers are always shallow except immediately after rain or the melting of snow, the water flowing in their beds will usually be very fully exposed to any cooling influences which may result from the weather.

Let us more closely examine what takes place in a small river, such as the Dodder, when the temperature falls considerably below the freezing point of still water. This stream has a rapid fall, and its longitudinal section presents a series of great and small inequalities which essentially promote the thorough refrigeration of water flowing over them. The following numbers will make this more clearly understood:

Height of Water above Sea, in Feet.	Distances from Weir above which Gronnd Ice was observed rising.
101 . .	Weir from which distances are counted.
107 . .	1825 feet, where crystals of Ice were found.
	3550 feet, Weir with Ice on stones.
125 . .	4375 feet, Rathfarnham bridge.
	1⅝ mile, a cascade.
176 . .	2⅓ miles, Templeogue bridge.
238 . .	3½ miles, Weir at Firhouse.
304 . .	4⅞ miles, Oldbawn bridge.
364 . .	5⅞ miles, opposite site of parchment mill.
474 . .	7¼ miles, near Ballynascorney Gap.

If, in addition to the rough section which may be formed from these numbers, the reader bears in mind that the bed of the Dodder contains masses of gravel, granite boulders, and projecting rocks, he will be satisfied that the conditions required for perfectly mingling the flowing water are all abundantly present. The Dodder is usually shallow, and it was in this state before the frost of January; thus the water, in falling over the weirs and torrential parts of its course, presented a very thin sheet of liquid to the refrigerating influences of the air, and losses of heat by surface radiation. Wherever the river flows most rapidly, it is also shallowest and most disturbed, and the water is therefore exposed at such places to the full intensity of the refrigerating actions. The colder particles at surface exchange their positions and temperatures with the particles at bottom, and a forced convection is thus brought about, which reduces the temperature of the entire mass below the freezing point. Another feature in the structure of the bed of the river now operates to bring about condition (2). This occurs whenever the water reduced below the freezing temperature arrives at the back of a weir or mill dam. In this position, the water at surface partakes both of conditions (1) and (2); but, while it freely loses its heat, it still retains a small velocity. The water at bottom is now almost perfectly still, and conditions (2) and (3) are much better fulfilled than at the surface. In this way ground ice and surface ice may both be formed nearly in the same cross section of the river.

It may be asked, why should not freezing take place in the water flowing between the bottom ice and surface ice, as well as above and below? This suggests the utility of attending more precisely to the physical conditions of the growth of ice crystals. The general influence of rough solid substances in promoting crystallization is well recognised, and the familiar experiment of plunging a vessel containing water into a freezing mixture shows the tendency of ice to commence its formation from even the most minute projections on the inside of the vessel. Some experiments recently described by M. Fred. Engelhardt bear still more conclusively on this point.* He poured water into iron boilers which were insulated from the influence of soil temperature by being elevated on trestles, and they were at the same time fully exposed on all sides to the action of a freezing temperature. The inside of one boiler was smooth, while another was interiorly coated with a few chips of iron and wood. Ice was formed in both boilers along the sides and bottoms, as well as on the surface, while the middle was still occupied with unfrozen liquid. From a comparison of both vessels, it seemed that the inequalities on the interior of the second greatly favoured the formation of rough crystalline bunches of ice. The residual unfrozen liquid suggests an explanation of the difficulty to which I have alluded with reference to the exclusive freezing of a river at surface and on its bed. This phenomenon is indeed only a particular instance of a general thermological law—namely, that all substances in passing from the liquid to the solid state evolve a certain amount of latent heat. It is thus, after various metals, sulphur, and other substances commence to crystallize from a state of fusion, we find, on breaking the crust of solid matter first formed, that a residuum of liquid enclosed in a solidified matrix may be decanted off. With regard to water, this process has been very clearly described by Professor Curtis, of Queen's College, Galway;† and, he refers, moreover, to the low conductivity of water for heat as an agency for confining the communication of the latent heat of congelation to the adjacent particles. If, therefore, from the prevalence of conditions favourable to freezing both at surface and along the bed of the still parts of such a river as the Dodder, ice should be formed in these positions, its growth will in itself interpose obstacles to the freezing of the middle waters.

The explanation here given of the formation of ground ice is, in substance, the same as that propounded several years ago by the late M. Arago;‡ but I venture to believe that there are some peculiar features in the phenomena which I have described, which may further elucidate the whole question. It cannot be maintained, as has been done, according to Arago,§ by one of our countrymen, that freezing at the bottom of cold still and clear water arises from the greater facility presented by still water as compared to moving water for the transmission of radiant heat from the underlying bed. In a discussion of the physical properties of water with reference to terrestrial climate at different geological epochs, published in 1859,‖ I alluded to the manner

---

* "Memoires de la Société des Sciences Naturelles de Strasbourg," tome vi.

† "On the Freezing of Water at Temperatures lower than 32° F.:" "Philosophical Magazine" for December, 1866.

‡ Arago, "Œuvres," vol. viii.

§ *Loc. cit.*, p. 176.

‖ "Atlantis," vol. ii., p. 208, January, 1859. Some of my conclusions regarding climate having been lately reproduced as new, I may be excused for briefly stating the properties of water to which I appealed when attempting to establish these conclusions:—1, its great capacity for heat; 2, its mobility; 3, the influence of evaporation and condensation; 4, the impermeability of water to obscure heat. The first three are distinctly adduced in section 2 of my essay (p. 210); while the 4th, now noticed in the text, is in which, from its imperfect permeability to the feeble rays of obscure heat, water acts as a kind of trap for the heat it acquires from sunshine. The same property allows the beds of still water reservoirs to retain their temperature, while the bottoms of running streams are cooled by the constant mingling of the upper and lower waters according to the forced convective action already mentioned.

If we reflect on the physical structure of the bed of the Dodder while looking over the graphical representation of temperature during the periods of frost, we cannot entertain a reasonable doubt as to the sufficiency of the physical conditions which produced the ground ice observed in the first week of January. On the 31st of December the mean temperature was below the freezing point; and from the 1st of January, when it was 28°·9 it fell to 11°·1 on the third. The fluctuations of minimum temperature are yet more remarkable. On the second of January the minimum temperature was nearly 20° below freezing, while on the third it descended to more than 29° below the same point. On the fifth a thaw commenced, but it proceeded slowly until midnight; and it was not fully developed until Sunday morning, when I witnessed the uprising through the water of fragments of ground ice which had been detached from the bottom. It remains to account for the action of the thaw in raising these pieces of ice. A reference to the remarks on the margin of the Temperature Table opposite January 5 and 6, shows that the aggregate result of the snow melted and of the rain which fell on these days was ·940 inch at the Phœnix Park. It is reasonable to suppose that the fall of snow and rain in the basin of the Dodder, owing to its greater elevation, was somewhat larger than this number would indicate. On the night of Saturday the minimum temperature was 43°·8 and the mean temperature of Sunday was 48°; and thus one of the first effects of the resulting thaw was a sudden and very considerable accession of water to the Dodder from its feeding streamlets. The coating of surface ice was thus burst from below upwards, and the slabs were rapidly swept along by the current, which, in accordance with a law of hydraulics, was gaining in velocity while increasing in volume. While the down scour of the river in its channel was thus considerably strengthened, the density of the water increased as its temperature rose with the progress of the thaw towards 40°. The combined operation of these causes would necessarily facilitate the detachment and floatation of those fragments of ground ice which were observed emerging at the surface of the river, and bringing with them manifest traces of their origin.

During the second period of frost I observed ice attached to stones over which water was flowing on the weirs, and also a few specimens of crystalline ice at the edges of the river, and under the current, such as I had noticed during the first period. I had no opportunity for

---

alluded to in these words:—"The heat which it [water] has acquired during the day shall have penetrated so *deeply* as to be incapable of being radiated backwards into space during the night." (See "Philosophical Magazine" for February and March, 1867.)

observing the breaking up of the ice at the second thaw; but, if I am correctly informed, it seems that the rough spongy and discoloured fragments of bottom ice did not make their appearance. The difference between the minima temperatures of the two periods of frost was nearly ten degrees; for the lowest temperature of the second period, which occurred on the 16th of January, was $12^{\circ}\cdot 5$; while the lowest of the first, which occurred on the third, was $2^{\circ}\cdot 8$. The difference in the resulting effects of the two periods with reference to the formation of ground ice may, therefore, be inferred to have arisen both from the inferior temperature of the first period and the suddenness of the thermal changes by which it was preceded and terminated.

XI.—Round Tower of Ardmore. By Hodder M. Westropp, Esq.

[Read April 8, 1867.]

The summit of the cone of the tower of Ardmore was formed of two stones fitted together. There is scarcely any trace of carving or sculpture on them, they are so worn by the weather and defaced by time. On the side of the larger stone is a kind of groove or fluting, very perfect for about six inches; a corresponding ornamentation was evidently on the other side. On the upper part is a slight projection, which originally may have been a carved ornament. The immediate top bears evident traces of something having been broken off. The lower inner portion of each stone is hollowed out into a kind of angle, evidently to meet a corresponding rise in the platform stone they rested upon. No iron bolt or rivet was used to firm them in their position. The two stones fitted together, and formed the apex of the conical top of the tower. Some of the old people of Ardmore recollect seeing a cross on the top of it, which, it is said, was shot off some forty years ago by a gentleman firing at a crow perched on the top: Croker makes mention of it as being like a crutch. This very probably was the remaining portion of an Irish wheel cross, such as is seen over the door of the tower at Antrim.

XII.—Description of Contents of a Cairn at Hyat Nugger, in the Dekhan. By Colonel Meadows Taylor. [Abstract].

[Read April 22, 1867.]

The articles enumerated in the accompanying list were found by Sir George Yule, K. S. I., late Resident at Hyderabad, and now a Member of the Council of India, in a cairn which formed one of a group near the town of Hyat Nugger, which is situated on the high road to Masulipatam, ten miles E. S. E. of the city of Hyderabad in the Dekhan. In my paper of 12th May, 1862, I brought to the notice of the Academy that the environs of Hyderabad afforded some