posteriorly; valves moderately convex; surface smooth, white; length 10, width 9, depth 5 millims.

Five examples of this interesting species were dredged in lat. 36° 56′ S., long. 150° 30′ E., off Twofold Bay, South Australia, in 120 fathoms.

The other species of Brachiopoda, dredged in the 'Challenger' Expedition, have been already named along with the depths at which they were found. It is, however, somewhat remarkable that the 'Challenger' Expedition did not bring back any of those red-coloured species which are so abundant near New Zealand, Japan, and other southern places.

IX. "Electrodynamic Qualities of Metals.* Part VII. Effects of Stress on the Magnetization of Iron, Nickel, and Cobalt." By Sir WILLIAM THOMSON, F.R.S., Professor of Natural Philosophy in the University of Glasgow. Received May 22, 1878.

(Abstract.)

This paper commences with a detailed description of a series of experiments on the effects of stress on the magnetism of soft iron, of which some first results were described in a preliminary notice, communicated to the Royal Society on the 10th of June, 1875, and published in the "Proceedings." A few months later, the author found that he had been anticipated by Villari† in the most remarkable of those results—that showing increase or diminution of magnetization by longitudinal pull, according as the magnetizing force is less than, or greater than, a certain critical value.

In the first series of experiments described in this paper, the amount of the magnetizing force is varied through a range of values from zero to 900, on a scale on which about $12\frac{1}{2}$ is the value of the vertical component of the terrestrial magnetic force at Glasgow, and the effects of hanging on and taking off weights of 7 lbs., 14 lbs., and 21 lbs.,‡ in changing the induced magnetism, are observed. The experiments were made at ordinary atmospheric temperatures, and at temperature 100° C. The results are shown in curves, of which the abscissas represent the magnetizing forces and other ordinates, the change of magnetism produced by "ons" and "offs" of the weight while the magnetizing force is kept constant. The Villari critical value was

* Phil. Trans., 1875. † Poggendorf's "Annalen," 1868.

‡ The wire was of about 22 Birmingham gauge, weighing therefore about 14 lbs. per nautical mile. It was so soft that it had experienced a considerable permanent stretch by 21 lbs.; it would probably break with 30 or 40 lbs. Steel pianoforte wire of same gauge bears about 230 lbs.

found to differ for the two temperatures, and for different weights: thus approximately:—

Amount of weight "on" and off."	Magnetizing force for which the "on" and "off" produce no change of magnetism.	
	At atmospheric temperature (being about 15° C.)	At temperature 100° C.
7 lbs.	266	230 or 290
14 „	281	286
21 „	288	310

The maximum effect of the "on" and "off" was found in each case with magnetizing force of from 50 to 60 of the arbitrary scale divisions (or about four times the Glasgow vertical force). Its amount differed notably, though not greatly, with the temperature, and, as was to be expected, greatly with the different amounts of pull; but it was not nearly three times as much with 21 lbs. as with 7 lbs.; thus approximately:—

Amount of weight "on" and "off."	Maximum effect in the way of augmentation of magnetism by "on" and diminution by "off."	
	Temperature about 15° C.	Temperature 100° C.
7 lbs.	31 scale divisions of ballistic galvanometer.	25 scale divisions.
14 „	35 do. do.	32·4 do. do.
21 „	54 do. do.	50·3 do. do.

The curves all tend to asymptotes parallel to the line of abscissas on its negative side for infinite magnetizing forces; and they indicate the following ultimate values for the two temperatures, and the different amounts of pull:—

Amount of weight "on" and "off."	Effect in the way of diminution of magnetism by "on" and augmentation by "off" when the magnetizing force is very great.	
	Temperature 15° C.	Temperature 100° C.
7 lbs.	6 scale divisions of ballistic galvanometer.	3 scale divisions.
14 „	13·5 do. do.	9·2 do. do.
21 „	21 do. do.	15·2 do. do.

For other features the curves themselves as given in the paper may be looked to.

Later experiments on the effects of pull transverse to the direction of magnetization showed correspondingly *opposite* effects to those of longitudinal pull, but with a "critical value" of magnetizing force nearly twice as great. That for longitudinal pull, according to the preceding figures, was about 23 times the Glasgow vertical force; for the transverse pull the critical value found was about 60 times the Glasgow vertical force. The transverse pull was produced by water pressure in the interior of a gun-barrel applied by a piston and lever at one end. Thus a pressure of about 1,000 lbs. per square inch, applied and removed at pleasure, gave effects on the magnetism induced in the vertical gun-barrel by the vertical component of the terrestrial magnetic force, and, again, by an electric current through a coil of insulated copper wire round the gun-barrel. When the force magnetizing the gun-barrel was anything less than about 60 times the Glasgow vertical force, the magnetization was found to be *less* with the pressure on than off. When the magnetizing force exceeded that critical value, the magnetization was *greater* with the pressure on than off. The residual (retained) magnetism was always less with the pressure on than off (after ten or a dozen "ons" and "offs" of the pressure to shake out as much of the magnetization as was so loosely held as to be shaken out by this agitation).

The vertical component of the terrestrial magnetic force at Glasgow is about ·43 c.-g.-s. units. Hence the critical values of the magnetizing force for longitudinal and transverse pull are approximately 10 and 25 c.-g.-s. units. With any magnetizing force between these limits the effect of pull whether transverse or longitudinal must be to diminish the magnetization. Hence it is to be inferred that equal pull in all directions would diminish, and equal positive pressure in all directions would increase, the magnetization under the influence of force between these critical values, and through some range above and below them; and not improbably for all amounts, however large or small, of the magnetizing force (?); but further experiment is necessary to answer this question.

The opposite effects of longitudinal and transverse pull, for magnetizing forces not between the critical range of from 10 to 25 c.-g.-s. units, show an aeolotropic magnetic susceptibility in iron under aeolotropic stress [that is, any stress other than pressure (whether positive or negative) equal in all directions.] Consideration of the relation of this result to Wiedemann's remarkable discovery of the induction of longitudinal magnetization by twisting an iron wire through which an electric current is maintained, is important and suggestive. In the present paper a counter-influence is pointed out, in the aeolotropic change of electric conductivity probably produced in the iron by

stress.* This influence illustrated by experiments made a few days ago for the author, by Mr. Macfarlane, in Glasgow, and Mr. Bottomley, in the Physical Laboratory of King's College, London, by kind permission of Professor Adams, which show in two very different ways that twisting a brass tube through which a current of electricity is maintained gives to the electric stream lines a spirality of opposite name to that which the twist gives to longitudinal filaments of the substance, and so proves that in aeolotropically stressed brass the electric conductivity is greatest and least in the directions of greatest and least pressure. The some law probably holds for iron. Wiedemann's result is that the end of the iron wire by which the current enters, becomes a true north or a true south pole, according as the twist is that of a right handed or of a left handed screw. This is the same direction of effect as would result from the aeolotropy of the magnetic susceptibility produced by the stress if the tangential magnetizing force in the outer part of the wire is less than the critical value, for which the effect of the stress is isotropic; but it is opposite to the effect due to the aeolotropy of the electric conductivity. Yet the author in repeating Wiedemann's experiments has found his result—the same in direction, and greatest in amount—with the strongest currents he has hitherto applied—currents strong enough to heat the wire seriously (but not yet measured or estimated in absolute measure). The reconciliation of the Wiedemann result with the conflicting influence of conductive aeolotropy, and with the influence of aeolotropy of magnetic susceptibility, which also is conflicting when the magnetizing force is great enough, is a difficulty which calls for investigation.

The paper includes a series of experiments on the effects of twist on magnetization of iron wire under longitudinal magnetizing force (the Glasgow vertical force alone in this first series). It confirms results of previous experimenters, Matteucci, Wertheim, and Edmond Becquerel, according to which twist in either direction diminishes the magnetization; and extends them to wires under different amounts of longitudinal pull. When the pull was great—approaching the limit of elasticity of the wire, the twist, even when well within the limits of elasticity, had much less effect in diminishing the magnetism than when the pull was small. The results are recorded in curves which show a very remarkable lagging of effect, or residue of influence of previous conditions.

The paper concludes with a description of experiments, showing in bars of nickel and cobalt effects of longitudinal pull opposite to those found by Villari for iron with magnetizing force below the critical

* See § 161 of Part V of this paper ("Electrodynamic Qualities of Metals," "Trans. Roy. Soc.," vol. cxlvi, Feb., 1856. Also Tomlinson, "Proc. Roy. Soc.," vol. xxvi, p. 401, 1877.

value—that is to say, the magnetization of the nickel and cobalt was diminished by pull. But this effect came to a maximum, and began to diminish markedly as if towards zero, when the magnetizing force was diminished. Hitherto the critical value, if there is one, has not been reached; but the experiments are being continued to find it, if it is to be found, with attainable degrees of magnetizing force.

(Addition, May 23, 1878.)

It had been reached, for nickel, in Glasgow, about the day on which this abstract was written; advantage having been taken of a kind loan, by Professor Tait, of a much smaller bar of nickel than those which had been specially made for the investigation, and which alone had been previously available. Mr. Thomas Gray, by whom the experiments were made, in the Physical Laboratory of the University of Glasgow, in the author's absence, found the critical value of the magnetizing force for Professor Tait's thin nickel bar to be about 600 times the Glasgow vertical force.

[The author is indebted to the celebrated metallurgical chemist, Mr. Joseph Wharton, of Philadelphia, for a splendid and unique set of bars, globes, and disks, of pure nickel and cobalt, which he kindly made, at his request, for this and other proposed investigations of electro-dynamic qualities of those metals.]

X. "On the Existence of a Rudimentary Head-Kidney in the Embryo Chick." By F. M. Balfour, M.A., Fellow of Trinity College, Cambridge, and Adam Sedgwick, B.A., Scholar of Trinity College, Cambridge. Communicated by Dr. M. Foster, F.R.S., Prælector of Physiology in Trinity College, Cambridge. Received May 20, 1878.

We have been for some time engaged in an investigation on the mode of growth of the developing Müllerian duct in the chick, and its possible derivation from the Wolffian duct; and, while carrying on our investigations on this point, were struck by some remarkable features of the abdominal opening of the Müllerian duct in its very early condition. We did not for some time pay much attention to these features, but finally devoted ourselves to their interpretation, and have been led to the conclusion that they form the rudiment of a head-kidney, "Vorniere" or "Kopfniere," identical with that present in Amphibia, Marsipobranchii, and Teleostei. We purpose first to give a short account of our observations, and then to proceed to state the grounds on which we have been led to compare the structures we have found with the head-kidney of the Ichthyopsida