

THURSDAY, SEPTEMBER 25, 1902.

## LEGENDS OF PALESTINE AND ARABIA.

*Theology and Ethics of the Hebrews.* By Archibald Duff, M.A., LL.D., B.D., Professor of Old Testament Theology, Yorkshire College, Bradford. Pp. xvii + 304. (London: John C. Nimmo, Ltd., 1902.)

*Syria and Palestine.* By Lewis Bayles Paton, Ph.D. With Five Maps. Pp. xxxvi + 302. (London: John C. Nimmo, Ltd., 1902.) Both in the "Semitic Series." Each 5s. net.

THE increasing number of popular books on early Semitic history and sociology marks the ever-widening interest taken in this branch of scientific research, especially as far as the results of modern Old Testament criticism are concerned. The writer of a popular handbook undertakes a serious responsibility; it is for him to weigh carefully the arguments for and against all important theories, and to set before the general reader a fair and unbiassed account of what he considers to be the certain and indubitable results of the labours of scholars. In all matters of Biblical criticism he must hold a middle course between the servile acceptance of traditional belief on the one hand, and a system of drastic and monotonous emendation on the other. Above all must he keep himself severely aloof from ephemeral hypotheses, for he is writing for the uncritical layman and not for the discriminating expert.

Dr. Duff's book on the theology and ethics of the Hebrews seems hardly to fulfil all the above requirements. The first section opens with the period of Hebrew history which begins with the fifteenth century B.C., and describes the Exodus from Egypt to Sinai. Then follows what is, to say the least of it, an unsatisfactory explanation of the episode of the Tables of the Law. According to Dr. Duff, "then or thereabouts two slabs were brought down from the heights. There were strange markings upon them, crystalline, fossil, or otherwise" (p. 9). Of the three possibilities, the last is certainly the most probable, as neither crystalline nor fossil markings are likely to be mistaken for writing, and as the mountain traditionally regarded as Sinai is of granite, it is hardly probable that fossils would be found there. However, Dr. Duff proceeds with his explanation: "There arose in time a sacred formula connected with this relic, whereby they called their god

" 'The Almighty Yahweh who sits  
Throned upon the winged creatures.'

"This seems to suggest that the seeming hieroglyphic figures on the slabs were fossils or else crystalline forms resembling winged creatures. Therefore the people called them 'Kroobs,' i.e. Griffins (Γρόψ)." The connection of Dr. Duff's "Kroobs" (which in the traditional transliteration is *cherub*) with Γρόψ, has been given up by the Oxford Hebrew Dictionary (Clarendon Press, 1892, p. 500). That such supposed fossil markings on granite could be mistaken for "hieroglyphic figures," or crystalline markings for "winged creatures" or "Kroobs," are

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explanations harder to understand than the difficulty which they are devised to solve.

Dr. Duff inclines to the opinion that the divine name, Yahweh, is a causative incipient from the root *hawah*, i.e. the god who caused rain to fall and thereby brought life and all things into being (p. 11). This is certainly possible, and appears to be as good an explanation as the other plausible view that Yahweh is the Kal of *hawah* (= *hayah*), i.e. "He Who Is."

When Dr. Duff reaches the third part of his book, wherein he describes the teachings of the prophets, he stands on firmer ground, and appears to know his subject better. Naturally, he begins with the caustic utterances of Amos against the luxury of Israel, and his warnings of the Assyrian approach; and, with the exception of a passage of "fine writing" on the first page, his *résumé* of this prophet is a good one. In the chapter on Hosea, which follows, the author has apparently been unable to make up his mind about a theory which, if it were true, would profoundly modify our conception of early Arabian and Hebrew history. On p. 61 he says: "Events on the Upper Nile or in Arabian muçur (*sic*) now left a southern prince So or Sewe (Sabako?) free to turn again to plots in the Asiatic direction"; but, in spite of this leaning towards the heresies of Dr. Winckler, the author inclines to the more usual view of the relations between Israel and Egypt at this time. He is certainly to be congratulated on not having gone over entirely to what on the face of it seems a possible theory, but which in reality has less in its favour than is at first sight apparent.

Taken as a whole, Dr. Duff's book will be found useful, and though the author's style is at times somewhat tedious, his matter has been well arranged, and the idea of the analysis of the "J" and "E" portions of the Old Testament at the end is an excellent one.

In the second of the two books under review Dr. Paton has endeavoured, as he says in his introduction, to "gather up the results of the most recent explorations, and combining them with the facts already known from the Bible and from other ancient sources, to present them in a clear and popular form." His book deals with the history of Palestine and its relations with Egypt and Mesopotamia from the earliest times down to Cyrus, and to this end the author has laid under contribution a large quantity of material both from Egyptian and Assyro-Babylonian sources, though apparently he has little first-hand knowledge of the original texts. A wider understanding of the languages of the peoples with which he deals would have prevented him from falling into certain errors that are to be found in his book. For instance, he has adopted the chronological system of Lehmann, and although he accepts Assurbanipal's dating for Kudurnankhundi, who invaded Babylonia 1635 years before Assurbanipal's time (p. 30), yet, apparently only on the ground of its extreme antiquity, he rejects Nabonidus's date for Naram-Sin, who is said by the former to have reigned 3200 years before (p. x.). Again, he seems unable wholly to accept the truth about the "Chedorlaomer" texts, and sums up his review of the facts with the words, "It still remains doubtful, therefore, whether Chedorlaomer is mentioned in the

"Babylonian monuments" (p. 34). Now, as the "Chedor-laomer" myth was long ago exploded by King ("Letters and Inscriptions of Hammurabi," vol. i. p. xxv.), there is no longer any question about this matter, at any rate so far as the tablets that have been discovered up to the present time show. Noticeable, also, is the translation of "Ya'aqob-el" and "Yoseph-el" as "Jacob-god" and "Joseph-god" (p. 42), which is misleading to the general reader, and almost seems to betray in the author an ignorance of the meaning of these names. Further, "Moriah" is hardly likely to be the equivalent of the Sumerian MAR.TU (p. 16).

In this book we again meet with the "Arabian-Muṣri" theory, though even its supporters do not seem to be very certain as to where they intend to fix the position of their hypothetical Muṣri. Even in the two maps where it is marked the position assigned to it is not the same in the one as in the other, and it has therefore apparently been given what is known mathematically as a *locus* in which its position varies, at one time shifting perilously near the borders of the southern Muṣri, *i.e.* Egypt (pp. 157 and 200). Since this so-called "epoch-making" theory has now begun to be reproduced in popular works, it is but right that the arguments on which its supporters rely should be examined in detail.

In 1893<sup>1</sup> Dr. Winckler published a theory that in addition to the two countries called in the Assyrian inscriptions Muṣri (Egypt and part of Northern Syria) there existed a third in Northern Arabia, and since then he has adduced a number of arguments in order to support this theory, both from the Assyrian and Hymyritic inscriptions. Among German scholars it has received little encouragement, but in England Dr. Winckler has been fortunate in finding an eloquent and receptive advocate in Prof. Cheyne, who has given it his sanction in the "Encyclopædia Biblica."<sup>2</sup> Since a popular handbook has absorbed and given credence to what is considered by the majority of critics to be a doubtful question, to say the least of it, it will be as well to state Dr. Winckler's arguments *seriatim*, in order that we may see how far they bear out his case. They may be briefly enumerated as follows:—

(1) Tiglath Pileser III. appointed a certain Idibi'ilu to be *ḫīpu* over Muṣri,<sup>3</sup> and this Idibi'ilu is mentioned elsewhere in the inscriptions of the same king,<sup>4</sup> where he is called "Idibi'ilu of Arubu" (*i.e.* Arabia). Hence, Dr. Winckler says that Muṣri cannot mean Egypt here, but is a country in Northern Arabia, apparently simply because Idibi'ilu was an Arab. Now there seems to be no reason for translating Muṣri as anything else than Egypt, for the Assyrians at this period were pushing their dominions rapidly down through Palestine. Further, we are not told that Tiglath Pileser conquered Egypt, but only that he appointed an Arabian sheikh as *ḫīpu* (an officer whose duties were obviously to watch the marches), a most natural and proper person for this purpose. So the new Muṣri theory receives no support from the first hypothesis.

(2) Yamani,<sup>5</sup> the leader of the revolt in Ashdod, flees

before the approach of Sargon *ana ite (mātu) Muṣuri ša paṭ (mātu) Meluḫḫa*, *i.e.* to the side of Muṣuri which borders on Meluḫḫa.<sup>1</sup>

If Meluḫḫa be "Sinai, Midian," as Dr. Winckler at first supposed,<sup>2</sup> there is no reason to assume that Muṣuri is a country lying to the east of this district, for if Muṣuri be translated "Egypt," such an identification entirely agrees with the Assyrian geographical description of the southern Muṣri. Besides, the most natural route for Yamani, who was fleeing from Ashdod before the Assyrian army advancing through Palestine from the north, led straight into Egypt, and not into Arabia, directly across the enemy's line of advance.

(3) Dr. Winckler argues that the Pir'u (spelt with the determinative prefix of persons and not officials) mentioned in the Assyrian texts<sup>3</sup> is not Pharaoh, as Schrader supposed, but the proper name of a sheikh of his North Arabian Muṣri, since he is once spoken of as *maliku*. But Pir'u is certainly called *šarru* in the same inscription, so this cannot be considered of any great importance. It was about this time that the Assyrians of the later Empire were coming into actual contact with the Southern Muṣri. Tiglath Pileser III., who pressed as far as its borders, mentions no king by name, but Sargon speaks of its king as Pir'u, evidently understanding it as a proper name. Now, we have an exact parallel to this in the Old Testament, where the Hebrews first speak of the King of Egypt as Pharaoh, evidently understanding it as a proper name, but later mention him either by name (Shishak), or with the addition of the royal title (Pharaoh-Necho, Pharaoh-Hophra). Further, in the last of the three texts quoted below in note<sup>3</sup>, there is surely no doubt that Haziti is Gaza, Rapiḫi is Raphia, and Sib'i is So (= Sēwē); and, these being granted, there is little to be gained by inventing an Arabian Muṣuri, when "Egypt" is the obvious explanation of the name. From this third line of argument, therefore, the new theory obtains no support.

(4) In the account of Sennacherib's battle at Eltekeh,

<sup>1</sup> It is doubtful whether any such meaning as "included in" or "belonging to" can be safely attached here to *ša paṭ*. Dr. Winckler's additional examples carry no weight (footnote, AOF, i. 27); the first, "Aphek im gebiete der provinz Samaria," rests on a misreading of *Samerina* for *Samena* . . . , or much less probably *Sameru* . . . This name was copied *Samena* . . . by Dr. Budge in his *Esarhaddon*, 1880, p. 119, in correction of W. A. I., iii. and TSBA, iv., but this correction is totally ignored by Winckler (*Untersuchungen*, 1880, p. 98), who repeats the old mistake *Samerina*, and apparently did not recognise it until his publication of *Muṣri, Meluḫḫa, Ma'tn* (1898, p. 8). Dr. Budge's translation, "Aphek, which borders on the country of Samena," still holds good, inasmuch as no suitable identification for Samena has been suggested (Winckler's later suggestion, *Shimeon*, being doubtful). Even if it were Samaria, the translation "On the borders of Samaria" would quite agree with the geographical position of Aphek. His second example is "Pillutu *ša paṭ* Ilamti Tigr. 14 (i R 67)" (read "Pillutu *ša paṭ* Ilamti Tigr. 14 (i R 67)"). As we do not know the exact locality of Pillutu, it is impossible to base any theories on the meaning of *ša paṭ* here, for the city in question may have been on the border of Elam.

<sup>2</sup> *Alt. Forsch.*, i. 27. We shall refer to Dr. Winckler's later theory that Meluḫḫa = Yaman further on.

<sup>3</sup> *Muṣri, Meluḫḫa, Ma'tn*, 1898, p. 2. Cf. (a) "Philistia, Judah, Edom and Moab . . . had brought presents to Pir'u, king (*šar*) of Muṣri, a chief (*maliku*) who could not save them." (b) "Of Pir', king of Muṣuri, Samsi, queen of Aribbi It'amra of Saba'at, kings of the side of the sea and the desert . . . their tribute I received." (c) "Hanunu, king of Haziti, with Sib'i the tartan of Muṣuri to the city of Rapiḫi to battle came against me; their defeat I accomplished. Sib'i feared the clash of my weapons and fled away, and his place was no more seen. Hanunu, king of Haziti, in hand I captured. The tribute of Pir'u," &c.

<sup>1</sup> *Altorientalische Forschungen*, i. 24.

<sup>2</sup> *ibid.*, 316f.

<sup>3</sup> *Annals*, i. 226, &c.; Winckler, *Alt. Forsch.*, i. 25.

<sup>4</sup> *Annals*, i. 240.

<sup>5</sup> Winckler, *Sargon*, Pr. I. 102; *Alt. Forsch.*, i. 27.

Dr. Winckler<sup>1</sup> considers the Muşur, which is here mentioned with Meluḥḥa as coming to the help of the Ekronites, to be the so-called North Arabian country, and not Egypt. But Egypt was the natural ally of Palestine, and there is no reason to suppose that the Muşur here mentioned is anything else but Egypt, especially as the scene of the battle was Eltekeh, which is either in or near Philistia.

(5) Dr. Winckler finds support for his Arabian Muşri<sup>2</sup> in a Himyaritic text (Glaser, 1155 = Halévy, 535) which mentions *Mşr*, 'Aşr, 'abr nhrn,<sup>3</sup> and *Mdi*. 'Aşr is mentioned elsewhere in the Himyaritic inscriptions (Glaser, 1083). The former of these inscriptions was assigned by Hartmann<sup>4</sup> to the year of the conquest of Egypt by Cambyses (525 B.C.), and there is little doubt that this dating is correct. *Mşr* undoubtedly refers to Egypt; *Mdi*, of which Dr. Winckler gives no explanation, is, as far as we can judge at present, Media; while the identification of *Aşr* is as yet uncertain. Hartmann has shown that the speculations of Hommel as to the possibility of this inscription dating back to the time of the eighteenth Egyptian dynasty (c. 1500 B.C.) are without foundation, and the same may be said for the theory promulgated by Dr. Winckler, according to whom this text gives a hint of the wars of the people of Ma'in (= Meluḥḥa) and its supposed northern dependency, his imaginary Muşri, against the Assyrians in Southern Palestine in the eighth century B.C.<sup>5</sup> The explanation of Hartmann is entirely sufficient; and no proof of the existence of an Arabian Muşri can be found in the Minæan inscriptions. It may be noted that Dr. Winckler does not accept the obvious meaning of the term 'abr nhrn, "across the river," i.e. in the eyes of the Arabs Persia, an explanation which entirely fits in with Hartmann's chronological theory.

(6) Dr. Winckler, however, has finally brought forward evidence which, on the face of it, seems good. He maintains that the small fragment of Assyrian tablet 83-1-18, 836 (which mentions Esarhaddon) proves the existence of Muşri as distinct from Mişri, i.e. Egypt. It "wird durch seine nebeneinandernennung von Muşri und Mişri d.h. von unserem Muşri und Ägypten," he says, "ja wol wenigstens die auseinanderhaltung beider länder von nun an bewirken,"

and he has attached such importance to it that he has published it in full.<sup>6</sup> Unfortunately, besides one or two other bad blunders<sup>7</sup> in a small text of six fragmentary lines, he has misread the one sign which was of importance to his theory.

In the fourth line Dr. Winckler reads, . . . mâ[ti] Mu-ş-ri u mâtu Mi-iş-[ri] . . . , thus proving to his own satisfaction that Muşri and Mişri were two distinct countries. But the *iş* in Mi-iş-[ri] ends at the break in the clay, and even from the very slight traces that remain, it is certain that the character is not *iş*. Taking into consideration the common conjunction of the country *Miluḥḥa* with Muşri, so well known to Assyriologists,

there can be no possible doubt that the sign was originally *luḥ*, and not *iş*, and the slight traces that remain (the traces of the top of another vertical wedge) make this hypothesis a certainty. Thus Dr. Winckler's attempted proof of a mention in Assyrian literature of a Muşri side by side with Mişri (Egypt) falls to the ground.

Dr. Winckler has therefore furnished no proof whatever of the existence of a North Arabian Muşri, and until he does so, it is impossible to believe in the existence of a Muşri other than Egypt and the well-known country in Northern Syria.

Apart from these matters, Dr. Paton has evidently spent much time and trouble on his book, and although he has been influenced in too great a degree by the school of Hommel, his compilation will probably be found useful. Both Dr. Paton and Dr. Duff have added an excellent index to their books, and if only they had had a wider acquaintance with the languages of Assyria and Egypt, they would probably have been able to speak in less uncertain tones of the results obtained from the study of cuneiform and hieroglyphic texts.

R. C. T.

#### OUR BOOK SHELF.

*The Elementary Principles of Chemistry.* By A. V. E. Young. Pp. xiv + 252 + 106. (London: Hirschfeld Brothers, Ltd., 1902.) Price 5s. net.

THIS book, which is of American authorship, provides an elementary course of inorganic chemistry based upon the quantitative system. There is a theoretical part, an experimental part, and an appendix giving hints on manipulation. The student is to perform the experiments, make notes, and then to turn to the theoretical part for fuller information on the topic of his experiments, the teacher supervising each portion of the work.

The author expresses the hope that his book will contribute "to making practicable and serviceable that which he enthusiastically believes is both scientifically and pedagogically an improvement on the older and still largely prevailing method." An examination of the book leads to the belief that this hope will be fulfilled, for there can be no doubt that the author is imbued with real educational zeal, and that he has bestowed much care and thought upon the arrangement of an excellent sequence of experiments illustrative of the main principles of chemistry.

A. S.

*P.O.P. (The Use of Silver Printing-out Papers).* By A. Horsley Hinton. Pp. 134. (London: Hazell, Watson and Viney, Ltd., 1902.) Price 1s. net.

SILVER printing-out papers are now so extensively used that a small volume like this cannot fail to be useful to a large number of those who practise photography. There is nothing particularly original in it, but a practical and successful photographer like the author cannot set down a series of instructions without giving many a useful hint. Current photographic literature and manufacturers' "instructions" furnish an almost endless variety of formulæ for the treatment of printing-out papers; it will therefore be distinctly advantageous to those whose experience of such papers is not large to have a small collection of selected formulæ such as is here given. The illustrations that show the extent of overprinting necessary to compensate for the loss by toning and fixing, and the kind of negative best suited for these processes, will be very welcome to the beginner. It would have been but little trouble to provide an index, the advantage of which in a book of practical instructions it is not necessary to point out.

<sup>1</sup> *Altor. Forsch.*, i. 27.

<sup>2</sup> *Muşri, Meluḥḥa, Ma'in*, p. 20.

<sup>3</sup> = 'eber ha-nahar (Winckler) [? hannahar].

<sup>4</sup> *Zeits. für Assyriol.*, x., 32.

<sup>5</sup> *Muşri, Meluḥḥa, Ma'in*, 18.

<sup>6</sup> *Muşri, Meluḥḥa, Ma'in*, p. 2.

<sup>7</sup> For *pa-na* read [DINGIR].ALAD (l. 3), and add a determinative prefix to the proper name in l. 5. Read *inā lib-bi* after *ša* in l. 3.

## LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

## Symbol for Partial Differentiation.

In his first letter (p. 53), Prof. Perry very properly drew attention to the desirability of greater definiteness in the notation for partial differential coefficients in the case of functions of two variables, the essence of his remarks being that it is not enough merely to change  $d$  into  $\partial$ , but that the variable which is for the nonce held to be constant should also be indicated. Apropos of this, and for the sake of historical interest, I quoted from a paper since published (*Proc. R.S. Edinb.* xxiv. pp. 151-194) a short paragraph regarding a passage<sup>1</sup> in Jacobi's writings of the year 1841, and containing a footnote with an old suggestion on the matter of notation. In his second letter (p. 271), Prof. Perry undertakes to show that this latter notation is objectionable so far as thermodynamics is concerned, and not to be compared with that which he himself uses. I regret to have to say that I was quite satisfied with his notation, and had no intention whatever of bringing the two into comparison, mine having been designed for much more complicated cases than those which occur in ordinary text-books on thermodynamics. His words are:—

"I use one letter  $E$  where on Mr. Muir's suggestion I must use six distinct symbols if I have to express any differential coefficient of  $E$ , and if I have to express all the differential coefficients of  $v$  I must use other six symbols; altogether I must use thirty of these curious symbols instead of five common letters, and, furthermore, I must keep them all in my head."

This is, of course, all a mistake. Without any desire, therefore, to spare Prof. Perry's head, but merely in order to undo a misrepresentation, however unwitting, I am forced to point out that if we are to have a perfectly definite notation in this connection, we must indicate three things, viz. (1) the dependent variable  $E$ ; (2) the two independent variables, say  $v$  and  $\rho$ ; and (3) whether the differentiation is to be performed with respect to  $v$  or  $\rho$ . Now, in the notation of my last letter these three are all cared for, thus

$$E_{v, \rho}^1;$$

or, since a vinculum contributes a "curious" look to the symbol, let it be written

$$E^1(v, \rho).$$

The notation used by Prof. Perry, viz.

$$\left(\frac{dE}{dv}\right)_\rho$$

is a trifle lengthier, but, as I have said, is equally definite, the main difference between the two arising from the fact that in the matter of differentiation he is a "dee-ist"; it is, however, excessively cumbersome when used in the complicated cases for which the other was designed. THOMAS MUIR.

Cape Town, South Africa, August 9.

It would have been presumption on my part to express my private opinion, which is in favour of Dr. Muir's symbol in general mathematical work, and so I referred merely to its use in thermodynamics where I think that such a use would be bad.

The form he now gives is handier, being a mnemonic for my symbol, but I submit that it is different from what he would use in other applications of mathematics. According to his general

system,  $\rho^1(v, \phi)$  implies that there is a function of  $v$  and  $\phi$  called  $\rho^1(v, \phi)$  which is differentiated. But  $\rho^1(t, E)$  implies that there is a function  $\rho^1(t, E)$ , and in thermodynamics  $\rho^1(v, \phi)$  is always

<sup>1</sup> Well worth reading. It begins at "Ut distinguerentur," on p. 320, and ends at bottom of p. 322 of vol. xxii. of *Crelle's Journal*.

equal to  $\rho(t, E)$ . If  $\rho$  is a functional symbol there can be no such equality, and I still think that the forms in which I put Dr. Muir's suggestion were the only ones consistent with his instructions. The new form would give no great trouble to a good mathematician perhaps, but it would quite unsettle the ordinary student of thermodynamics.

A man who insists on "dee-ism" in those parts of higher mathematics where it is clumsy is an obstacle to progress. But if Dr. Muir had my experience in dealing with men who know only a little mathematics and who wish to use what they know, he would, I think, be a "dee-ist" in elementary work.

JOHN PERRY.

## PROF. JOHN JAMES HUMMEL.

JOHN JAMES HUMMEL was born in 1850 at Clitheroe, in Lancashire. His father was a native of Switzerland and his mother English.

His scientific education was obtained at the Zurich Polytechnic, where he studied under Bolley, Städeler, Wislicenus and Weith. On returning to England in 1870, he became chemist in the calico printworks of Messrs. Jas. Black and Co., of Alexandria, near Glasgow, and remained there six years, busily and successfully engaged with new dyeing problems incident to the introduction of artificial alizarine and other coal-tar dyes. He was subsequently connected with other printing and dyeing firms, until in 1879 he decided to gratify his taste for science and teaching by applying for the post of Instructor in the dyeing department established at the Yorkshire College by the Clothworkers' Company of London. On taking up work at the College, Hummel applied himself with the utmost assiduity to devising and developing a system of instruction in dyeing. In this difficult undertaking he relied upon his own ideas, and he will always rank as a pioneer in this branch of teaching. He was a firm believer in the value of pure science, and always protested against that superficial teaching of technology too often attempted in compliance with the wishes of self-styled practical men. The course of teaching which he devised has been adopted very widely in this country and has attracted much attention abroad. The Dyeing School at the Yorkshire College has drawn students from all parts of the world.

Hummel's original contributions to his subject have always been marked by mastery of the subject in hand and scrupulous attention to detail. The burden of teaching and administrative duties severely restricted his time for experimental investigations, but his desire to have such work in progress in his department was gratified in the most handsome way by the Clothworkers' Company, which has associated a research chemist with the professor of dyeing.

The last few years of Hummel's life were devoted to the planning and organisation of important extensions of his department, which is now in possession of extremely ample and well-appointed buildings. In this, as in all other work, Hummel did not spare himself, and the strain doubtless told upon his health.

As an expert on his subject, Hummel was in constant demand. He lectured occasionally on important developments of dyeing before the Society of Arts, the Imperial Institute and other institutions, and he was a juror at the last Paris Exhibition. As an author, he was best known by his admirable text-book of dyeing, which has had a very large circulation and has been translated into a great variety of languages.

His labours have done much for the college with which he was associated and for the important industry that he so earnestly desired to serve. Fortunately, he has left a large number of disciples who, in different parts of the world, are carrying on the work which he originated.

A. S.

THE BRITISH ASSOCIATION AT BELFAST.

THE Belfast meeting of the British Association was concluded as we went to press last week. The weather during the meeting was not all that might have been desired, but both the local committee and the visitors have reason to be thankful that the deluge which flooded Belfast a few days before the opening meeting did not occur a few days later.

The flags of the presidents were in imminent danger of destruction on account of this flood. They had been placed on a table in the Grosvenor Hall ready to be hung up for the opening address, and were saved only by the timely action of the Rev. Mr. Kerr, who divesting himself of some of his clothing, waded in to their rescue. The water afterwards rose to a height of several feet in the Hall, an occurrence never before experienced there.

With the exception of the garden party given by the local executive committee in the Botanic Gardens Park, when the rain came punctually at the hour named on the cards and departed with the guests, all the other outdoor functions went off with nothing more than a sprinkle or two.

The garden parties of the Earl and Countess of Shaftesbury and of Lord and Lady O'Neill at their picturesque residences were favoured with dry but cool afternoons, as was also that of Mr. and Mrs. J. Brown. This last included a visit to the linen factory of Mr. G. Herbert Brown, and an inspection of Mr. Brown's physical laboratory and of various applications of electric power to domestic appliances, among which an electrically driven lawn mower and the ice-making, knife-cleaning and meat-chopping machines in the kitchen offices seemed to attract most attention. The excursions arranged for Saturday were well attended, as also were those planned by the Belfast Naturalists' Field Club for the Thursday after the meeting.

General and warm approval has been expressed regarding the arrangements made by the local officials for the reception and comfort of the members, and although these were smaller in number than on the last occasion, this was not due to any falling off in those visiting Belfast, but rather to the apathy of local people, judging by the smaller number of associates' and ladies' tickets issued, as shown by the following table:—

	1874.	1902.
Old Life Members ... ..	102	243
New " " " " " " " "	13	21
Old Annual Members ... ..	232	314
New " " " " " " " "	85	84
Associates ... ..	817	647
Ladies ... ..	630	305
Foreign Members ... ..	12	6
	1951	1620

It has been questioned whether this falling off, especially in the number of ladies' tickets, may not be ascribed in a considerable degree to the educational methods of Ireland and their effect on the tastes of those brought up under their influence within the last thirty years.

The educational note struck in the admirable Presidential Address of Prof. Dewar seemed to ring through the entire proceedings, and not only in the new Section devoted to the subject, but in joint discussions, and notably in the excellent address of Prof. Perry in Section G, do we find this question prominent. New opinions seem to be growing, and among these are the ideas that the English public-school system must be relegated to the limbo of inefficiency and that the technical school of the kind made in Germany is all very well over there, but almost useless here.

From a scientific point of view, the meeting was without doubt an admirable one. Many important papers were brought before the sections.

At the concluding meeting of the Association, the following votes of thanks were unanimously adopted:— (1) To the Lord Mayor and Corporation for their reception of the Association; to the President and Council of the Queen's College, the Presbyterian College, the Methodist College and the Elmwood Presbyterian Church for the use of rooms; and to the Harbour Commissioners for their reception. (2) To the local secretaries—Mr. John Brown, Mr. Ferguson and Prof. Fitzgerald—Dr. Kyle Knox (the local treasurer) and the local committee for the excellent arrangements made for the reception of the Association in Belfast. (3) To the noblemen, gentlemen and public bodies who have entertained the Association; to the firms who have opened their works; to the citizens who have hospitably entertained members; to the gentlemen who have contributed to the success of the excursions; to the committees of clubs, libraries and other institutions who have opened their premises to the members of the Association; to the Belfast Tramway Company; and to the Belfast Press, for their admirable reports of the proceedings.

A noteworthy event of the meeting was the speech given by Prof. C. S. Minot, President of the American Association, in which he invited members of the British Association to attend the meeting to be held early next January at Washington. Prof. Minot said he had been directed by the council of his Association to express the hope that as many members as possible of the British Association would attend the Washington meeting. A vote had been passed to the effect that all members of the British Association would be received upon presenting themselves at the meetings in America as members of the American Association without further requirement. In future, as has already been announced in these columns, the annual meetings of the American Association will begin on the first Monday after Christmas and extend throughout the week. The scientific societies affiliated with the Association have agreed to this arrangement, and the universities have consented to the establishment of this "Convocation Week," in which the meetings of scientific societies are to be held. It is expected that the first meeting to be held next January under this rule will be the most important scientific gathering ever held in America. In the course of his remarks, Prof. Minot said:—

It was the duty, he believed, which they should all perform to attend these gatherings and take part in international intercourse. Many Americans had come to the British Association, and they had always been treated with the greatest hospitality. They arrived strangers and went away friends; they brought expectations, and took back realisations and a grateful memory. He asked for one moment in which to remind them of a new historic condition never existing in the world before. It was the first time that two great nations existed with a common speech, a common past, a common history; would they not therefore so work together that they might build up a common future? And for the scientific man this duty came first. Each nation was governed, not by the Government, but by the men of learning and above all by the universities. Nowhere, he believed, in the Anglo-Saxon world had science yet taken its place in the universities. Nowhere in the Anglo-Saxon world had the full value of scientific knowledge throughout the whole range of life, from the university down to every practical affair—nowhere, he said, had the full power of the world of science been established.

Prof. Dewar, in replying on behalf of the Association said:—

They were all delighted to hear the kind invitation which had been extended to the members of the Association by their brother workers on the other side of the Atlantic. The great blunder we in the United Kingdom were perpetrating for many years past was in remaining ignorant of what was being done on the other side of the Atlantic. He had again and again said to manufacturers and those interested in industrial progress that if they would subsidise their chief officials by a donation which would enable them to spend their short holiday by going to see what

could be seen during a three weeks' residence in the United States, to note how they economise time there, how a person could be transferred from place to place, the freedom with which one is allowed to see the great internal organisation—if they did that they would be repaid one-hundredfold. He did not know of anything that had occurred to himself personally which had affected him so much as a short visit which he had the honour of paying to America. Both in the universities and in applied industries it was a revelation to him, and he was sure it would be a personal gratification to every member of that Association, and an entirely new revelation to them, if they took advantage of the invitation offered. He hoped some of the officials of the British Association would be present on the great occasion in Washington.

In bringing the meeting to a close, Prof. Dewar referred to the work of Joseph Black, Thomas Andrews, James Thomson, Lord Kelvin and Prof. Tait, who were connected with Belfast and had given it a leading place in scientific history.

## SECTION D.

### ZOOLOGY.

OPENING ADDRESS BY PROF. G. B. HOWES, D.Sc., LL.D., F.R.S., PRESIDENT OF THE SECTION.

#### *The Morphological Method and Progress.*

It is now twenty-eight years since this Association last assembled in Belfast, and to those present who can recall the meeting the proceedings of Section D will be best remembered for the delivery of an address by Huxley "On the Hypothesis that Animals are Automata, and its History," one of the finest philosophic products of his mind. At that date the zoological world was about to embark on a period of marked activity. Fired by the influence of the "Origin of Species," which had survived abuse and was taking immediate effect, the zoological mind, accepting the doctrine of evolution, had become eager to determine the lines of descent of animal forms. Marine observatories were in their infancy; the *Challenger* was still at sea; the study of comparative embryology was but then becoming a science; and when, reflecting on this, we briefly survey the present field, we can but stand astonished at the enormity of the task which has been achieved.

Development has proceeded on every hand. The leavening influence, spreading with sure effect, has in due course extended to the Antipodes and the East, in each of which portions of the globe there has now arisen a band of earnest workers pledged to the investigation of their indigenous fauna, with which they are proceeding with might and main. Of the Japanese, let it be said that not only have they filled in gaps in our growing knowledge, for which they alone have the materials at hand, but that, with an acumen deserving the highest praise, they have put us right on first principles. I refer to the fact that they have shown, with respect to the embryonic membranes of the common chick, that we in the West, with our historic associations, our methods and our skill, contenting ourselves with an ever-recurring restriction to the germinal area, have, by an error of orientation, missed an all-important septum, displaced under an inequality of growth.

Those of us who have lived and worked throughout this memorable period have had a unique experience, for never has there been progress so rapid, accumulation of observations so extensive and exact. Of the 386,000 living animal species, to compute the estimate low, every one available has been lain under hand, with the result that our annual literary output now amounts to close upon 10,000 contributions, the description of new genera and subgenera, say 1700. More than one-half of this vast series refers to the Insecta alone; but notwithstanding this, the records of facts of structure and development, with which most of us are concerned, now amount to a formidable mass, calculated to awe the unlettered looker-on, to overwhelm the earnest devotee, unless by specialising he can secure relief. As an example of what may occur, it may be remarked that a recent exploration of the great African lakes has resulted in the discovery of over 130 new species.

As to the nature of this unprecedented progress, it will suffice to consider the Earthworms. In 1874 few were known to us. An advance in our knowledge, which had then commenced, had made known but few more which seemed likely to yield result. Darwin's book upon them had not appeared. Some were exotic, it is true, but no one suspected that a group so restricted in their

habits could reveal aught beyond a dull monotony of form and structure. Never was surmise more wide of the mark, for the combined investigations of a score of earnest workers in all parts of the world have in the interval recorded some 700 odd species of about 140 genera. Mainly exotic, they exhibit among themselves a structural variation of the widest possible range. Not only do we recognise littoral and branchiate forms, but others achatous and leech-like in habit, to the extent of the discovery of a morphological overlap with the leeches, under which we are now compelled to remove them from their old association with the flat worms, and to unite them with the earthworms. And we even find these animals, as represented by the *Acanthodrilide*, coming prominently into considerations which involve the theory of a former Antarctic continent, one of the most revolutionary zoo-geographical topics of our time.

This case of the earthworm may be taken as typical of the rest, since for each and every class and order of animal forms, the progress of the period through which we have passed since last we assembled here has produced revolutionary results. Our knowledge of facts has become materially enhanced; our classifications, at best but the working expression of our ideas, have been to a large extent replaced in clearer, more comprehensive schemes; and we are to-day enabled to deduce, with an accuracy proportionate to our increased knowledge of fact, the nature of the interrelationships of the living forms which with ourselves inhabit the earth.

Satisfactory as is this result, it must be clearly borne in mind that its realisation could not have come about but for a knowledge of the animals of the past; and turning now to palæontology, it may be said that at the time of our last meeting in this city the scientific world was just becoming entranced by the promise of unexpected results in the exploration of the American Tertiary beds, then being first opened up. The Rocky Mountain district was the area under investigation, and with this, as with the progress in our knowledge of recent forms, no one living was prepared for the discoveries which shortly came to pass. To consider a concrete case, we may premise that study of the placental mammals had justified the conclusion that their ancestors must have had equal and pentadactyle limbs, a complete ulna and fibula, a complete clavicle, and a skull with forty-four teeth; and must have realised, that is, the predominant term of the living *Insectivora* as generally understood. Who among the zoologists of our time does not recall with enthusiasm the revelation which arose from the discovery, during these early days, in the Eocene of Central North America, of the genera at first described as *Eo-* and *Helohyus*? The evidence of the existence, in the locality named, of these forty-four toothed peccaries, as they were held to be, rendered clearer the records of the later Tertiary deposits of the old world, which were those of hogs, and, in correlation with the facts then known, suggested that the Rocky Mountain area was the home of the ancestral porcine stock, and that in Early Tertiary times their descendants must have migrated, on the one hand, across the northern belt, of which the Aleutian Islands now mark the course, into the old world, to beget, by complication of their teeth, the pigs and hogs; and on the other into Central South America, to give rise, by numerical reduction of teeth and toes, to the peccaries, still extant.

Migration in opposite directions with diversity of modification was the refrain of this remarkable find, far-reaching in its morphological and zoo-geographical effects. Nor can we allude with less fervour to the still more striking case of the horses, which proved not merely a similar, though perhaps a later, migration, but a parallelism of modification in both the old and new worlds, culminating in the latter in extinction, whereby it became necessary, on the advent of civilised man, to carry back the old-world horse to its ancestral American home. No wonder that this should have provoked our Huxley to the remark that in it we have the "demonstrative evidence of the occurrence of evolution," and that the facts of palæontology came to be regarded as certainly not second to those of the fascinating but seductive department of embryology, at the time making giant strides.

I have endeavoured thus to picture that state of zoological science at the time of our last meeting here; and I wish now to confine myself to some of the broader results since achieved on the morphological side. But let us first digress, in order to be clear as to the meaning of this phrase.

We do not expect the public to be accurate in their usage of scientific terms; but it is to me an astounding fact that among trained scientific experts, devotees to branches of science other than our own, there exists a gross misunderstanding as to the

limitations of our departments. I quote from an official report in alluding to "comparative anatomists, or biologists, as they call themselves," and I but cite the words of an eminent scientific friend, in referring to biology and botany as coequal. In endeavouring to get rid of this prevailing error, let it be once more said that the term "biology" was introduced at the beginning of the nineteenth century by Treviranus and Lamarck, and that in its usage it has come to signify two totally distinct things as employed by our continental contemporaries and ourselves. By "Biologie" they understand the study of the organism in relation to its environment. We, following Huxley, include in our term biology the study of all phenomena manifested by living matter; botany and zoology; and by morphology we zoologists mean the study of structure in all its forms, of anatomy, histology and development, with palæontology—of all, that is, which can be preferably studied in the dead state, as distinct from physiology, the study of the living in action. Comparative morphology, the study of likeness and unlikeness, is the basis of our working classifications, and it is to the consideration of the morphological method, and the more salient of its recent results, that I would now proceed, in so far as it may be said to have marked progress and given precision to our ideas within the last eight-and-twenty years. I would deal in the main with facts, with theories only where self-evident, ignoring that type of generalisation to which the exclusive study of embryology has lent itself, which characterises, but does not grace, a vast portion of our recent zoological literature.

To the earnest student of zoology, intent on current advance, the mental image of the interrelationships of the greater groups of animal forms is ever changing, kaleidoscopically it may be, but with diminishing effect in proportion as our knowledge becomes the more precise.

Returning now to American palæontology, we may at once continue our theme. In this vast field, expedition after expedition has returned with material rich and plentiful; and while, by study of it, our knowledge of every living mammalian order, to say the least, has been extended, and in some cases revolutionised, we have come to regard the Early Tertiary period as the heyday of the mammals, in the sense that the present epoch is that of the smaller birds. No wonder then that there should have been discovered group after group which has become extinct, or evidence that in matters such as tooth-structure there is reason to believe that types identical with those of to-day have been previously evolved but to disappear. To contemplate the discovery of the Titanotheria, the Amblyopoda, the Dinocerata, with their strange diminutive brain, chief among the heavier ungulate forms, is to consider the Mammalia anew; and when it is found that among late discoveries we have (1) that of a series of Rhinocerotidae, which though not yet known to extend so far back in time as the primitive tapirs and horses are complete as far as they go; (2) that among the Ruminants we have, in the Oreodontidae of the American Eocene, primitive forms with a dentition of forty-four teeth, an absence of diastemata, a pentadactyle manus, a tetradactyle pes with traces of a hallux, and, as would appear from an example of Mesoreodon, a bony clavicle, such is unknown in any later ungulate, we are aroused to a pitch of eager enthusiasm as to the outcome of labours now in hand; for, as I write, there reaches me a letter to the effect that for most of the great vertebrate groups, and not the mammals alone, collections are still coming in, each more wonderful than the last.

In the extension of our knowledge of the Ancylopodia, an order of mammals named after the Ancylotherium of Pikermi and Samos, which occur in the Early Tertiary deposits of Europe, Asia, North America and abundantly in Patagonia, we have been made aware of the existence of genera whose salient structural features combine the dentition of an ungulate with the possession of pointed claws, believed to have been retractile like those of the living cats. Conversely to these unguiculate herbivores, which include genera with limbs on both the artio- and perisso-dactyle lines, there have been found, among the so-called Mesonychidae, undoubted primitive carnivores, indications of a type of terminal phalanx seal-like and approximately non-unguiculate; from all of which it is clear that we have in the rocks the remains of forms extinct which transpose the correlations of tooth and claw deducible from the living orders alone. Further, among the primitive pentadactyle Carnivora we meet, in the genus *Patriofelis*, with a reduction of the lower incisors to two, and characters of the fore-limb which, with this, suggest the seals. It is, however, probable that these characters are in

no way indicative of direct genetic relationship between the two, for, inasmuch as these animals were accustomed to seek their food in the water of the lake by which they dwelt, their seal-like characters may be but the expression of adaptation to a partially aquatic mode of life—of parallelism of modification with the seals and nothing more.

Early in the history of their inquiry, our American confrères recorded from the Pliocene the discovery of camel-like forms possessed of a full upper incisor dentition; for example, the genera *Protolabis* and *Ithygrammodon*; and now they have arrived at the conclusion that while the camels are of American origin, one of their most characteristic ruminants, the Prongbuck (*Antilocapra*), would conversely appear to be the descendant of an ancestor (*Blastomeryx*) who migrated from the old world.

Sufficient this concerning the work in mammalogy of the American palæontologists. While we return them our devout and learned admiration, we would point out that the brilliance of their discoveries has but beclouded the recognition of equally important investigations going on elsewhere. In Argentina there have proceeded, side by side with the North American explorations, researches into the Pleistocene or Pampa fauna, which in result are not one whit behind, as has been proved by the recognition of a whole order of primitive ungulates, the *Toxodontia*, by that of toothed cetaceans with elongated nasals, as in the genera *Prosqualodon* and *Argyroctetus*, and of sperm whales with functional premaxillary teeth, viz. *Physodon* and *Hypocetus*, to say nothing of giant armadillos and pigmy glyptodonts.

It will be remembered by some present that, from Patagonian deposits of supposed Cretaceous age, there was exhibited at our Dover meeting the skull of a horned chelonian *Meiolania*, which animal we were informed, is barely distinguishable from the species originally discovered in Cook's Island, one of the Society group, and which, being a marsh turtle highly specialised, would seem in all probability to furnish a forcible defence for the theory of the Antarctic continent. But more than this, renewed investigation of the Argentine beds by the members of the Princeton University of North America have recently resulted in collections which, we are informed, seem likely to surpass all precedent in their bearings upon our current ideas, not the least remarkable preliminary announcement being the statement that there occurs fossil a mole indistinguishable, so far as is known, from the golden mole (*Chrysochloris*) of South Africa.

Before I dismiss this fascinating subject, let me disarm the notion, which may have arisen, that the palæontological work of the old world is done. Far from it! Even our American cousins have to come to us for important fossil forms; as, for example, the genus *Pliohyrax* of Samos and the Egyptian desert, while among the rodents and smaller carnivores there are large collections in our national museum waiting to be worked over afresh.

If one part of the globe more than another is just now the centre of interest concerning its vertebrate remains, it is the Egyptian desert. Here there have recently been found the bones of a huge cetacean associated, as in South America, with those of a giant snake, one of the longest known, since it must have reached a length of thirty feet. There also occur the remains of other snakes, of chelonians of remarkable adaptive type, of crocodylians, fishes and other animals. Interest, however, is greatest concerning the Mammalia, which for novelty are quite up to the American standard, as with an upper and a lower jaw of an anomalous creature, concerning which we can only at present remark that it may be a marsupial, or more probably a carnivore, which has taken on the rodent type in a manner peculiarly its own. Important beyond this, however, are a series of Eocene forms which more than fill a long-standing gap, viz., that of the ancestors of the Elephants and Mastodons, which hitherto stopped short in the Middle Miocene of both old and new worlds. As represented by the genus *Mærittherium*, they have three incisors above and two below, of which the second is in each case converted into a short but massive tusk. An upper canine is present, and in both upper and lower jaws a series of six cheek-teeth, distinct and bunodont in type. In the allied *Barytherium*, of which a large part of the skeleton is known, the upper incisors were presumably reduced to two, the tusks enlarged, with resemblances in detail to the Dinoceratan type.

So far as these remains are known, they appear to present in their combined characters all that the most ardent evolutionist

could desire. There are with them Mastodons which simplify our knowledge of this group; and among the last discovered remains Sirenians, which, in presenting a certain similarity to the afore-named *Mæritherium*, strengthen the belief in the proboscidian relationships of these aquatic forms. Finally, and perhaps most noticeable of all, there is the genus *Arsinoitherium*, a heavy brute with an olfactory vacuity which outrivals that of *Grypotherium* itself, and is surmounted by a monstrous fronto-nasal horn, swollen and bifid, for which the most formidable among the Titanotheres might yearn in vain. There is an occiput to match! The suggestion that this extraordinary beast has relationships with the Rhinocerotidae is absurd, since its tooth pattern alone inverts the order of this type. That it is a proboscidian may be nearer the mark, and if so it shows once more how subtle were the mammals of the past. Great as is this result, much remains to be done or done again, if only from the fact that in seeking to determine homologies our American brethren, in the opinion of some of us, have placed too much reliance on a so-called tritubercular theory of tooth genesis, of which we cannot admit the proof. How, we would ask, is it conceivable that a transversely ridged molar of Diprotodon type can be of tritubercular origin?

Sufficient for the moment of palæontological advance, except to remark that the zoologist who neglects this branch of morphology misses the one leavening influence; neglects the court on whose ruling arguments deduced from embryological data alone must either stand or fall. We may form our own conclusions from facts of the order before us; but it is when we find their influence on the master-mind prompting to action, like that of Huxley with his mighty memoir of 1880, in which he revised our subclass terms, that we appreciate them to the full.

With this consideration we pass to the living forms, and I have only time in dealing with these to comment on advance which affects our broadest conceptions and classifications of the past.

To commence with the Mammalia, we now know that the mammary gland when first it appears is in all forms tubular, and that this type is no longer distinctive of the Monotremata alone. We know, too, that the intranarial position of the epiglottis when at rest, long known for certain forms, is a distinction of the class. It explains the presence of the velum palatinum, by its association with the glottis for the restriction of the respiratory passage, the connection being lost in man alone, under specialisation of the organ of the voice.

Similarly, the doubly ossified condition of the coracoid may now be held diagnostic, for it is known that the epicoracoidal element, originally thought to characterise the monotremes alone, is always present, and that reduction to a varying degree characterises the metacoracoid, which retires, as in man, as the so-called coracoid epiphysis.

Our conceptions of the interrelationships of the Marsupialia and Placentalia have during the period we are considering been delimited beyond expectation, by the discovery of an allantoic placenta in a polyprotodont marsupial, in place of the vitelline, present in its allies. When it is remembered that in the formation of the placenta of the rabbit and a bat there is realised a provisional vitelline stage, it is tempting to suggest that the evidence for the direct relationship of the two mammalian subclasses first named overlaps (there being a placental marsupial on the one hand, a marsupial placental on the other), much as we have come to regard *Archæopteryx* as an avian reptile, the *Odontornithes* as reptilian birds. These facts, moreover, prove that the type of placenta inherited by the Placentalia must have been discoidal, and that from that all others were derived.

Equally important concerning our knowledge of the Marsupialia is the discovery, first made clear by Prof. Symington, of this College, that Owen was correct in denying them a corpus callosum. How Owen arrived at this conclusion it is difficult to conceive; but in these later days the history of discovery is largely that of method; and it is by the employment of chrome-silver, methylene-blue, and other reagents, which in differentiating the fibre-tracts enable us to delimit their course, that this conclusion has been proved. By the corpus callosum we now understand a series of neo-pallial fibres which transect the alveus and are present only in the Placentalia.

There is no department of mammalogy in which recent work has been more luminous than this which concerns the brain; and, to mention but one result, it may be said that in the renewed study of the commissures there has been found a fibre-

tract characteristic of the Diprotodontia alone, so situated as to prove that they and the Placentalia must have specialised on diverse lines from a polyprotodont stock. Interesting this, the more, since the phalangers and kangaroos are known to be polyprotodont when young. And when we add the discovery that in the detailed relationship of its commissures the brain of the Elephant Shrew, a lowly insectivore, alone among that of all Placentalia known, realises the marsupial state, as does its accessory organ of smell, we have to admit the discovery of annectant conditions just where they should occur.

The morphological method is sound!

The master hand which has given us this result has also reinvestigated the Lemurs. From an exhaustive study of the brain or its cast of all species of the order, living and extinct, there has come the proof that the distinctive characters of the lemuroid brain are intelligible only on a knowledge of the pithecoïd type; that its structural simplicity in the so-called lower lemurs is due to retrogressive change, in some species proved to be ontogenetic; and that the Tarsier, recently claimed to be an insectivore, is a lemur of lemurs. It is impossible to over-estimate the importance of this conclusion, which receives confirmation in recent palæontological work; and there is demanded a reinvestigation of those early described Tertiary fossil forms placed on the Ungulo-lemuroid border line, as also a reconsideration of current views on the evolution of the primates and of man.

In dismissing the Mammalia, we recall the capture during the period we review of three new genera, a fourth, the so-called *Neomylon*, having proved by its skull to be *Grypotherium Darwinii*, already known. The African Okapi, an object of sensation beyond its deserts, has found its place at last. To have been dubbed a donkey, a zebra and a primitive hornless giraffe is distinction indeed; and we cannot refrain from contrasting the nonsensical statement that its discovery is "the most important since *Archæopteryx*" with the truth that it is a giraffine, horned for both sexes, annectant between two groups well known. As a discovery it does not compare with that of the Mole-marsupial, and it falls into insignificance beside that of the South American diprotodont *Cœnolestes*, the survivor of a family which there flourished in Middle Tertiary times.

Passing to Birds and Reptiles, it will be convenient to consider them together. A knowledge of their anatomy has extended on all hands, and in respect to nothing more instructively than their organs of respiration. Surprise must be expressed at the discovery, in the chelonian, of a mode of advancing complication of the lung suggestive of that of birds. On looking into this, I find that Huxley, who rationalised our knowledge of the avian lung and its sacs, was aware of the fact that in our common Water-tortoise (*Emys orbicularis*), the lung is sharply differentiated along the bronchial line into a postero-dorsal more cellular mass, an antero-ventral more sacular, of which the posterior vesicle, in its extension and bronchial relationships, strangely simulates the so called abdominal sac of birds. He had already instituted comparison with the Crocodiles, and was clearly coming to the conclusion that the arrangement in the bird is but the result of extreme specialisation of a type common to all Sauropsida with a "cellular" lung. The respiratory process in the bird may be defined as transpulmonary, and it is an interesting coincidence that, as I write, there comes to hand a memoir, supporting Huxley's conclusion, and establishing the fact that there is a fundamental principle underlying the development and primary differentiation of all types of vertebrate lung.

The discovery of the *Odontornithes* in the American Cretaceous is so well known, that it is but necessary to remark that nine genera and some twenty species are recognised. To *Archæopteryx* I shall return. Before dismissing the Chelonian, however, it must be pointed out that palæontology has definitely clenched their supposed relationship to the Plesiosaurs. Of all recent palæontological collections there are none which, for care in collecting and skill in mounting, surpass the reptilian remains from the English Jurassic (Oxford Clay) now public in our national museum. The Plesiosaurs of this series must be seen to be appreciated, and nothing short of a merciful Providence can have interposed, to ensure the generic name *Cryptocleidus*, which one of them has received, since the hiding of the clavicle, its diagnostic character, is an accomplished fact. It is due to secondary displacement, under the approximation in the middle line of a pair of proscapular lobes, present in the Plesiosauria and Chelonian alone, and until the advent of this discovery mis-



interpreted. Taken in conjunction with other characters of little less importance, conspicuously those of the plastron and pelvis, this decides the question of affinity, and proves the Chelonia to have had a lowly ancestry, as has generally been maintained.

Recent research has fully recorded the facts of development of the rare New Zealand reptile *Sphenodon*, and it has more than justified the conclusion that it is the sole survivor of an originally extensive and primitive group, the Rhynchocephalia, as now understood. To confine our attention to its skeleton, as that portion of its body which can alone be compared with both the living and extinct, it may be said that positive proof has been for the first time obtained that the developing vertebral body of the terrestrial vertebrata passes through a paired cartilaginous stage, and that in its details the later development of this body is most nearly identical with that of the lower Batrachia. There has long been a consensus of opinion that the forward extension of the pterygoids to meet the vomers in the middle line, known hitherto in this animal and the crocodiles alone, is for the terrestrial Vertebrata a primitive character; and proof of this has been obtained by its presence in all the Rhynchocephalia known. The same condition has also been found to exist in the Plesiosaurs, the Ichthyosaurs, the Pterodactyles, the Dicotylodontia, the Dinosaurs, and with modification in some Chelonians. It has, moreover, been found in living birds; a most welcome fact, since *Archæopteryx*, in the possession of a plastron, carries the avian type a stage lower than the Dinosaurs. It is pertinent here to remark that, inasmuch as in those Dinosaurs (*e.g.* *Compsognathus*) in which the characters of the hind limbs are most nearly avian, the pelvis, in respect to its pubis, is at the antipodes of that of all known birds, and the fore-limb is shortened in excess of that of *Archæopteryx* itself, the long supposed dinosaurian ancestry for birds must be held in abeyance.

Passing through the Rhynchocephalia to the Batrachia, we have to countenance progress most definite in its results. The skull, the limbs and their girdles are chiefly concerned, and this in a very remarkable way.

In the year 1881 there was made known by Prof. Frierip, of Tübingen, the discovery that the hypoglossus nerve of the embryo mammal is possessed of dorsal ganglionated roots. Again and again have I heard Huxley insist on the fact that the ventral roots of this nerve are serial with the spinal set, but never did he suspect the rest. It is, however, a most intensely interesting fact that, whereas by a Huxleian triumph the vertebral theory of the skull was overthrown, in these later Huxleian days the proof of the incorporation of a portion of the vertebral region of the trunk into the mammalian occiput should have marked the succeeding epoch in advance. The existence of twelve pairs of cranial nerves which all the Amniota possess involves them in this change; and the fact that in all Batrachia there are but ten, enables us to draw a hard-and-fast line between batrachian and amniote series.

It may be urged, as an objection, that since we have long been familiar with a fusion of vertebrae and skull in various piscine forms, the force of this distinction is weakened. But this cannot be; since, in respect to the investing sheaths and processes of development which lie at the root of the genesis of the vertebral skeleton, the fishes stand distinct from the Batrachia and Amniota, which are agreed. So forcible is this consideration that it behoves us to express it in words, and I have elsewhere proposed to discriminate between the series of terrestrial Vertebrata as *archæo-* and *syn-craniate*.

Similarly there is no proof that any batrachian, living or extinct (and in this I include the Stegocephala as a whole) possesses a costal sternum. So far as their development is known, the cartilages in these animals called "sternal" are either coracoidal or *sui generis*. The costal sternum, like the syn-craniate skull, is distinctive of the Amniota alone. Had the Stegocephala possessed it even in cartilage, there is reason to think it might have been preserved, as it has been in the colossal Mososaur *Tylosaurus* of the American Cretaceous. When to this it is added that whereas, in the presence of a costal sternum, the mechanism of inflation of the lung involves the body-wall, in its absence it mainly involves the mouth (as in all fishes and batrachians), the hard and sharp line between the Batrachia and Amniota may be expressed by the formula that the former are *archæocraniate* and *stomatophysous*, the latter *syn-craniate* and *somatophysous*.

There are allied topics which might be considered did our

time permit; but one certain outcome of this is that there is an end to the notion of a batrachian ancestry for the Mammalia. And when, on this basis, we sum up the characters demanded of the stock from which the Mammalia have been derived, we find them to be precisely those occurring outside the Mammalia in the Anomodont Reptiles alone. Beyond the sternum and skull, the chief characters are the possession of short and equal pentadactyle limbs, with never more than three phalanges to a digit, a complete fibula and clavicle, a doubly ossified coracoid, a heterodont dentition—a combination which, wholly or in part, we now associate with the Permian genera *Procolophon*, *Pariasaurus*, and others which might be named, the discovery of which constitutes one of the morphological triumphs of our time.

Beyond this, it may be added, concerning the Batrachia, that among living pedate forms the Anura have alone retained the pentadactyle state and the complete maxillo-jugal arch, and that the Eastern *Tylotriton*, in the possession of the latter, becomes the least modified urodele extant. These facts lead to the extraordinary conclusion that the living Urodela, while of general lowly organisation, are one and all aberrant; and it is not the least important sequel to this that, despite their total loss of limbs, the Apoda, in the retention of the dermal armour and other features which might be stated, are the most primitive Batrachia that exist.

The batrachian phalangeal formula 22343 was until quite recently a difficulty in the determination of the precise zoological position of the class; but it has now been overcome, by the discovery of a *Keraterpeton* in the Irish Carboniferous having three phalanges on the second digit of both fore- and hind-limbs, and by that in the Permian of Saxony of a most remarkable creature, *Scleurocephalus*, which, if rightly referred to the Stegocephala, had a head encased, as its name implies, in an armature like that of a fish, and the phalangeal formula of a reptile, 23454.

Passing from the Batrachia to the Fishes, we have still to admit a gap, since an interminable discussion on fingers and fins has not narrowed it in the least. In compensation for this, however, we have to record within the fish series itself progress greater, perhaps, than with the higher groups. Certainly is this the case if, as to bulk, the literature in systematics and palæontology be alone taken into account.

Of the Dipnoi our knowledge is fast becoming complete. We know that *Lepidosiren* forms a burrow; and, in consideration of a former monstrous proposal to regard this animal, with its fifty-six pairs of ribs, and Protopterus, with its thirty to thirty-five, as varieties of a species, it is the more interesting to find that the Congo has lately yielded a Protopterus (*P. Dolloii*) with the lepidosiren rib formula, viz., fifty-four pairs.

As a foremost result of American palæontological research we have to record the occurrence, in the Devonian of Ohio, of a series of colossal fishes known as the Arthrodira, the supposed dipnoan affinities of which are still a matter of doubt.

We have evidence that the osseous skeleton in a plate-like form first appeared as a protection for the eye of a primitive shark. And coming to recent forms having special bearings on the teachings of the rocks, we have to acknowledge the capture in the Japanese seas of a couple of ancient sharks, of which one (*Cladoselachus*), since observed to have a distribution extending to the far North, is a survivor from Devonian times; the other (*Mitsukurina*) a genus whose grotesqueness leaves no doubt of its identity with the Cretaceous lamnoid *Scapanorhynchus*. In the elucidation of the Sturiones, and the determination of their affinities with the ancient Paleoniscidae a master stroke has been achieved. In the Old Red genus *Palaespondylus* we have become familiar with an unmistakable marsipobranch, possessing, as do certain living fishes, a notochord, annulated, but not vertebrated in the strict sense of the term. The climax in Ichthyopalæontology, however, has been reached in the discovery of Silurian forms, which, there is every reason to believe, explain in an unexpected way the hitherto anomalous Pteras- and Cephalaspidians, by involving them in a community of ancestry with the primitive Elasmobranchs. The genera *Thelodus*, *Drepanaspis*, *Ateleaspis* and *Lanarkia* chief among these annectant and ancestral forms, are among the most remarkable vertebrate fossils known.

Passing to the Recent Fishes alone, the discovery which must take precedence is that of the mode of origin of the skeletogenous tissue of their vertebral column. The fishes, unlike all the higher Vertebrata, have, when young, a notochord invested in

a double sheath, there being an inner chordal sheath, an outer cuticular, which latter is alone present in all the higher groups. The skeletogenous cells, by whose activity the cartilaginous vertebral skeleton is formed, arise outside these sheaths; but whereas, when proliferating, they in one series remain outside, they in the other, by the rupture of the cuticular sheath, invade the chordal. This distinction enables us to discriminate between a *Chordal series*, which embraces the Chimæroids, Elasmobranchs and Dipnoi, and a *Perichordal*, consisting of the Teleosts, Ganoids and Cyclostomes.

In consideration of the enormity of the structural gap between the cyclostomes and the higher Vertebrata this is an extraordinary result. For be it remembered that, in addition to their well-known characters, the lampreys and hags (1) in the total absence of paired fins; (2) in the presence of branchiæ, ordinarily seven in number, fourteen in *Bdellostoma polytremæ*, numerically variable in individuals of certain species between six and fourteen, and doubtfully asserted in the young of one to be originally thirty-five; and (3) in the carrying up of their oral hypophysis by the nasal organ, whereby it perforates the cranium from above, as contrasted with all the higher Vertebrata, in which, carried in with the mouth-sac, it perforates it from beneath, exhibit morphological characters of an extraordinary kind. And if we are to express these characters in terms, we may distinguish the Cyclostomes as *apterygial* and *epicraniate*, the higher Vertebrata as *hypocraniate*.<sup>1</sup> But this notwithstanding, the aforementioned subdivision of the Pisces into two series, which would associate the teleosts and ganoids with the cyclostomes, as distinct from the rest, receives support from recent study of the head-kidney by a Japanese, who seeks to show that the organ so called in the Elasmobranchs is of a late-formed type peculiar to itself; and it is also in agreement with one set of conclusions previously deduced from the study of the reproductive organs.

To deal further with the fishes is impossible in this Address, except to remark that recent discovery in the Gambia that the young of the Teleostean genera *Heterotis* and *Gymnarchus* bear filamentous external gills, renders significant beyond expectation the alleged presence of these among the loaches, and shows that adaptive organs of this type are valueless as criteria of affinity.

In palæontology, as in recent anatomy, our records of detail have increased beyond precedent, often but to show how deficient in knowledge we are, how contradictory are our theories and facts.

In dismissing the fishes, I wish to comment upon our accepted terms of orientation. To speak of the median fins as dorsal, caudal and anal, of the pelvic as ventral, and of the pectoral in its varying degrees of forward translocation as abdominal or thoracic, though a convention of the past, is to-day inaccurate and absurd. I question if the time has not come at which the terms thoracic (pulmocardiac) and abdominal are intolerable, as expressing either the subdivisions of the body-cavity or anything else, outside the Mammalia, which alone possess a diaphragm. Even in the birds, to grant the utmost, the subdivision of the cœlom, if accurately described, must be into pulmonary, hyper-pulmonary and cardio-abdominal chambers; while with the reptiles the modes of subdivision are so complex that a special terminology is necessary for each of the several types extant.

In the fishes, where the pericardium is alone shut off, the retention of the mammalian terms but hampers progress. This was indeed felt by Duméril, when in 1865 he attempted a revisionary scheme. Since, however, one less fantastic than his seems desirable, I would propose that for the future the "anal" fin be termed *ventral*, the "ventral" *pelvic*; and that for the several positions of the pelvic, that immediately in front of the vent, primitive and embryonic (which is the position for the Elasmobranchs, Sturiones, Lower Siluroids and all the higher Vertebrata), be termed *proctal*, the so-called "abdominal" *pro-proctal*, the so-called "thoracic" *jugular* (in that it denotes association with the area of the "collar-bone"), and the so-called "jugular" *mental*. The necessity for this becomes the more desirable, now that it is known that a group of Cretaceous fishes (the Ctenothrissidæ), hitherto regarded as Berycoids, are

<sup>1</sup> It is an interesting circumstance, if their "ciliated sac" is rightly homologised, that Amphioxus and the Tunicata present a corresponding dissimilarity, allowance being made for the fact that in Botryllus, Good-siria and Polycarpa the sac overlies the ganglion. It is pertinent here to recall the ammocete-like condition of the "endostyle" in *Oikopleura labellum*.

in reality of clupeoid affinity, despite the fact that at this early geologic period they had translocated their pelvic fin into the jugular ("thoracic") position.

The sum of our knowledge acquired during the last twenty-eight years proves to us that, among the bony fishes, the structural combination which would give us a premaxillo-maxillary gape dentigerous throughout, a proctal pelvic fin, a heart with conal valves, would be the lowest and most primitive. Inasmuch as this character of the heart, so far as at present known, exists only among the Clupeosoces (pikes and herrings and their immediate allies), these must be regarded as lowly forms; wherefore it follows that the possession of but a single dorsal fin is not, as might appear, a necessary index of a highly modified state.

Before I dismiss the vertebrates, a word or two upon a recent result of morphological inquiry which concerns them as a whole. I refer to the development of the skull. Up to 1878 it was everywhere thought and taught that the cartilaginous skull was a compound of paired elements, known as the trabeculæ cranii and parachordals, and that the former contributed the cranial wall. Huxley in 1874, from the study of the cranial nerves of fishes, had reiterated the suggestion he made in 1864, when dealing with the skull alone, that the trabeculæ might be a pair of præ-oral visceral arches, serial with those which support the mouth and carry the gills. The next step lay with the Sturgeon, in which in 1878 it was found that the cranial wall is originally distinct. And later, when the facts were more fully studied in sharks, batrachians, reptiles and birds, it became evident that the trabeculæ, though ultimately associated with the cranial wall, take no share in its formation, and that when first they appear they are disposed at right angles to the parachordals and the axis, serially with the visceral arches behind. Huxley was right; and although this consideration by no means exhausts the category of independent cartilages now known to contribute to the formation of the skull, it proves that the cartilaginous cranium, like the bony one, which in the higher vertebrate forms replaces it, is in its essence compound.

I now pass to the Invertebrata. Of the Oligochæta and Leeches I have spoken, and we may next consider the Arthropods. Of the Insecta, our knowledge has gained precision, by the conclusion that the primitive number of their Malpighian tubes is six, and by the study of development of these in the American cockroach *Doryphora*, which has rendered it probable they may be modified nephridia, carried in as are those of some oligochætes with the proctodeal invagination. An apparent cervical placenta has been discovered in the orthopteran *Hemimerus*, which would seem to suggest homology with the so-called "trophic vesicle" of the Peripatoids, as exemplified by *P. Novae-Britannica*. In this same orthopteran there have been recognised, in secondary proximity to the "lingua," reduced maxillule, which, fully developed and interposed between the mandible and first maxilla, in *Japyx*, *Machilis*, *Forficula* and the *Ephemera* larva, give us a fifth constituent for the insectan head. And when it is found that all the abdominal segments of the common cockroach, when young, are said to bear appendages, of which the cerci are the hindermost, we have a series of facts which revolutionise our ideas. Little less striking is the discovery that in the caterpillar of the bombycine genera *Lagoa* and *Chrysopyga* seven pairs of pro-legs occur.

The fuller study of the apertures of the tracheate body has resulted in the discovery that the Chilopoda are more nearly related to the Hexapoda than to the Diplopods; wherefore it is proposed to reclassify the Tracheata, in accordance with the position of the genital orifice, into Pro- and Opisthogaona. In a word, the "Myriapoda," if a natural group, are diphyletic.

Our knowledge of the Peripatoids (*Arthropoda malacopoda*) has increased in all that concerns distribution and structure. They are now known, for example, from Africa, the West Indies, Australia and New Zealand, and for examples from the two latter localities and Tasmania the generic name *Ooperipatus* has but lately been proposed, to include three species, characterised by the possession of an ovipositor, of which two have been observed to lay eggs.

Work upon the Crustacea in our own land, notorious for the tendencies of some of its devotees in their sticking for priority, has within the last twelve years advanced beyond all expectation. Much of our literature has been systematised, and an enormous increase in our knowledge of new forms has to be admitted, thanks to memoirs such as those of the "Investigator,"

"Naples Zoological Station," and others which might be named; while in the discovery and successful monographing, in the intervals of six years' labour at other groups, of a new family of minute Copepods (the Choniostomatidae), parasitic on the Malacostraca, embracing forty-three species, difficult to find, we have an almost unique achievement. The hand which gave us this has also provided a report which embraces the description of a nauplius of exceptional type, which, by a process of reasoning by elimination, masterly in its method, has been "run to ground" as in every degree of probability the larva of Darwin's apodal barnacle *Protolepas bivineta*, of which only the original specimen is known.

There is but one other crustacean record equal in rank with this, viz., the discovery of the genus Anaspides. Originally obtained from a fresh-water pool on Mount Wellington, Tasmania, at 4000 feet, it has since been found in two other localities. It is unique among all living forms, in combining within itself characters of at least three distinct suborders of "prawns," for with a schizopod body it combines the double epipodial lamellæ of an amphipod, the head of a decapod (pedunculated eyes and antennular statocysts) apart from characters peculiarly its own. There is reason to believe that the nearest living ally to this remarkable creature is a small eyeless species (*Bathynella natana*) obtained from a Bohemian well; and if its presumed relationships to the Palæozoic "pod-shrimps" be correct, this heterogeneous assemblage may perhaps be the representatives of a group of primitive Malacostraca, through which, by structural divergence, the establishment of the higher crustacean suborders may have come about.

It is pertinent to this to note that work upon cave-dwelling and terrestrial forms, upon "well-shrimps" and the like, has produced important results. And interesting indeed is the recent discovery of three species, living at 800-900 feet above sea-level, in Gippsland, one an amphipod, two of them isopods, which, though surface-dwellers, are all blind. While they prove to be species of genera normally eyed, they in their characters agree with well-known American forms; and the bleaching of their bodies and atrophy of their eyes proclaim them the descendants of cave-dwelling or subterranean ancestors, among whom the atrophy took place.

Huxley in 1880 rationalised our treatment of the higher Crustacea, by devising a classification by gills, expressive of the relationships of these to the limb-bases, interarticular membranes and body-wall. Hardly had his influence taken effect when, by work extending over the years 1886 to 1893, in the study of Penæus, the Phyllopods, Ostracods and other forms, evidence had been accumulating to show that the crustacean appendage, even to the mandible itself, has primarily a basal constituent (protopodite) of three segments; that the branchiæ one and all are originally appendicular in origin; and that the numerical reduction of the basal (protopoditic) segments to two, with the assumption of a non-appendicular relationship by the gills, is due to coalescence of parts, with or without suppression. The evidence for this epoch-making conclusion, which simplifies our conceptions and brings contradictory data into line, is as irresistible as it is important, and there has been nothing finer in the whole history of crustacean morphology. With it, the attempt to explain the supposed anomalous characters of the antennule by appeal to embryology goes to the wall; and, taking a deep breath, we view the Crustacea in a new light.

There remains for brief consideration one carcinological discovery second to none which bears on the significance of larval forms. It is that of the Trilobite *Triarthrus Becki*, obtained in abundance from the Lower Silurian near New York, with all its limbs preserved. In the simplicity of its segmentation and the biramous condition of its limbs it is primitive to a degree. Chief among its characters are the total absence of jaws in the strict sense of the term, and the fact that of its three anterior pairs of appendages the third is certainly and the second is apparently biramous, the first uniramous and antenniform. In this we have a combination of characters known only in the nauplius larva among all living crustacean forms; and the conclusion that the adult trilobite, like that of the Euphausiacea, Sergestidae, Penæidae, the Ostracods and Cirripedes of to-day, was derived by direct expansion of the nauplius larva can hardly be doubted. Much yet remains to be done with the study of the *Triarthrus* limbs; and the suggestion of a foliaceous condition by those of the pygidium, which are youngest, is a remarkable fact, the meaning of which the future must decide. We should expect the condition to be a provisional one, since while we admit the

primitive nature of the phyllopods as an Order, we cannot regard the foliation of their appendages as anything but a specialisation. Be this as it may, the structural community between the nauplius larva and the trilobite is now proved; and when we add that in the yolk-bearing higher Crustacean types (e.g. *Astacus*) a perceptible halt in the development may be observed at the three-limb-bearing stage; that in *Mysis* the vitelline membrane is shed but to make way for a nauplius cuticle; and that the median nauplius eye has long been found sessile on the adult brain of representative members of the higher crustacean groups, up to the lobster itself, our belief in the ancestral significance of the nauplius larval form is established beyond doubt.

The thought of the nauplius suggests other larval forms. The gastrula is no longer accepted without reserve; the claims of the blastula, planula, parenchymella, not to say the plakula, have all to be borne in mind. It is of the Trochophore, however, as familiar as the nauplius, that I would rather speak, as influenced by recent research. It is supposed to be primitive for the molluscs and chaetopod worms at least; and various attempts have been made to bolster it up, and to show that if we allow for adaptive change, its characters, well known, are constant within the limits of its simpler forms.

It is now more than forty years ago that the late Lacaze-Duthiers described for Dentalium a larval stage, characterised by the possession of recurrently ciliated zones, which by reduction, with union and translocation forwards, give rise to the trochal lobe. It is now known that in the American pelecypod *Yoldia limatula* a similar stage is found, in which a "test," of five rows of ciliated cells, is present; and of the young of *Dondersia banyulensis* the like is true. But whereas in the *Yoldia* the ciliated sac is ultimately shed, in the Myzomenian the escape of the embryo is accompanied by rupture which liberates the anterior series of ciliated zones in a manner strongly suggestive of forward concentration, leaving the posterior circlet with its cilia attached.

This "test" has also been seen in two species of *Nucula*, and pending fuller inquiry into the Myzomenian and a reinvestigation of Dentalium, I would suggest that this recurrently ciliated sac is representative of a larval stage antecedent to the trochophore, for which the term *protrochal* may suffice. This term has indeed been already applied to a larva of certain Polychaeta, which might well represent a modification of that for which I am arguing; and quite recently it appears to have been observed near Ceylon for a species of the genus *Marphysa*.

The discovery of this larva in *Dondersia* was accompanied by that of a later-formed series of dorsal spicular plates, which for once and for all, in realising a chitonid stage, demolish the heresy of the "Solenogastres," mischievous as suggesting an affinity with the worms. Like that of the supposed cephalopod affinities of the so-called "Pteropods," it must be ignored as an error of the past.

Returning to the protrochal stage, whatever the future may reveal concerning it, by bringing together the Lamellibranchiata, Scaphopoda and Polyplacophora, it associates in one natural series all the bilaterally symmetrical Mollusca except the cephalopods. In doing this, it deals the death-blow to the supposed Rhipidoglossan affinity of the Lamellibranchiata; and in support of this conclusion I would point out that the recently discovered eyes of the mytilids are in the position of those of the embryo Chiton, and that just as Dentalium, in the formation of its mantle, passes through a lamellibranchiate stage, so are there lamellibranchs in number in which a tubular investment is found.

This protrochal larva has an important part to play. It may very possibly explain phenomena such as the compound nature of the trochal lobe of the limpet, the presence of a post-oral ciliated band in the larva of the ship-worm, and of a præ-anal one in that of various molluscan forms. In view of it, we must hesitate before we fully accept the belief in the ancestral significance of the trochophore. And it is certain that an idea, at one time entertained, that the Rotifer (*Trochosphæra*) which so closely resembles it as to bear its name is its persistent representative is wrong, since this is now known to be but the female of a species having a very ordinary male.

Through the Rhipidoglossa we pass to the Gastropods, which are one and all asymmetrical, for even *Fissurella*, *Patella* and *Doris*, when young, develop a spiral shell; while Huxley in 1877 had observed that the shell of *Aplysia*, in its asymmetry, betrays its spiral source.

The notion, which until recently prevailed, that among these gastropods the non-twisted or so-called euthyneurous condition of the visceral nerve-cords, as exemplified by the Opisthobranchs, is a direct derivative of that of the Chitons has been proved to be erroneous, since the nerves in Actæon and Chilina, like those of the prosobranchs, are twisted or streptoneurous. And as to the torsion of the gastropod body, recent research, in which one of my pupils has played a part, involving the discovery of paired reno-pericardial apertures in *Haliotis*, *Patella* and *Trochus*, has resulted in proof that the dextral torsion which leads to the monocardiac condition does not uniformly affect all organs lying primitively to the left of the rectum, as we have been taught; since, concerning the renal organs, it is the *primitively* (pretorsional) left one which remains as the functional kidney, its ostium as the genital aperture. Nor is the primitively right kidney necessarily lost, for while its ostium remains as the renal orifice, its body, by modification and reduction, may become an appendage of the functional kidney, the so-called nephridial gland. And we now know there are cases of sinistral torsion of the visceral hump, in which the order of suppression of the organs is not reversed, the arrangement being one of adaptation of a dextral organisation to a sinistral shell.

Though thus specialised and asymmetrical as a group, the gastropods are yet plastic to an unexpected degree. Madagascar has yielded a *Physa* (*P. lamellata*) with a neomorphic gill, a character shared by species of *Planorbis* (*P. cornutus* and *P. marginatus*), and an *Ancylus* in which the lung-sac is suppressed; while St. Thomas's Island has given us a snail (*Thyrophorella Thomensis*), the peristome of whose shell is produced into a protective lid.

In palæontology, history records the fact that in 1864 Huxley observed that the genus *Belemnites* appears to have borne but six free arms; a startling discovery which lay dormant till the present year. And the recent study of the fauna of the great African lakes, in bringing to light the existence of a halolimnic molluscan series in Lake Tanganyika, has opened up new possibilities concerning the palæontological resources of enormous aqueous deposits, recently discovered in the interior, and has entirely changed our geological conceptions of the nature of Equatorial Africa.

Time prevents my dealing with other groups, and it must suffice to say that with those I have not considered substantial work has been done. From what has been said, it is natural to expect that in some direction or another so vast an accumulation of facts must have extended the Darwinian teaching; and it is now quite clear that this has been the case with the two post-Darwinian principles known as "Substitution" and "Isomorphism" or "Convergence."

The former may be exemplified by nothing better than the case of the Rays and Skates, in which, under the usurpation of the propelling function of the tail by the expanded pectoral fins, the tail, free to modify, becomes in one species a lengthy whip-lash, in another a vestigial stump, in others, by the development of powerful spines, a formidable organ of defence. In both the Rays and certain other fishes subject to the working of this law, modification goes further still, in the appearance of electric organs in remotely related genera and species, by specialisation of the muscular system of the trunk or tail, or, as in the case of *Malapterurus*, of "tegumental glands." In this we have a difficulty admitted by Darwin himself, which now becomes clear and intelligible, since there is nothing new. There has simply come about the conversion, in one case of the energy of muscular contraction, in the other of glandular secretion, into that of electrical discharge, with accompanying structural change. The blind locust (*Pachyramina fuscifer*) of the New Zealand Limestone caves presents an allied case, since here, under the reduction of the eye, the antennæ, elongated to a remarkable degree, have become the more efficiently tactile; and it is an interesting question whether this principle may not explain the attenuation of the limbs in the recently discovered American Proteoid (*Typhlomolga Rathburni*) of the Texan subterranean waters.

And as to isomorphism, by which we mean the assumption of a similar structural state by members of diverse or independent groups, I would recall the case of the Eocene Creodont *Patriofelis* and the Seals, and that of the Myriapods to which I have already alluded, and would cite that of the Dinosaurs and Birds, heterodox though it may appear, for reasons I have given.

As our knowledge increases, there is every reason to believe that, in the non-appreciation of these principles in the past, not a few of our classifications are wrong. We have even had our bogies, as, for example, the so-called Phylemaria, which deceived the very elect; and before I close I wish to deal briefly with a question of serious doubt, which these considerations suggest.

It is that of the position in the zoological series of the Limuloids, popularly termed the King Crabs. These creatures, best known from the opposite shores of the Northern Pacific, but found in the oriental seas as well as far south as Torres Strait, have been since 1829 the subject of a difference of opinion as to their zoological position and affinities. Within the last twenty years there have been three determined advances upon them, and of these the third and most recent may be first discussed. It has for its object the attempt to prove that they are intimately associated with the cephalaspidian and other shield-bearing fishes of the Devonian and Silurian epochs, and that through them they are ancestral to the Vertebrata. The latest phase of this idea is based on the supposed existence in a *Cephalaspis* of a series of twenty-five to thirty lateral appendages of arthropod type. When, however, it is found that the would-be limbs are but the edges of body-scutes misinterpreted, suspicion is aroused; and when, working back from this, an earlier attempt reveals the fact that the author, compelled to find trabeculæ, in order to force a presupposed comparison between the architecture of the Cephalaspidian head-shield and the Limulus' prosomal hood, resorts to a comparison between the structure of the former in general and that of the cornu of the latter, with details which on the pi-cine side are not to date, the argument must be condemned. It violates the first principles of comparative morphology, and is revolting to common sense; and as to the fishes concerned, we know that they have nothing whatever to do with the Limuloids, for we have already seen that, with their allies the Pteraspidae, they are a lateral branch of the ancestral piscine stem.

The second advance upon the king crabs has very much in common with the first. It has engrossed the attention of an eminent physiologist for the last six or seven years, and by him it was in detail set before Section I at our meeting of 1896. Suffice it to say that it specially aims at establishing a structural community between the king crabs and certain vertebrates, favourable to the conviction that the Vertebrata have had an arthropod ancestry. When we critically survey the appalling accumulation of words begotten of this task, it is sufficient to consider its opening and closing phases. At the outset, under the conclusion that the vertebrate nervous axis is the metamorphosed alimentary canal of the arthropod ancestor, the necessity for finding a digestive gland is mainly met by homologising the so-called liver of the arthropod with the cellular arachnoid of the larval lamprey, in violation of the first principles of comparative histology! At the close we find ingenious attempts to homologise nerve tracts and commissures related to the organs of sense, such as are invariably present wherever such organs occur. Sufficient this to show that the comparison, in respect to its leading features, is in the opening case strained to an unnatural degree, in the closing case no comparison at all. Finding, as we do, that the rest of the work is on a par with this, we are compelled to reject the main conclusion as unnatural and unsound; and when we seek the explanation of this remarkable course of action, we are forced to believe that it lies in the failure to understand the nature of the morphological method. For the proper pursuit of comparative morphology, it is not sufficient that any two organisms chosen here and there should be compared, with total disregard of even elementary principles. Comparison should be first close and with nearly related forms, passing later into larger groups, with the progressive elimination of those characters which are found to be least constant. And necessary is it, above all things, that in instituting comparison it should be first ascertained what it is that constitutes a crustacean a crustacean, a marsipobranch a cyclostome, and so on for the rest. We have tried to accept this theory, fascinated both by the arguments employed and by the idea itself, which for ingenuity it would be difficult to beat, but we cannot; and we dismiss it as misleading, as a fallacy, begotten of a misconception of the nature of the morphological method of research. It is of the order of events which led Owen to compare a cephalopod and a vertebrate, led Lacaze-Duthiers to regard the Tunicata and Lamellibranchs as allied; and with these and other heresies it must be denounced.

Passing to the third advance, extending over the last twenty years, it may be said to consist in the revival of a theory of 1829, which boldly asserts that *Limulus* is an Arachnid. In the development of the defence there have been two weak points but lately strengthened, viz., the insufficient consideration of the palæontological side of the question and of the presence of tracheæ among the Arachnida. Under the former there was, until recently, assumed the absence of the first pair of appendages in the Eurypterida; but it may be said that they have since been observed in *Eurypterus Fischeri* of the Russian Silurian, and *E. scoticus* from the Pentland Hills, in both of which they consist of small chelate appendages flexed and limuloid in detail, somewhat reduced perhaps, and enclosed by the bases of the succeeding limbs, which become apposed as the anterior end is reached. Since by this discovery the Limuloids, Eurypterids and Scorpionids are brought into a numerical harmony of limb-bearing parts, we may at once proceed to other points at issue. So far as the broader structural plan of *Limulus* and the Scorpion are concerned, all will agree to a general community, except for the organs of respiration; but concerning the coelom, the mobile spermatozoa and the more detailed features under which *Limulus* is held to differ from the Crustacea and to resemble the Arachnida, I would remark that while motile spermatozoa are characteristic of the Girripedes, the rest of the argument is weakened, by the probability that the "arachnidan" characters which remain may well have been possessed by the crustacean ancestors, and that *Limulus*, though specialised, being still an ancient form, might have retained them. The difficulty does not seem to me to lie in this, or with the excretory organs, if we are justified in accepting the aforementioned argument that the so-called Malpighian tubes may be turned nephridia, ectodermal in origin, and in knowledge of the existence of endodermal excretory diverticula in the Amphipods. These facts would seem to suggest that as our experience widens, differences of this kind will disappear.

As to the tracheal system, now adequately recognised by the upholders of the arachnid theory, the presumed origin of tracheæ from lung-books, the probability that the ram's-horn organ of the Chernetidæ may be tracheal, the presence of tracheæ in a simple form in the Acari, and, by way of an anomaly, in a highly organised form on the tibiæ of the walking legs of the harvestmen (Phalangidæ), are all features to be borne in mind. While I am prepared to admit that this wide structural range and varied distribution of the tracheæ lessens their importance as a criterion of affinity, I cannot accept as conclusive the evidence for the assumed homology between lung-books and gills. And here it may be remarked that a series of paired abdominal vesicles, recently found in the remarkable arachnid *Kœnenia*, invaginate as a rule but in one example everted, seized upon in defence of this homology, have not been so regarded by those most competent to judge.

There remains the entosternite, an organ upon which much emphasis has been placed. Not only does a similar organ exist, apart from an endophragmal system, in *Apus*, *Cyclops*, some Ostracods and Decapods, but, regarding the question of its histology, it may be pointed out that, from all that is at present known, the structural differences between these several entosternites do not exceed those between the cartilages of the Sepia body. And when it is found that the figures and descriptions of the entosternite of *Mygale* ("Mygale sp.," "Mygalomorphous Spider," *auct.*) have been thrice presented upside down! the reliability of this portion of the argument is lessened, to say the least.

Recent observation has sought to clench the homology of the four posterior pairs of limbs of the King Crab and Scorpion, by appeal to a furrow on the fourth segment in the former, believed to denote an original division into two; but I hesitate to accept this until myological proof has been sought.

Returning, amidst so much that is problematic, to the sure ground of palæontology, I wish to point out that when all is considered in favour of the arachnid theory there still remains another way of interpreting the facts.

In both *Limulus* and the Scorpion the first six of the eighteen segments are well known to be fused into a prosoma bearing the limbs, but while in the Scorpion the remaining twelve are free, in *Limulus* they are united into a compact opisthosomal mass. In dealing with the living arthropods, there is no character determinative of position in the scale of this or that series more trustworthy than the antero-posterior fusion of segments. It has been called the process of "cephalisation," and the degree of

its backward extension furnishes the most trustworthy standard of highness or lowness in a given assemblage of forms. In passing from the lower to the higher Crustacea, we find this fusion increasing as we ascend: and it therefore becomes necessary to compare the Scorpion with the other Arachnida, *Limulus* with the Eurypterida, in order the better to determine the position of each in its respective series, by the application of this rule.

As to the number of segments present, variation is a matter of small concern, in consideration of the mode of origin of segmentation and the wide numerical range—from seven in the Ostracods to more than sixty in *Apus*—the segments of the crustacean class present.

On the arachnid side, in the Solifugæ but the third and fourth segments are fused; the remaining four of the prosomal series with the ten which remain are free. In *Kœnenia* four of the prosomal segments alone unite; the fifth and sixth with the rest are free. And when we pass to the Limuloids and the descending series of their allies, we find it distinctive of the Eurypterida that all the opisthosomal segments are free. If we can trust these comparisons, we must conclude that the Eurypterida of the past, in respect to their segmentation, simplify the Limuloid type, on lines similar to that on which the Solifugæ and *Kœnenia* simplify the Higher Arachnid and Scorpionid type, and that therefore, if the degree of antero-posterior fusion of segments has the significance attached to it, *Limulus* and *Scorpio* must each stand at the summit of its respective series. If this be admitted, it has next to be asked if, in comparing them, we may not be comparing culminating types, which might well be isomorphic.

The scorpions are known fossil by two genera, *Palæophonus* and *Proscorpius*, from the Silurian of Gotland and Lanarkshire, the Pentland Hills and New York State; while recent research, in the discovery of the genus *Strabops*, has traced the Eurypterida back to the Cambrian, leaving the scorpions far behind. One striking feature of the limbs of the Palæozoic Eurypterids is their constantly recurring shortness and uniformly segmented character, long known in *Slimonia*, and less conspicuously in *Pterygotus* itself, retained with development of spines in three of five known appendages of the recently described eurypterid giant *Stylonurus*. The minimum length yet observed for these appendages is that of the Silurian species *Eurypterus Fischeri*, discovered by Holm in Russia in 1898. This creature is one of the few eurypterids in which all the appendages are preserved, and it is the more strange therefore that the advocates of the arachnid theory should ignore it in their most recent account. Allowing for the specialisation of its sixth prosomal appendage for swimming, the fifth is but little elongated, the second, third and fourth are each in total length less, by far, than the transverse diameter of the prosoma, and uniformly segmented, giving the appearance of short antennæ. They seem to be seven-jointed, and are just such appendages as exist in the simpler crustacean and tracheate forms; and in the fact that their structural simplicity is correlated with the independence of the whole series of opisthosomal segments they lend support to the argument for isomorphism.

With this conclusion, we turn once more to the Scorpions, if perchance something akin to it may not be in them forthcoming. The Silurian genus *Palæophonus*, especially as represented by the Gotland specimen, reveals the one character desired. Its body does not appear to be in any marked degree simpler than that of the living forms; but on turning to its limbs, we find the four posterior pairs, in length much shorter than those of any living species, all but uniformly segmented. In this they approximate towards the condition of the limbs of the Eurypterida just dismissed, and their condition is such that had they been found fossil in the isolated state they would have been described as the limbs of a Myriapod, and not of a scorpion at all. Indeed, their very details are what is required, since in the possession of a single terminal claw they differ from the limbs of the recent scorpions as do those of the Chilopoda from the hexapods.

With this the scorpionid type is carried back, with a structural simplification indicative of a parallelism with the other arthropod groups; and while the facts do not prove the total independence of the scorpionid and limuloid series, they bring the latter into closer harmony with the Eurypterida of the past. They prove that the Silurian Scorpions simplify the existing Scorpionid type, on precisely the lines on which the Eurypterida simplify the Limuloid; and they do so in a manner which suggests that a distinction between the *Crustacea vera* and the *Crustacea giganteostraca* (to include the Eurypterida and

Xiphosura) is the nearest expression of the truth. It becomes thereby the more regrettable that in a recent revision of the taxonomy of the Limuloids the generic name *Carcinoscorpius* should have found a place.

I foresee the objection that the antenniform condition of the shorter limbs may be secondary and due to change. There is no proof of this. Against it, it may be said that the number of the segments is normal, and that where nature effects such a change, elongation is with the multi-articulate state the only process known; as, for example, with the second leg of the Phryniidae, the so called second pareiopod of the Polycarpidea and the last abdominal appendage of Apeudes.

That advances such as we have now considered should lead to new departures is a necessity of the case; and it but remains for me to remind you that within the last decade statistical and experimental methods have very properly come more prominently into vogue, in the desire to solve the problems of variation and heredity. Of the statistical method, by no means new, I have but time to recall to you the Presidential Address of 1898 by my friend and predecessor in this chair, himself a pioneer; and of the experimental method I can but cite an example, and that a most satisfactory one, justifying our confidence and support. It concerns the late Prof. Milne-Edwards, who in 1864 described, from the Paris Museum, the head of a rock lobster (*Palinurus penicillatus*), having on the left side an antenniform eye-stalk. With the perspicuity distinctive of his race, he argued in favour of the "fundamental similarity of parts susceptible to revert to their opposite states." The matter remained at this till, on the removal of the ophthalmite of certain Crustacea, it was found that in regeneration it assumes a uniramous multiarticulate form; and it is an interesting circumstance that in the common crayfish the biramous condition normal to the antennule may occur. An example this of a fact which no other method could explain.

When all is said and done, however, it is to the morphological method that I would appeal as most trustworthy and sound. And when we find (1) that in certain compound Tunicates the atrial wall, in the egg development delimited by a pair of ectoblastic invaginations, in the bud development may be formed from the parental endodermic branchial sac; (2) that regenerated organs are by no means derivative of the blastemata whence they originally arose; (3) that in the development of a familiar star-fish the inner cells of the earliest segmentation stages, by intercalation among the outer, contribute half the fully-formed blastula; (4) that there are Diptera in existence in which, while it is well-nigh impossible to discriminate between the adult forms, there is reason to believe the pupa cases are markedly and constantly distinct; it becomes only too evident that the later embryonic and adult states are those most trustworthy for all purposes of comparison, and that it is by these that our animals can best be known and judged. Caution is, however, necessary with senility and age, since certain skulls have been found to assume at this period characters and proportions strikingly abnormal, and by virtue of the most important discovery, which we owe to the Japanese, that in certain Holothurians the calcareous skeletal deposits may so change with age as to render specific diagnoses based on their presumed immutability invalid. Advance, real and progressive, is in no department of zoological inquiry better marked than comparative morphology, and it is for the preeminence of this that I would plead. Educationally, it affords a mental discipline second to none.

We live by ideas, we advance by a knowledge of facts, content to discover the meaning of phenomena, since the nature of things will be for ever beyond our grasp.

And now my task is done, except that I feel that we must not leave this place without a word of sympathy and respect for the memory of one of its sons, an earnest devotee to our cause. William Thompson, born in Belfast, 1806, became in due time known as "the father of Irish natural history." By his writings on the Irish fauna, and his numerous additions to its lists, he secured for himself a lasting fame. In his desire to benefit others, he early associated himself with the work of the Natural History Society, which still flourishes in this city. He was President of this Section in 1843, and died in London in 1852, while in the service of our Association, in his forty-seventh year, beloved by all who knew him. His memory still survives; and if, as a result of this meeting, we can inspire in the members of the Natural History and Philosophic Society of this city, as it is now termed, and of its Naturalists' Field Club an enthusiasm equal to his, we shall not have assembled in vain.

## SECTION G.

## ENGINEERING.

OPENING ADDRESS BY PROF. JOHN PERRY, M.E., D.Sc., LL.D., F.R.S., PRESIDENT OF THE SECTION.

THIS Section has had sixty-six Presidents, all different types of engineer. As each has had perfect freedom in choosing the subject for his Address, and each has known of the rule<sup>1</sup> that Presidential Addresses are not subject to debate afterwards, and as, being an engineer, he has always been a man of originality, of course he has always chosen a subject outside his own work. An engineer knows that the great inventions, the great suggestions of change in any profession, come from outsiders. Lawyers seem like fish out of water when trying to act as law-makers. The radical change that some of us hope to see before we die in the construction of locomotives will certainly not come from a locomotive superintendent who cannot imagine a locomotive which is not somehow a lineal descendant of the Rocket.

Hence it is that in almost every case the President of this Section has devoted a small or large part of his Address to the subject of the education of engineers. I grant that every President has devoted his life to the education of one engineer—himself—and it is characteristic of engineers that their professional education proceeds throughout the whole of their lives. Perhaps of no other man can this be said so completely. To utilise the forces of Nature, to combat Nature, to comprehend Nature as a child comprehends its mother, this is the pleasure and the pain of the engineer.<sup>2</sup> A mere scientific man analyses Nature; takes a phenomenon, dissects it into its simpler elements, and investigates these elements separately in his laboratory. The engineer cannot do this. He must take Nature as she is, in all her exasperating complexity. He must understand one of Nature's problems as a whole. He must have all the knowledge of the scientific man, and ever so much more. He uses the methods of the scientific man, and adds to them methods of his own. The name given to these scientific methods of his own or their results is sometimes "common-sense," sometimes "character," or "individuality," or "faculty," or "business ability," or "instinct." They come to him through a very wide experience of engineering processes, of acquaintance with things and men. No school or college can do more than prepare a young man for this higher engineering education which lasts through life. Without it a man follows only rule of thumb, like a sheep following the bell-wether, or else he lets his inventiveness or love of theory act the tyrant.

When a man has become a great engineer and he is asked how it happened, what his education has been, how young engineers ought to be trained, as a rule it is a question that he is least able to answer, and yet it is a question that he is most ready to answer. He sees that he benefited greatly by overcoming certain difficulties in his life; and forgetting that every boy will have difficulties enough of his own, forgetting that although a few difficulties may be good for discipline many difficulties may be overwhelming, forgetting also that he himself is a very exceptional man, he insists upon it that those difficulties which were personal to himself ought to be thrown in the path of every boy. It often happens that he is a man who is accustomed to think that early education can only be given through ancient classics. He forgets the dulness, the weariness of his schooldays. Whatever pleasure he had in youth—pleasure mainly due to the fact that the average Anglo-Saxon boy invents infinite ways of escaping school drudgery—he somehow connects with the fact that he had to learn classics. Being an exceptional boy, he was not altogether stupefied and did not altogether lose his natural inclination to know something of his own language; and he is in the habit of thinking that he learnt English through Latin, and that ancient classics are the best mediums through which an English boy can study anything.<sup>3</sup>

<sup>1</sup> The Committees of Sections G and L have arranged a discussion on "The Education of Engineers," this Address being regarded as opening the discussion. Thus the rule is not in force this year.

<sup>2</sup> Of all the unskilled labour of the present day, surely that of the modern poet is the most grotesque. How much more powerful and powerless man seems to us now; how much more wonderful is the universe than it was to the ancients! Yet our too learned poets prefer to copy and recopy the sentiments of the ancients rather than try to see the romance which fills the lives of engineers and scientific men with joy.

<sup>3</sup> The very people who talk so much of learning English through Latin neglect in the most curious ways those Platt-Deutsch languages, Dutch and Scandinavian, a knowledge of which is ten times more valuable in the study of what is becoming the speech of the world. And how they do scorn Lowland Scotch!

The cleverest men of our time have been brought up on the classics, and so the engineer who cannot even quote correctly a tag from the Latin grammar, who never knew anything of classical literature, insists upon it that a classical education is essential for all men. He forgets the weary hours he spent getting off Euclid and the relief it was to escape from the class-room not quite stupefied, and he advocates the study of pure mathematics and abstract dynamics as absolutely necessary for the training of the mind of every young engineer. I have known the ordinary abominable system of mathematical study to be advocated by engineers who, because they had passed through it themselves, had really got to loathe all kinds of mathematics higher than that of the grocer or housekeeper. They said that mathematics had trained their minds, but they did not need it in their profession. There is no profession which so much requires a man to have the mathematical tool always ready for use on all sorts of problems, the mathematical habit of thought the one most exercised by him; and yet these men insist upon it that they can get all their calculations done for them by mathematicians paid so much a week. If they really thought about what they were saying, it would be an expression of the greatest contempt for all engineering computation and knowledge. He was pitchforked into works with no knowledge of mathematics, or dynamics, or physics, or chemistry, and, worse still, ignorant of the methods of study which a study of these things would have produced; into works where there was no man whose duty it was to teach an apprentice; and because he, one in a thousand, has been successful, he assures us that this pitchforking process is absolutely necessary for every young engineer. He forgets that the average boy leaves an English school with no power to think for himself, with a hatred for books, with less than none of the knowledge which might help him to understand what he sees, and he has learnt what is called mathematics in such a fashion that he hates the sight of an algebraic expression all his life after.

I do not want to speak of boys in general. I want only to speak of the boy who may become an engineer, and before speaking of his training I want to mention his essential natural qualification—that he really wishes to become an engineer. I take it to be a rule to which there are no exceptions that no boy ought to enter a profession—or, rather, to continue in a profession—if he does not love it. We all know the young man who thinks of engineering things during office hours and never thinks of them outside office hours. We know how his fond mother talks of her son as an engineer who, with a little more family influence and personal favour, and if there was not so much competition in the profession, would do so well. It is true, family influence may perhaps get such a man a better position, but he will never be an engineer. He is not fit even to be a hewer of wood and drawer of water to engineers. Love for his profession keeps a man alive to its interests all his time, although, of course, it does not prevent his taking an interest in all sorts of other things as well; but it is only a professional problem that warms him through with enthusiasm. I think we may assume that there never yet was an engineer worth his salt who was not fond of engineering, and so I shall speak only of the education of the young man who is likely to be fond of engineering.

How are we to detect this fondness in a boy? I think that if the general education of all boys were of the rational kind which I shall presently describe, there would be no great difficulty; but as the present academic want of system is likely to continue for some time, it is well to consider things as they are. Mistakes must be made, and the parent who tries during the early years of his offspring to find out by crafty suggestion what line his son is likely to wish to follow will just as probably do evil by commission as the utterly careless parent is likely to do evil by omission. He is like the botanical enthusiast who digs up plants to see how they are getting on. But in my experience the Anglo-Saxon boy can stand a very great deal of mismanagement without permanent hurt, and it can do no kind of boy any very great harm to try him on engineering for a while. Even R. L. Stevenson, whose father seems to have been very persistent indeed in trying to make an engineer of him against his will, does not seem, to a Philistine like myself, to have been really hurt as a literary man through his attendance on Fleeming Jenkin's course at Edinburgh—on the contrary, indeed. It may be prejudice, but I have always felt that there is no great public person of whom I have ever read who would not have benefited by the early training which is suitable for an engineer.

I am glad to see that Mr. Wells, whose literary fame, great as it is, is still on the increase, distinguishes the salt of the earth or saviours of society from the degraded, useless, luxurious, pleasure-loving people doomed to the abyss by their having had the training of engineers and by their possessing the engineer's methods of thinking.

It may be that there are some boys of great genius to whom all physical science or application of science is hateful. I have been told that this is so, and if so I still think that only gross mismanagement of a youthful nature can have produced such detestation. For such curious persons, engineering experience is, of course, quite unsuitable. I call them "curious" because every child's education in very early years is one in the methods of the study of physical science; it is Nature's own method of training, which proceeds successfully until it is interfered with by ignorant teachers who check all power of observation and the natural desire of every boy to find out things for himself. If he asks a question, he is snubbed; if he observes Nature as a loving student, he is said to be lazy and a dunce, and is punished as being neglectful of school work. Unprovided with apparatus, he makes experiments in his own way, and he is said to be destructive and full of mischief. But however much we try to make the wild ass submit to bonds and the unicorn to abide by the crib, however bullied and beaten into the average schoolboy type, I cannot imagine any healthy boy suffering afterwards by part of a course of study suitable for engineers, for all such study must follow Nature's own system of observation and experiment. Well, whether or not a mistake has been made, I shall assume the boy to be likely to love engineering, and we have to consider how he ought to be prepared for his profession.

I want to say at the outset that I usually care only to speak of the average boy, the boy usually said to be stupid, ninety-five per cent. of all boys. Of the boy said to be exceptionally clever I need not speak much. Even if he is pitchforked into works immediately on leaving a bad school, it will not be long before he chooses his own course of study and follows it, whatever course may have been laid down for him by others. I recollect that when in 1863 I attended an evening class held in the Model School, Belfast, under the Science and Art Department, on Practical Geometry and Mechanical Drawing, there was a young man attending it who is now well known as the Right Honourable William J. Pirrie. He had found out for himself that he needed a certain kind of knowledge if he was to escape from mere rule-of-thumb methods in shipbuilding work; it could at that time be obtained nowhere in the North of Ireland except at that class, and of course he attended the class. For forty two years the Science and Art Department, which has recently doubled its already great efficiency, has been giving chances of this kind to every clever young man in the country, from long before any Physical Science was taught in any English public school.<sup>1</sup> The one essential thing for the exceptional boy is that he shall find within his reach chances to take advantage of; chances of learning; chances of practice; and, over and above all, chances of meeting great men. It takes me off my subject a little, but I should like here to illustrate this matter from my own personal experience.

I had already been an apprentice for four years at the Lagan Foundry when I entered Queen's College for a course of Civil Engineering. I suppose that there never was on this earth a college so poorly equipped for a course of engineering study. Even the lecture room—this lecture room in which you are now sitting—was borrowed from the Physics Professor. There was a narrow passage, ironically called a "Drawing Room," and this was the only space reserved for engineering in a town whose engineering work was even then very important. There were some theodolites and levels and chains for surveying, but nothing else in the way of apparatus. But there was as Professor a man of very great individuality; he acted as President of this Section twenty-eight years ago. I can hardly express my obligations to Prof. James Thomson. It was my good fortune to be a pupil both of this great man and of his younger brother, Lord Kelvin, as well as of Dr. Andrews. It is not because these three men were born in Belfast that we here call them great. It is not because Tait, late of Edinburgh, and

<sup>1</sup> I once stated that my workshop at Clifton College in 1871 was the first school workshop in England. I understand that this is a mistake; there had been a workshop at Rossall for some years. But I believe I am right in saying that my physical laboratory at Clifton was the first school laboratory in England. These ideas were not mine; they were those of the Headmaster, now the Bishop of Hereford.

Purser, now the President of Section A, were professors at this College that we call them great. All the scientific men of the world are agreed to call these men very great indeed. To come in contact with any of them, even for a little while, as a student, altered for ever one's attitude to Nature. It was not that they gave us information, knowledge, facts. The syllabuses of their courses of study were nothing like so perfect as that of the smallest German polytechnic. And yet if a youth with a liking for physical science had gone to a German Gymnasium to the age of nineteen, and had become a walking encyclopædia on leaving one's polytechnic at the age of twenty-four, the course of that life-study would not have done for him as much good as was done by a month's contact with one of these men. People call it "personal magnetism" and think there is something occult about it. In truth, they revealed to the student that he himself was a man, that mere learning was unimportant, that one's own observation of some common phenomenon might lead to important results unknown to the writers of books. They made one begin to think for oneself for the first time. Let me give an example of how the thing worked.

James Thomson was known to me as the son of the author of my best mathematical books, but more particularly as the man who had first used Carnot's principle in combination with the discovery of Joule, and I often wondered why Rankine and Clausius and Kelvin got all the credit of the discovery of the second law of thermodynamics. Men think of this work of his merely as having given the first explanation of regelation of ice and the motion of glaciers. He was known to me as the inventor of the Thomson Turbine and Centrifugal Pump and Jet Pump. His name was to be found here and there in all my text-books, always in connection with some thoroughly well-worked-out investigation, as it is to be found in all good text-books now; for wherever he left a subject, there that subject has remained until this day; nobody has added to it or found a mistake in it. He was to me a very famous man, and yet he treated me as a fellow-student. One of his early lectures was about flowing water, and he told us of a lot of things he had observed, which also I had observed without much thought; and he showed how these simple observations completely destroyed the value of everything printed in every text-book on the subject of water flowing over gauge-notches, even in the otherwise very perfect Rankine. I felt how stupid I had been in not having drawn these conclusions myself, but in truth till then I had never ventured for a moment to criticise anything in a book. I have been a cautious critic of all statements in text-books ever since. If any engineer wants to read what is almost the most instructive paper that has ever been written for engineers, let him refer to the latest paper written by James Thomson on this subject.<sup>1</sup> The reasoning there given was given to me in lectures in this very room in 1868, and had been given to students for many years previous.

Again, soon afterwards, he let me see that although I had often looked at the whirlpool in a basin of water when the central bottom hole is open, and although I had read Edgar Allen Poe's mythical description of the Maelstrom, I had been very much too careless in my observation. Among other things, Thomson had observed that particles of sand gradually passed along the bottom towards the hole. When he found out the cause of this, it led him at once to several discoveries of great importance. Indeed, the study of this simple observation gave rise to all his work on (1) What occurs at bends of pipes and channels, and why rivers in alluvial plains bend more and more; (2) The explanation of the curious phenomena that accompany great forest fires; (3) The complete theory of the great wind circulation of the earth, published in its final form as the Bakerian Lecture of the Royal Society in 1892.

But why go on? He taught me to see that the very commonest phenomenon had still to reveal important secrets to the understanding eye and brain, and that no man is a true student unless he is a discoverer. And so it was with Kelvin and Andrews. Their names were great before the world, and yet they treated one as a fellow-student. Is any expenditure of money too large if we can obtain great men like these for our Engineering Colleges? Money is wanted for apparatus and more particularly for men, and we spend what little we have on bricks and mortar!

The memory of a man so absolutely honest as Prof. James Thomson was compels me to say here that I was in an exceptionally fit state to benefit by contact with him, for I

<sup>1</sup> Brit. Assoc. Report, 1876, pp. 243-266.

hungered for scientific information.<sup>1</sup> I do not think that there was so much benefit for the average student whose early education had almost unfitted him for engineering studies. To work quantitatively with apparatus is good for all students, but it is absolutely necessary for the average student, and, as I said before, there was no apparatus. Also the average student cannot learn from lectures merely, but needs constant tutorial teaching, and the Professor had no assistant.

Anybody who wants to know what kind of engineering school there ought to be in such a college as this can see excellent specimens (sometimes several in one town) in Glasgow, Birmingham, Liverpool, London, Manchester, Leeds, Bristol, Nottingham, Edinburgh and other great cities. There the fortunate manufacturers have given many hundreds of thousands of pounds for instruction in applied science (engineering). In America the equipment of such schools is much more thorough and there are large staffs of teachers, for fortunate Americans have contributed tens of millions of pounds for this kind of assistance to the rising generation. Germany and Switzerland compete with America in such preparation for supremacy in manufacture and engineering, and nearly every country in the world is more and more recognising its importance as they see the great inventions of Englishmen like Faraday and Perkin and Hughes and Swan developed almost altogether in those countries which believe in education. Even one hundred thousand pounds would provide, Queen's College, Belfast, with the equipment of an engineering school worthy of its traditions and position, and Belfast is a city in which many large business fortunes have been made.

It is interesting to note that the present arrangements of the Royal University of Ireland, with which this College is affiliated, are such that most of the successful graduates in engineering of Queen's University would now be debarred from taking the degree. Even in London University, Latin is not a compulsory subject for degrees in science; Ireland has taken a step backwards towards the Middle Ages at the very time when other countries are stepping forward.

Well equipped schools of applied science are getting to be numerous, but I am sorry to say that only a few of the men who leave them every year are really likely to become good engineers. The most important reason for this is that the students who enter them come usually from the public schools; they cannot write English; they know nothing of English subjects; they do not care to read anything except the sporting news in the daily papers; they cannot compute; they know nothing of natural science; in fact, they are quite deficient in that kind of general education which every man ought to have.

I am not sure that such ignorant boys would not benefit more by entering works at once than by entering a great engineering school. They cannot follow the College courses of instruction at all, in spite of having passed the entrance examination by cramming. Whereas after a while they do begin to understand what goes on in a workshop; and if they have the true engineer's spirit, their workshop observation will greatly correct the faults due to stupid schoolwork.<sup>2</sup>

Perhaps I had better state plainly my views as to what general education is best for the average English boy. The public schools of England teach English through Latin, a survival of the time when only special boys were taught at all, and when there was only one language in which people wrote. Now the *average* boy is also taught Latin, and when he leaves school for the army or any other pursuit open

<sup>1</sup> Some of our most successful graduates went direct to works from the Model School, Belfast, and afterwards attended this College. No school in the British Islands could have given better the sort of general education which I recommend for all boys. English subjects were especially well taught, so that boys became fond of reading all manner of books. There were good classes in freehand and machine drawing, classes in chemistry and physics (at that time I believe that there were no such classes in any English public school), and the teaching of mathematics was good. Some of the masters started classes also under the Science and Art Department. Some of the masters had much individuality, and there was no outside examination to restrain it; there was only encouragement. Evidence has been given before a committee of the London School Board as to the excellence of the teaching at this school forty years ago. Foreign languages were not in the regular curriculum, but they could be studied by boys inclined that way; and in my opinion this is the position that all languages other than English ought to take in any British school. With such preparation a boy was eager and able to understand what went on in engineering works from his first day there.

<sup>2</sup> When I was young I remember that there were many agricultural colleges in Ireland; they have all but one been failures. Why? Because the entering pupils were not prepared by early education to understand the instruction; this had done as much as possible to unfit them.



to average boys he cannot write a letter, he cannot construct a grammatical sentence, he cannot describe anything he has seen. The public-school curriculum is always growing, and it is never subtracted from or rearranged. There is one subject which ordinary schoolmasters can teach well—Latin.<sup>1</sup>

The other usual nine subjects have gradually been added to the curriculum for examination purposes; they are taught in water-tight compartments—or, rather, they are only crammed, and not taught at all. Our school system resembles the ordinary type of old-established works, where gradual accretion has produced a higgledy-piggledy set of shops which one looks at with stupefaction, for it is impossible to get business done in them well and promptly, and yet it seems impossible to start a reform anywhere. What is wanted is an earthquake or a fire—a good fire—to destroy the whole works and enable the business to be reconstructed on a consistent and simple plan. And for much the same reason our whole public-school system ought to be “scrapped.” What we want to see is that a boy of fifteen shall be fond of reading, shall be able to compute and shall have some knowledge of natural science; or, to put it in another way, that he shall have had mental training in the study of his own language, in the experimental study of mathematics and in the methods of the student of natural science. Such a boy is fit to begin any ordinary profession, and whether he is to enter the Church, or take up medicine or surgery, or become a soldier, every boy ought to have this kind of training. When I have advocated this kind of education in the past I have usually been told that I was thinking only of boys who intend to be engineers; that it was a specialised kind of instruction. But this is very untrue. Let me quote from the recommendations of the 1902 Military Education Committee (Report, p. 5):—

1 Only one subject—Latin—is really educational in our schools. I do not mean that the average boy reads any Latin author after he leaves school, or knows any Latin at all ten years after he leaves school. I do not mean that his Latin helps him even slightly in learning any modern language, for he is always found to be ludicrously ignorant of French or German, even after an elaborate course of instruction in these languages. I do not mean that his Latin helps him in studying English, for he can hardly write a sentence without error. I do not mean that it makes him fond of literature, for of ancient literature or history he never has any knowledge except that Caesar wrote a book for the third form, and on English literature his mind is a blank. But I do mean that as the ordinary public-school master is really able to give a boy easy mental exercises through the study of Latin, this subject is in quite a different position from that of the others. If any proof of this statement is wanted, it will be found in the published utterances of all sorts of men—military officers, business men, lawyers, men of science, and others—who, confessedly ignorant of “the tongues,” get into a state of rapture over their school experiences and the efficiency of Latin as a means of education. All this comes from the fact, which schoolboys are sharp enough to observe, that English schoolmasters can teach Latin well, and they do not take much interest in teaching anything else. It is a power inherited from the Middle Ages, when there really was a simple system of education. I ask for a return to simplicity of system. English (the King’s English; I exclude Johnsonese) is probably the richest, the most complex language, the one most worthy of philologic study; English literature is certainly more valuable than any ancient or modern literature of any other country yet admiration for it among learned Englishmen is wonderfully mixed with patronage and even contempt. At present, is there one man who can teach English as Latin is taught by nearly every master of every school? Just imagine that English could be so taught by teachers capable of rising to the level of our literature!

I have often to give advice to parents. I find the average parent exceedingly ignorant of his son’s character or inclinations or ability. He pays a schoolmaster handsomely for taking his son off his hands except during holidays. During the holidays, so terrible to a parent, he sees his son as little as possible. One question always asked is: Do you think it better to have “theoretical” instruction (they always call it by this absurd name) before or after an actual apprenticeship in works? Of course, such a question cannot be answered offhand. You tell the parent, to his great astonishment, that you must see the boy himself. When at length you see him, the chances are that you will find him to be what the schoolmasters are making of all our average boys. No part of his school work has been a pleasure to him, and, although he has had to work hard at his books, not one of the above three powers is his—power to use books and to write his own language; the language of his nurse, his mother, his mistress that is to be, his enemies and friends; the only language in which he thinks—power to compute and a liking for computation—power to understand a little of natural phenomena. Honestly I practically never find that such a boy has had any education at all except what he has obtained at home or from his school companions or from his sports. Even his sports are to keep him healthy of body only and not at all to cultivate his mental powers. Those old games like “Prisoners’ Base,” which really developed in a wonderful way not only all the muscles of the body, but also the thinking power, are scorned in the public schools. Think now how such a boy is handicapped if we pitchfork him into works where it is nobody’s duty to teach him anything, or send him to college, where he cannot understand the lectures. Of course, if he is very eager to be an engineer he will, by hook or by crook, get to understand things. I have met some such men—clever, successful engineers in spite of all sorts of adverse circumstances—but the best of them are willing to admit that they are, and have always been, greatly hurt by the absence of the three powers which I have specified. And if this has been so in the past, when the scientific principles underlying engineering have been simple, how much more so is it now, when every new discovery in physics is producing new branches of engineering!

“The fifth subject which may be considered as an essential part of a sound general education is experimental science; that is to say, the science of physics and chemistry treated experimentally. As a means of mental training, and also viewed as useful knowledge, this may be considered a necessary part of the intellectual equipment of every educated man, and especially so of the officer, whose profession in all its branches is daily becoming more and more dependent on science.” When statements of this kind have been made by some of us in the past, nobody has paid much attention; but I beg you to observe that the headmaster of Eton and the headmaster of St. Paul’s School are two of the members of the important Committee who signed this recommendation, and it is impossible to ignore it. Last year, for the first time, the President of the Royal Society made a statement of much the same kind, only stronger, in his annual address. I am glad to see that the real value of education in physical science is now appreciated; that mere knowledge of scientific facts is known to be unimportant compared with the production of certain habits of thought and action which the methods of scientific study usually produce.

As to English, the Committee say: “They have no hesitation in insisting that a knowledge of English,<sup>1</sup> as tested by composition, together with an acquaintance with the main facts of the history and geography of the British Empire, ought in future to hold the first place in the examination and to be exacted from all candidates.” The italics are mine. It will be noticed that they say nothing about the practical impossibility of obtaining teachers. As to mathematics, the Committee say: “It is of almost equal importance that every officer should have a thorough grounding in the elementary part of mathematics. But they think that elementary mechanics and geometrical drawing, which under the name of practical geometry is now often used as an introduction to theoretical instruction, should be added to this part of the examination, so as to ensure that at this stage of instruction the practical application of mathematics may not be left out of sight.” As Sir Hugh Evans would have said, “It is a very discretion answer—the meaning is good”; but I would that the Committee had condemned abstract mathematics for these army candidates altogether.

This report appears in good time. It would be well if Committees would sit and take evidence as to the education of men in the other professions entered by our average boys. It is likely that when an authoritative report is prepared on the want of education of clergymen, for example, exactly the same statements will be made in regard to the general education which ought to precede the technical training; but perhaps a reference may be made in the report to the importance of a study of geology and biology as well as physical science. Think of the clergyman being able to meet his scientific enemies in the gate!

Thanks mainly to the efforts of a British Association Committee, really good teaching of experimental science is now being introduced into all public schools, in spite of most persistent opposition wearing an appearance of friendliness. In consequence, too, of the appointment of a British Association Committee last year, at what might be called the psychological moment, a great reform has already begun in the teaching of mathematics.<sup>2</sup> Even in the regulations for the Oxford Locals for 1903, Euclid is repudiated. It seems probable that at the end of another five years no average boy of fifteen years of age will have been compelled to attempt any abstract reasoning about things of which he knows nothing; he will be versed in experimental mathematics, which he may or may not call mensuration; he will use logarithms, and mere multiplication and division will be a joy to him; he will have a working power with algebra and sines and cosines; he will be able to tackle at once any curious new problem which can be solved by squared

<sup>1</sup> This Committee recommends for the Woolwich and Sandhurst candidates a reform that has already been carried out by London University. No dead language is to be compulsory, but unfortunately some language other than English is still to be compulsory. Those boys, of whom there are so many, who dislike and cannot learn another language are still to be labelled “uneducated.” Must there, then, be national defeat and captivity before our chosen race gives up its false academic gods? We think of education in the most slovenly fashion. The very men who say that utility is of no importance are the men who insist on the usefulness of a knowledge of French or German. They say that a man is illiterate if he knows only English, although he may be familiar with all English literature and with other literatures through translations. The man who has passed certain examinations in his youth and never cares to read anything is said to be educated. The men of the city of the Violet Crown, were they not educated? And did they know any other than their own language?

<sup>2</sup> Discussion last year and report of Committee, published by Macmillan.

paper; and he will have no fear of the symbols of the infinitesimal calculus. When I insist that a boy ought to be able to compute, this is the sort of computation that I mean. Five years hence it will be called "elementary mathematics." Four years ago it was an unorthodox subject called "practical mathematics," but it is establishing itself in every polytechnic and technical college and evening or day science school in the country. Several times I have been informed that on starting an evening class, when plans have been made for a possible attendance of ten or twenty students, the actual attendance has been 200 to 300. Pupils may come for one or two nights to a class on academic mathematics, but then stay away for ever; a class in practical mathematics maintains its large numbers to the end of the winter.<sup>1</sup>

Hitherto the average boy has been taught mathematics and mechanics as if he were going to be a Newton or a Laplace; he learnt nothing and became stupid. I am sorry to say that the teaching of mechanics and mechanical engineering through experiment is comparatively unknown. Cambridge writers and other writers of books on experimental mechanics are unfortunately ignorant of engineering. University courses on engineering—with one splendid exception, under Prof. Ewing at Cambridge—assume that undergraduates are taught their mechanics as a logical development of one or two axioms; whereas in many technical schools under the Science and Art Department, apprentices go through a wonderfully good laboratory course in mechanical engineering. We really want to give only a few fundamental ideas about momentum and the transformations of energy and the properties of materials, and to give them from so many points of view that they become part of a student's mental machinery, so that he uses them continually. Instead of giving a hundred labour-saving rules which must be forgotten, we ought to give the one or two ideas which a man's common-sense will enable him to apply to any problem whatsoever and which cannot be forgotten. A boy of good mathematical attainments may build on this experimental knowledge afterwards a superstructure more elaborate than Rankine or Kelvin or Maxwell ever dreamt of as being possible. Every boy will build some superstructure of his own.

I must not dwell any longer on the three essential parts of a good general education which lead to the three powers which all boys of fifteen ought to possess; power to use books and to enjoy reading; power to use mathematics and to enjoy its use; power to study Nature sympathetically. English Board School boys who go to evening classes in many technical schools after they become apprentices are really obtaining this kind of education. The Scotch Education Board is trying to give it to all boys in primary and secondary schools. It will, I fear, be some time before the sons of well-to-do parents in England have a chance of obtaining it.

When a boy or man of any age or any kind of experience enters an engineering college and wishes to learn the scientific principles underlying a trade or profession, how ought we to teach him? Here is the reasonable general principle which Prof. Ayrton and Armstrong and I have acted upon, and which has so far led us to much success. Whether he comes from a bad or a good school, whether he is an old or young boy or man, approach his intelligence through the knowledge and experience he already possesses. This principle involves that we shall compel the teacher to take the pupil's point of view<sup>2</sup> rather than the pupil the teacher's; give the student a choice of many directions in which he may study; let lectures be rather to instruct the student how to teach himself than to teach him; show the student how to learn through experiment and how to use books, and, except for suggestion and help when asked for, leave him greatly to himself. If a teacher understands the principle he will have no difficulty in carrying it out with any class of students. I myself prefer to have students of very different qualifications and experience in one class because of the education that each gives to the others. Usually, however, except in evening classes, one has a set of boys coming from much the

same kind of school, and, although perhaps differing considerably as to the places they might take in an ordinary examination, really all of much the same average intelligence. Perhaps I had better describe how the principle is carried out in one case—the sons of well-to-do parents such as now leave English schools at about fifteen years of age.

It was for such boys that the courses of instruction at the Finsbury Technical College (the City and Guilds of London Institute) were arranged twenty-two years ago. It was attempted to supply that kind of training which ought already to have been given at school, together with so much technical training as might enable a boy at the end of a two years' course to enter any kind of factory where applied science was important, with an observing eye, an understanding brain and a fairly skilful hand. The system, in so far as it applies to various kinds of mechanical engineering, will be found described in one of a small collection of essays called "England's Neglect of Science," pp. 57-67.<sup>1</sup> I am sure that any engineer who reads that description will feel satisfied that it was the very best course imaginable for the average boy of the present time. A boy was taught how he must teach himself after he entered works. If after two or three years in the works he cared to go for a year or so to one of the greater colleges, or did not so care, it was assumed that he had had such a training as would enable him to choose the course which was really the best for him.

Old Finsbury students are to be found everywhere in important posts. The experiment has proved so successful that every London Polytechnic, every Municipal Technical School in the country has adopted the system, and in the present state of our schools I feel sure that all important colleges ought to adopt the Finsbury system. It hardly seems appropriate to apply the word "system" to what was so plastic and uncrystallised and had nothing to do with any kind of ritual.

The Professors were given a free hand at Finsbury, and there were no outside examiners. I need not dwell upon the courses in Chemistry and Physics; some critics might call the subjects *Rational Chemistry and Applied Physics*; they were as different from all other courses of study in these subjects as the courses on Rational Mathematics and Mechanics differed from all courses elsewhere. The course on Mechanics was really one on Mechanical Engineering. There were workshops in wood and iron, not to teach trades, but rather to teach boys the properties of materials. There were a steam-engine and a gas-engine, and shafting and gearing of many kinds, and dynamos which advanced students in turn were allowed to look after under competent men. There was no machine which might not be experimented with occasionally. Elementary and advanced courses of lectures were given; there was an elaborate system of tutorial classes, where numerical and squared paper exercise work was done; there were classes in experimental plane and solid geometry, including much graphical calculation; boys were taught to make drawing-office drawings in pencil only, and tracings and blue prints, such as would be respected in the workshop, and not the ordinary drawing-class drawings, which cannot be respected anywhere; but the most important part of the training was in the Laboratory, in which every student worked, making quantitative experiments. An offer of a 100-ton testing-machine for that laboratory was made, but refused; the advanced students usually had one opportunity given them of testing with a large machine, but not in their own laboratory. I consider that there is very little educational value in such a machine; the student thinks of the great machine,<sup>2</sup> and not of

<sup>1</sup> The ideas in this Address have been put forward many times by Prof. Ayrton and myself. See the following, among other publications:—"England's Neglect of Science" (Fisher Unwin); "Practical Mechanics," 1881 (Cassell); "Applied Mechanics," 1897 (Cassell); "The Steam Engine, &c.," 1898 (Macmillan); "The Calculus for Engineers," 1897 (Arnold); Recent Syllabuses and Examination Papers of the Science and Art Department in Subjects I., VII., V<sub>6</sub>, and XXII.; Summary of Lectures on Practical Mathematics (Board of Education); The Work of the City and Guilds Central Technical College (*Journal of the Society of Arts*, July 9, 1897); Inaugural Lecture at Finsbury, 1879; Address at the Coventry Technical Institute, February, 1898; "Education of an Electrical Engineer" (*Journal of the Society of Telegraph Engineers and of Electricians*, September, 1882); Presidential Address, Institution of Electrical Engineers, January, 1892; "The Best Education for an Engineer" (*NATURE*), October 12, 1899; Address at a Drawing-room Meeting, March, 1887.

<sup>2</sup> These great testing-machines, so common in the larger colleges, seem to have destroyed all idea of scientific experiment. There is so much that the engineer wants to know, and yet laboratory people are persistently and lazily repeating old work suggested and begun by engineers of sixty years ago. For example, men like Fairbairn and Robert Napier would long ago have found out the behaviour of materials under combined stresses. We do not even know the condition of strength of iron or steel in a twisted shaft which is also a beam. The theory of strength of a gun or thick tube under

<sup>1</sup> To many men it will seem absurd that a real working knowledge of what is usually called higher mathematics, accompanied by mental training, can be given to the average boy. In the same way it seemed absurd 500 years ago that power to read and write and cipher could be given to everybody. These general beliefs of ours are very wonderful.

<sup>2</sup> Usually it is assumed that there is only one line of study. In mathematics it is assumed that a boy has the knowledge and power and past experience and leisure of an Alexandrian philosopher. In mechanics we assume the boy to be fond of abstract reasoning, that he is a good geometrician who can do the most complex things in geometrical conics, but cannot possibly take in the simplest idea of the calculus.

the tiny specimen. Junior students loaded wires and beams, or twisted things with very visible weights, and saw exactly what was happening, or they studied vibrating bodies. Many hours were devoted to experiments on a battered, rusty old screw-jack, or some other lifting-machine, its efficiency under many kinds of load being determined, and students studied their observations using squared paper, as intently as if nobody had ever made such experiments before. There was one piece of apparatus, an old fly-wheel bought at a rag and-bone shop, to which kinetic energy was given by a falling weight, which, I remember, occupied the attention of four white-headed directors of Electric Companies in 1882 (evening students) for many weeks. A casual first measurement led on to corrections for friction and stiffness of a cord, and much else of a most interesting kind. At the end of six weeks these gentlemen had gained a most thorough computational acquaintance with every important principle of mechanics, a knowledge never to be forgotten. They had also had a revelation such as comes to the true experimenter—but that is too deep a subject.

Perhaps teachers in the greater colleges will smile in a superior way when they hear of this kind of experimental mechanics being called engineering laboratory work. True it was elementary mechanics; but is not every principle which every engineer constantly needs called a mere elementary principle of mechanics by superior persons? I find that these elementary principles are very much unknown to men who have passed through elaborate mathematical studies of mechanics. Students found out in that laboratory the worth of formulæ; they gained courage in making calculations from formulæ, for they had found out the extent of their own ignorance and knowledge.

I have never approved of elaborate steam-engines got up for students' laboratory exercise-work. A professor who had devoted much thought for a year to the construction of such a four-cylinder engine showed a friend how any one or any two or any three or all four cylinders, with or without jacketing, could be used in all sorts of ways. The friend ventured to say: "This engine will be used just once and never after." The professor was angry, but his friend proved to be right. The professor made experiments with it once himself with a few good students. Unfortunately, it was not a sufficiently elaborate investigation for publication. Afterwards he never had time personally to superintend such work; his assistants were busy at other things; his students could not be trusted with the engine by themselves, and to this day it stands in the laboratory a beautiful but useless piece of apparatus. At Finsbury there was an excellent one-cylinder engine with vaporising condenser. It drove the workshops and electric generators. On a field-day it drove an electric generator only, and perhaps thirty students made measurements. Each of them had already acted as stoker and engine-driver, as oiler and tester of the machinery, lighting fires, taking indicator diagrams, weighing coals, opening and closing cocks from seven in the morning to ten at night, so that everything was well known to him. They maintained three different steady loads for trials of three hours each. They divided into groups, one from each group ceasing to take a particular kind of observation every ten minutes and removing to another job. All watches were made to agree, and each student noted the time of each observation. These observations were:—Taking indicator diagrams, checking the speed indicator, taking temperature of feed-water, quantity of feed by meter (the meter had been carefully checked by gauge-notch, and every other instrument used by us had been tested weeks before), taking the actual horse-power passing through a dynamometer coupling on the shaft, taking boiler and valve-chest pressures and vacuum pressures on the roof and in the engine-room, weighing coals (the calorific value had already been tested), taking the horse-power given out by the dynamo, counting the electric lamps in use, and so on. Each student was well prepared beforehand. During the next week he reduced his own observations, and some of the results were

hydraulic pressure is no clearer now than it was fifty years ago. The engineer asks for actual information derived from actual trial, and we offer him the "could kail bet again" stuff falsely called "theoretical," which is found in all the text-books (my own among others). These great colleges of university rank ought to recognise that it is their duty to increase knowledge through the work of their advanced students. The duty is not neglected in the electrical departments of some of the colleges. Perhaps the most instructive reference is to the work done at the Central Technical College of the City and Guilds Institute at South Kensington, as described by Prof. Ayrton in some of the papers already referred to. I cannot imagine a better development of the Finsbury idea in the work of the highest kind of Engineering College.

gathered on one great table. One lesson that this taught could never be forgotten—how the energy of one pound of coal was disposed of. So much up the chimney or by radiation from boiler or steam-jacket and pipes; in condensation in the cylinder; to the condenser; in engine friction; in shaft friction, &c. I cannot imagine a more important lesson to a young engineer than this one taught through a common working engine. The students had the same sort of experience with a gas-engine. I need hardly say how important it was that the Professor himself should take charge of the whole work leading up to, during, and after such a field-day.

The difficulty about all laboratory exercise work worth the name is that of finding demonstrators and assistants who are wise and energetic. Through foolishness and laziness the most beautiful system becomes an unmeaning routine, and the more smoothly it works the less educational it is. In England just now the curse of all education is the small amount of money available for the wages of teachers—just enough to attract mediocre men. I have been told, and I can easily imagine, that such men have one talent over-developed, the talent for making their job softer and softer, until at length they just sit at a table, maintaining discipline merely by their presence, answering the questions of such students as are earnest enough to come and worry them. In such cases it is absolutely necessary to periodically upset their clockwork arrangements. After such an artificial earthquake one might be reminded of what occurred at the pool of Bethesda, whose waters had their healing property restored when the angel came down and troubled them. But for a permanently good arrangement there ought to be very much higher wages all round in the teaching profession.

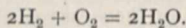
No kind of engineering has developed so rapidly as the electrical. Why, it was at the meeting here in Belfast twenty-eight years ago (I remember, for I was a Secretary of Section A that year, and took the machine to pieces afterwards in Lord Kelvin's laboratory) that there was exhibited for the first time in these islands a small Gramme machine. This handmaid of all kinds of engineering is now so important that every young engineer may be called uneducated who has not had a training in that kind of mechanical engineering which is called electrical engineering. Prof. Ayrton's laboratory at Finsbury is the model copied by every other electrical engineering laboratory in the world. He and I had the same notions; we had both been students of Lord Kelvin; we had worked together in Japan since 1875; but whereas I was trying to make my system of teaching mechanical engineering replace an existing system, or want of system, there was no existing system for his to replace. Thus it will be found that in every electrical engineering laboratory the elementary principles are made part of a pupil's mental machinery by many quantitative experiments, and nobody suggests that it is mere elementary physics which is being taught—a suggestion often enough made about the work in my mechanical laboratory. When students know these elementary principles well, they can apply their mathematics to the subject. As they advance in knowledge they are allowed to find out by their own experiments how their simple theories must be made more complex in real machines. Their study may be very complete, but, however much mathematics and graphical calculation may come in, their designs of electrical machinery are really based upon the knowledge acquired by them in the electrical and mechanical laboratories.

The electrical engineer has an enormous advantage over other engineers; everything lends itself to exact calculation, and a completed machine or any of its parts may be submitted to the most searching electrical and magnetic tests, since these tests, unlike those applied by other engineers, do not destroy the body tested. But for this very reason, as a finished product, the electrical engineer cannot have that training in the exercise of his judgment in actual practical work after he leaves a college that some other engineers must have. In tunnelling, earth-work and building, in making railways and canals, the engineer is supremely dependent on the natural conditions provided for him, and these conditions are never twice the same. There are no simple laws known to us about the way in which sea and river currents will act upon sand and gravel, and engineers who have had to do with such problems are continually appealing to Nature, continually making observations and bringing to bear upon their work all the knowledge and habits of thought that all their past experience has given them. I do not know that there is any job which a good teacher would have greater

pleasure in undertaking than the arrangement of a laboratory in which students might study for themselves such problems as come before railway, canal, river, harbour and coast-protection engineers; there is no such laboratory in existence at the present time, and in any case it could only be of use in the way of mere suggestion to an engineer who had already a good knowledge of his profession.

It was a curious illustration of mental inertia that the usual engineering visitor, even if he was a professor of engineering, always seemed to suppose that the work done at Finsbury was the same as that done in all the great engineering colleges. As a matter of fact, no subject was taught there in the same manner as it was taught elsewhere.<sup>1</sup>

Most of the students were preparing for electrical or mechanical engineering, and therefore we thought it important that nearly every professor or demonstrator or teacher should be an engineer. I know of nothing worse than that an engineering student should be taught mathematics or physics or chemistry by men who are ignorant of engineering, and yet nothing is more common in colleges of applied science.<sup>2</sup> The usual courses are only suitable for men who are preparing to be mere mathematicians, or mere physicists, or mere chemists. Each subject is taken up in a stereotyped way, and it is thought quite natural that in one year a student shall have only a most elementary knowledge of what is to the teacher such a great subject. The young engineer never reaches the advanced grounds which might be of use to him; he is not sufficiently grounded in general principles; his whole course is only a preliminary course to a more advanced one which there is no intention of allowing him to pursue, and, not being quite a fool, he soon sees how useless the thing is to him. The Professor of Chemistry ought to know that until a young engineer can calculate exactly by means of a principle, that principle is really unknown to him. For example, take the equation supposed to be known so well,



It is never understood by the ordinary elementary chemical student who writes it down so readily. Every one of the six cunning ways in which that equation conveys information ought to be as familiar to the young engineer as they are, or ought to be, to the most specialised chemist. Without this he cannot compute in connection with combustion in gas and oil engines and in furnaces. But I have no time to dwell on the importance of this kind of exact knowledge in the education of an engineer.

Mathematics and physics and chemistry are usually taught in watertight compartments, as if they had no connection with one another. In an engineering college this is particularly bad. Every subject ought to be taught through illustrations from the professional work in which a student is to be engaged. An engineer has been wasting his time if he is able to answer the questions of an ordinary examination paper in chemistry or pure mathematics. The usual mathematical teacher thinks most of those very parts of mathematics which to an ordinary man who wants to *use* mathematics are quite valueless, and those parts which would be altogether useful and easy enough to understand he never reaches; and, as I have said, so it is also in chemistry. Luckily, the physics professor has usually some small knowledge of engineering; at all events he respects it. When the pure mathematician is compelled to leave the logical sequence which he loves to teach mechanics, he is apt scornfully to do what gives him least trouble; namely, to give as "mechanics" that disguised pure mathematics which forms ninety per cent. of the pretence of theory to be found in so many French and German books on machinery. As pure mathematical exercise work it is even meaner than the stupid exercises in school algebras; as pretended engineering it does much harm because a student does not find out its futility until after he has gone through it, and his enthusiasm for mathematics applied to engineering problems is permanently hurt. But how is a poor mathematical professor who dislikes engineering, feeling like Pegasus harnessed to a common waggon—how is he to distinguish good from evil? He fails to see how worthless are some of the books on "Theoretical Mechanics"

written by mathematical coaches to enable students to pass examinations. An engineer teaching mathematics would avoid all futilities; he would base his reasoning on that experimental knowledge already possessed by a student; he would know that the finished engineer cannot hope to remember anything except a few general principles, but that he ought to be able to apply these, clumsily or not, to the solution of any problem whatsoever. Of course he would encourage some of his pupils to take up Thomson and Tait, or Rayleigh's "Sound," or some other classical treatise as an advanced study.<sup>1</sup>

Not only do I think that every teacher in an engineering college ought to have some acquaintance with engineering, but it seems to me equally important to allow a professor of engineering, who ought, above all things, to be a practical engineer, to keep in touch with his profession. A man who is not competing with other engineers in practical work very quickly becomes antiquated in his knowledge: the designing work in his drawing-office is altogether out of date; he lectures about old difficulties which are troubles no longer; his pupils have no enthusiasm in their work because it is merely academic and lifeless; even when he is a man distinguished for important work in the past his students have that kind of disrespect for his teaching which makes it useless to them. If there is fear that too much well-paid professional work will prevent efficiency in teaching, there is no great difficulty in applying a remedy.

One most important fact to be borne in mind is that efficient teachers cannot be obtained at such poor salaries as are now given. An efficient labourer is worthy of his hire; an inefficient labourer is not worthy of any hire, however small. Again, there is a necessity for three times as many teachers as are usually provided in England. The average man is in future to be really educated. This means very much more personal attention, and from thoughtful teachers. Is England prepared to face the problem of technical education in the only way which can lead to success, prepared to pay a proper price for the real article? If not, she must be prepared to see the average man remaining uneducated.

Advocacy of teaching of the kind that was given at Finsbury is often met by the opposition, not only of pure mathematicians and academic teachers, but I am sorry to say also of engineers. The average engineer not merely looks askance at, he is really opposed to the college training of engineers, and I think, on the whole, that he has much justification for his views. University degrees in engineering science are often conferred upon students who follow an academic course, in which they learn little except how to pass examinations. The graduate of to-day, even, does not often possess the three powers to which I have referred. He is not fond of reading, and therefore he has no imagination, and the idea of an engineer without imagination is as absurd as Teufelsdröckh's notion of a cast-iron king. He cannot really compute, in spite of all his mathematics, and he is absurdly innocent of the methods of the true student of Nature. This kind of labelled scientific engineer is being manufactured now in bulk because there is a money value attached to a degree. He is not an engineer in any sense of the word, and does not care for engineering, but he sometimes gets employment in technical colleges. He is said to teach when he is really only impressing upon deluded pupils the importance of formulæ and that whatever is printed in books must be true. The real young engineer, caught in this eddy, will no doubt find his way out of it, for the healthy experience of the workshop will bring back his common-sense. For the average pupil of such graduates there is no help. If he enters works, he knows but little more than if he had gone direct from school. He is still without the three qualifications which are absolutely necessary for a young engineer. He is fairly certain to be a nuisance in the works and to try another profession at the end of his pupilage. But if it is his father's business he can make

<sup>1</sup> It is really ludicrous to see how all preachers on technical education are supposed by non-thinking people to hold the same doctrine. The people asking for reform in education differ from one another more than Erasmus and Luther, and John of Leyden and Knipperdoling.

<sup>2</sup> At the most important colleges the usual professor or tutor is often ignorant of all subjects except his own, and he generally seems rather proud of this; but surely in such a case a man cannot be said to know even his own subject.

<sup>1</sup> One sometimes finds a good mathematician brought up on academic lines taking to engineering problems. But he is usually *stale* and unwilling to go thoroughly into these practical matters, and what he publishes is particularly harmful, because it has such an honest appearance. When we do get, once in forty years, a mathematician (Osborne Reynolds or Dr. Hopkinson) who has common-sense notions about engineering things, or a fairly good engineer (Rankine or James Thomson) who has a common-sense command of mathematics, we have men who receive the greatest admiration from the engineering profession, and yet it seems to me that quite half of all the students leaving our technical colleges ought to be able to exercise these combined powers if mathematics were sensibly taught in school and college. We certainly have had enough of good mathematicians meddling with engineering theory and of engineers with no mathematics wasting their time in trying to add to our knowledge.

a show of knowing something about it, and he is usually called an engineer.

Standardisation in an industry usually means easier and cheaper and better manufacture, and a certain amount of it must be good even in engineering, but when we see a great deal of it we know that in that industry the true engineer is disliked. I consider that in the scholastic industry there has been far too much standardisation. Gymnasien and polytechnic systems are standardised in Germany, and there is a tendency to import them into England; but in my opinion we are very far indeed from knowing any system which deserves to be standardised, and the worst we can copy is what we find now in Germany and Switzerland. What we must strive for is the discovery of a British system suiting the British boy and man. The English boy may be called stupid so often that he actually believes himself to be stupid; but of one thing we may be sure, he will find in some way or other an escape from the stupefying kind of school work to which the German boy submits. And if it were possible to make the average English boy of nineteen pass such a silly school-leaving examination as the German boy,<sup>1</sup> and to pass through a polytechnic, I am quite sure that there would be little employment among common-sense English engineers for such a manufactured article. But is it possible that British boys could be manufactured into such obedient academic machines, without initiative or invention or individuality, by teachers who are none of them engineers? No, we must have a British system of education. We cannot go on much longer as we have done in the past without engineering education, and, furthermore, it must be such as to commend itself to employers. Of my Finsbury students I think I may say that not one failed to get into works on a two or three years' engagement, receiving some very small wage from the beginning, and without paying a premium. To obtain such employment was obviously one test of fitness to be an engineer,<sup>2</sup> because experienced men thought it impossible. One test of the system was the greater ease with which new men obtained employment in shops which had already taken some of our students. It is certainly very difficult to convince an employer that a college man will not be a nuisance in the shops. In Germany and France, and to a less extent in America, there is among employers a belief in the value of technical education. In England there is still complete unbelief. I have known the subscribers of money to a large technical college in England (the members of its governing board) to laugh, all of them, at the idea that the college could be of any possible benefit to the industries of the town. They subscribed because just then there was a craze for technical education due to a recent panic. They were ignorant masters of works (sons of men who had created the works), ignorant administrators of the college affairs and ignorant critics of their mismanaged college. I feel sure that if the true meaning of technical education were understood, it would commend itself to Englishmen. Technical education is an education in the scientific and artistic principles which govern the ordinary operations in any industry. It is neither a science nor an art, nor the teaching of a handicraft. It is that without which a master is an unskilled master; a foreman an unskilled foreman; a workman an unskilled workman; and a clerk or farmer an unskilled clerk or farmer. The cry for technical education is simply a protest against the existence of unskilled labour of all kinds.<sup>3</sup>

<sup>1</sup> The following is, I understand, a stock question at certain gymnasien: "Write out all the trigonometrical formulæ you know." I asked my young informant, "Well, how many did you write?" "Sixty-two," was the answer. This young man informed me that a boy could not pass this examination unless he knew "all algebra and all trigonometry and all science." Strassburg geese used to be fed in France; now they are fed in Germany. German education seems to be like smothering a fire with too much fuel or wet slack which has the appearance of fuel.

<sup>2</sup> I have pointed out how natural it is that business men should feel somewhat antagonistic to college training. Poorly paid, unpractical teachers, with no ideas of their own, have in the past taught in the very stupidest way. They have called themselves "scientific" and "theoretical" till these words stink in the nostrils of an engineer. When I was an apprentice, and no doubt it is much the same now, if an apprentice was a poor workman with his hands he often took to some kind of study which he called the science of his trade. And in this way a pawkiness for science got to be the sign of a bad workman. But if workmen were so taught at school that they all really knew a little physical science, it would no longer be laughed at. When a civil or electrical engineer is unsuccessful because he has no business habits, he takes to calculation and the reading of so-called scientific books, because it is very easy to get up a reputation for science. The man is a bad engineer in spite of his science, but people get to think that he is an unpractical man because of his scientific knowledge. I do believe that the unbelief in technical education so very general has this kind of illogical foundation. Four hundred years ago, if a layman could read or write he was

To have any good general system the employers must cooperate. Much of the training is workshop practice, and it cannot be too often said that this is not to be given in any college. The workshop in a college serves a quite different purpose. Now how may the practice best be given? I must say that I like the Finsbury plan very much indeed, but there are others. When I attended this college in winter I was allowed to work in the Lagan Foundry in summer. In Japan the advanced students did the same thing; they had their winter courses at the college, and the summer was spent in the large Government workshops; the system worked very well indeed.<sup>1</sup> In Germany recently the great unions of manufacturers made facilities for giving a year of real factory work to the polytechnic students, but it seems to me that these men are much too old for entrance to works, and, besides, a year is too short a time if the finished product is to call itself a real engineer. Possibly the British solution may be quite different from any of these. A boy may enter works at fourteen on leaving a primary school or not later than sixteen on leaving a secondary school. In either case he must have the three powers to which I have already referred so often. It will be recognised as the duty of the owners of works to provide, either in one large work or near several works, in a well-equipped school following the Finsbury principle, all the training in the principles underlying the trade or profession which is necessary for the engineer.

No right-thinking engineer has been scared by the newspaper writers who tell us of our loss of supremacy in manufacture, but I think that every engineer sees the necessity for reform in many of our ways, and especially in this of education. People talk of the good done to our workmen's ideas by the strike of two years ago; it is to be hoped that the employers' ideas were also expanded by their having been forced to travel and to see that their shops were quite out of date.<sup>2</sup> In fact, we have all got to see that there is far too much unskilled labour among workmen and foremen and managers, and especially among owners. There may be some kinds of manufacture so standardised that everything goes like a wound-up clock and no thought is needed anywhere; but certainly it is not in any branch of engineering. Many engineering things may be standardised, but not the engineer himself. Millions of money may build up trusts, but they will be wasted if the unskilled labour of mere clerks is expected to take the place of the thoughtful skilled labour of owners and managers. I go further, and say that no perfection in labour saving tools will enable you to do without the skilled, educated, thoughtful, honest, faithful workman with brains. I laugh at the idea that any country has better workmen than ours, and I consider education of our workmen<sup>3</sup> to be the corner-stone of prosperity in all engineering manufacture. It is from the workman in countless ways that all hints leading to great inventions come. New countries like America and Germany have their chance just now; they are starting, without having to "scrap" any old machinery or old ideas, with the latest machinery and the latest ideas. For them also the time will come when their machines will be getting out-of-date and the cost of "scrapping" will loom large in their eyes. In the meantime they have taught us lessons, and this greatest of all lessons—that unless we look ahead with much judgment, unless we take reasonable precautions, unless we pay some regard to the fact that the cleverest people in several nations are hungry for our trade and jealous of our supremacy, we may for a time lose a little of that supremacy. In the last

probably a useless person who, because he could not do well otherwise, took to learning. What a man learnt was clumsily learnt; usually he learnt little with great labour and made no use of it; therefore reading and writing seemed useless. Now that everybody is compelled to read and write, it is not a usual thing to say that it hurts a man to have these powers.

<sup>1</sup> It was the idea of Principal Henry Dyer.

<sup>2</sup> Not only is there an enormous improvement in the use of limit gauges and checking and tools, and the careful calculation of rates of doing work by various tools and general shop arrangement, but attention is being paid to the comfort of workmen. There are basins and towels, and hot and cold water for them to wash in. In the old days it would have been called faddy philanthropy. Now, owners of works who scorn all softness of heart provide perfect water-closets for their men; their workshops are kept at a uniform temperature; the evil effect of a bad draught in producing colds, or a bad light in hurting the eyes, is carefully considered. In some of these works it is actually possible for a workman or a member of his family to get a luxurious hot bath for a penny. Will this really pay? Some clever, hard-headed men of my acquaintance say they already see that it does pay very well indeed.

<sup>3</sup> The old apprenticeship system of training men has broken down, and this is the cause of most of our industrial troubles. An apprenticeship system suited to modern conditions is described fully on pp. 68-88 of "England's Neglect of Science."

twenty-three years I have written a good deal about the harm done to England by the general dislike that there is among all classes for any kind of education. I do not say that this dislike is greater than it used to be in England; I complain that it is about as great. But I have never spoken of the decadence of England. It is only that we have been too confident that those manufactures and that commerce and that skill in engineering, for which Napoleon sneered at us, would remain with us for ever. Many writers have long been pointing out the consequences of neglecting education; prophesying those very losses of trade, that very failure of engineers to keep their houses in order, which now alarms all newspaper writers. Panics are ridiculous, but there is nothing ridiculous in showing that we can take a hint. We have had a very strong hint given us that we cannot for ever go on with absolutely no education in the scientific principles which underlie all engineering. There is another important thing to remember. Should foreigners get the notion that we are decaying, we shall no longer have our industries kept up by an influx of clever Uitlanders, and we are much too much in the habit of forgetting what we owe to foreigners, Fleming and German, Hollander, Huguenot and Hebrew, for the development of our natural resources. Think of how much we sometimes owe to one foreigner like the late Sir William Siemens.

But I am going too far; there is after all not so very much of the foolishness of Ishbosheth among us, and I cannot help but feel hopeful as I think lovingly of what British engineers have done in the past. We who meet here have lived through the pioneering time of mechanical and electrical and various other kinds of engineering. Our days and nights have been delightful because we have had the feeling that we also were helping in the creation of a quite new thing never before known. It may be that our successors will have a better time, will see a more rapid development of some other applications of science. Who knows? In every laboratory of the world men are discovering more and more of Nature's secrets. The laboratory experiment of to-day gives rise to the engineering achievement of to-morrow. But I do say that, however great may be the growth of engineering, there can never be a time in the future history of the world, as there has never before been a time, when men will have more satisfaction in the growth of their profession than engineers have had during the reign of Queen Victoria.

And now I want to call your attention to a new phenomenon. Over and over again has attention been called to the fact that the engineer has created what is called "modern civilisation," has given luxuries of all kinds to the poorest people, has provided engines to do all the slave labour of the world, has given leisure and freedom from drudgery, and chances of refinement and high thought and high emotion to thousands instead of units. But it is doing things more striking still. Probably the most important of all things is that the yoke of superstitions of all kinds on the souls of men should be lifted. The study of natural science is alone able to do this, but education through natural science for the great mass of the people, even for the select few called the distinguished men of the country, has been quite impossible till recently. I say that it is to engineers that the world owes the possibility of this new study becoming general. In our country nearly all discoveries come from below. The leaders of science, the inventors, receive from a thousand obscure sources the germs of their great discoveries and inventions. When every unit of the population is familiar with scientific ideas, our leaders will not only be more numerous, but they will be individually greater. And it is we, and not the schoolmasters, who are familiarising the people with a better knowledge of Nature. When men can hardly take a step without seeing steam-engines and electro-motors and telegraphs and telephones and steamships, with drainage and water works, with railways and electric tramways and motor-cars; when every shop-window is filled with the products of engineering enterprise, it is getting rather difficult for people to have any belief in evil spirits and witchcraft.

All the heart-breaking preaching of enthusiasts in education would produce very little effect upon an old society like that of England if it were not for the engineer. He has produced peace. He is turning the brown desert lands of the earth into green pastures. He is producing that intense competition among nations which compels education. If England has always been the last to begin reform, she has always been the most thorough and steadfast of the nations on any reform when

once she has started on it. Education, pedagogy, is a progressive science; and who am I that I should say that the system of education advocated by me is that which will be found best for England? In the school education of the average boy or man England has as yet had practically no experience, for she has given no real thought to it. Yet when she does, I feel that although the Finsbury scheme for engineers may need great improvement, it contains the germ of that system which must be adopted by a race which has always learnt through trial and error, which has been led less by abstract principles or abstract methods of reasoning than any race known in history.

#### NOTES.

WE learn from the *Times* that the work at the Ben Nevis Observatory is to be continued for another year without change in its character. The Meteorological Council in London has agreed to continue its grant of 250*l.* to the low-level observatory at Fort William and the grant of 100*l.* to the high-level observatory. The proceeds derived from furnishing newspapers with meteorological reports and from other sources will amount, it is hoped, to about 150*l.*, the sum hitherto yielded. The balance of the cost of maintenance, amounting to about 1000*l.*, has been readily subscribed by the public. This satisfactory arrangement will enable the staff to prosecute its work without interruption until the Parliamentary Committee inquiry has reported.

REUTER telegrams state that both craters of the Soufrière have been active since September 11, that communication by wireless telegraphy is to be established between Martinique and Guadeloupe, and that a shock of earthquake was felt in many of the northern towns of South Australia on Friday morning last. A severe shock was also experienced in Adelaide in the evening of the same day.

THE medals and prizes will be distributed to the students of the Royal College of Science, South Kensington, in the theatre of the Victoria and Albert Museum at 2.30 p.m. on Thursday next. The opening address of the new session will be delivered by Prof. John Perry, F.R.S., and Sir Arthur Rücker, F.R.S., will also speak.

THE death is announced in the *Athenaeum* of Theodor v. Heldreich, director of the Botanic Gardens at Athens. The deceased botanist, who was in his eighty-first year, devoted his attention mainly to the flora of Greece, and was the author of numerous works.

AMONG the deaths of foreign men of science we notice the following:—M. Damour—a member of the Paris Academy of Sciences—at the age of 94, and Prof. O. G. Nordenström, of the Stockholm School of Mines. The former was well known for his chemical analyses of rare minerals, and the latter was an authority on mining and the author of numerous technical memoirs.

THE suggestion that a public subscription should be opened for the purpose of purchasing the house in which Pasteur was born and presenting it to the town of Dôle was brought before the French Association at its recent session.

A SCHEME has been proposed to the Italian Minister of Posts and Telegraphs by Mr. Marconi for the creation of a radio-telegraphic station communicating with the stations established or to be established by the Marconi companies in London and in America. The scheme, which is still under consideration, would, if carried out, cost about 70,000 lire. It was announced at a dinner given in Mr. Marconi's honour that the King of Italy had bestowed the Cross of a Grand Officer of the Italian Order of the Crown upon the inventor.

A PRELIMINARY report on the subject of the wireless telegraphy experiments conducted by a board of naval officers

has, according to the *Western Electrician*, been submitted to the U.S. Navy Department. The board reported that it had tried the Rochefort system with some success, messages having been received and sent with accuracy, and that it was now proposed to test in turn a French and two German systems.

On Friday afternoon last, Mr. Stanley Spencer, the aeronaut, sailed from the Crystal Palace in the airship he has constructed. A successful voyage over London was made, and the vessel descended at Eastcote, near Pinner.

THE *British Medical Journal* states that arrangements are nearly completed for the formation of a new society to be known as the Therapeutical Society, which shall concern itself with the medicinal properties of every kind of natural product of value in practical medicine. As new countries are opened up, plants hitherto unknown are brought to this country, and, as our contemporary remarks, the society may fulfil a most useful function if it undertakes to study the chemical, pharmacological and therapeutical qualities of such plants, especially those which are believed by the natives of the countries from which they come to possess valuable medicinal properties. The first president will be Sir W. T. Thiselton-Dyer, K.C.M.G., F.R.S., and the first hon. secretary Dr. T. E. B. Brown, master of the Society of Apothecaries. The meetings are to be held in the house of the Society of Apothecaries, and the first will take place shortly to make the necessary preliminary arrangements for the first year's work.

PART of an expedition for the survey of the Gold Coast set sail from Liverpool on Saturday last. The remaining members of the expedition, numbering between thirty and forty, and consisting of trained surveyors from the Ordnance Survey and surveyors from Queensland and New Zealand, will leave for West Africa on October 4.

AN inquiry into the earthquakes in Guatemala and Martinique has been undertaken by Prof. Sapper, of Tübingen, who has obtained leave of absence for the purpose from the Württemberg Government.

AN international exhibition of photography is to be held in Moscow in the spring of next year. It will be divided into the following sections:—(1) Scientific photography; (2) artistic photography; (3) photography applied to printing; (4) works on photography; (5) technical applications of photography; (6) photography considered as a special industry.

THE following rewards are offered by the Government of South Australia for the discovery and working within the State of a deposit or deposits of marketable mineral manure—500*l.* if found on Crown lands; 250*l.* if found on freehold lands. It is stipulated (1) that the deposit is easily accessible and within a reasonable distance of a railway or seaport, and not within twenty-five miles of any discovery on account of which any bonus has been paid; (2) that the deposit is sufficiently abundant and is available at a price which will allow of it being remuneratively used for agricultural purposes; (3) that the product is of a good marketable quality, averaging not less than 40 per cent. of phosphate of lime. In the event of a phosphate of a lower average composition being discovered, it may be recommended that a portion of the reward be paid. Applications must reach the Minister for Agriculture, Adelaide, not later than December 31.

It was found from the examination of 55,000 children in some thirty-six public schools in New York that no fewer than 12 per cent. suffered from contagious diseases of the eyes.

To prevent such children from attending the institutions, a routine examination of the eyes is in future to be made at regular intervals, and for this purpose ophthalmic surgeons have been appointed.

JUDGING from the reports issued by the teachers in the various West Indian islands, the experiment of introducing the subject of agriculture into the elementary schools, which was due to a suggestion made by the Commissioner of the Imperial Department of Agriculture, has already begun to yield satisfactory results. The best accounts come from Jamaica, where the training college at Kingston provides a suitable centre for imparting instruction to teachers in training and special classes; here, too, good practical work has been accomplished. School gardens are being instituted, notably in Jamaica, Trinidad and Tobago, but in some of the islands they have not proved so successful owing to predial larceny. A full account of the agricultural conference appears in the last number of the *West Indian Bulletin*, when besides these reports several papers of an economic nature were read. The Hon. Sydney Olivier pointed out the necessity for careful sorting and good packing of exported fruit if West Indian growers hoped to establish a market in England and America. He suggested that an inspector should be appointed to report on the condition of the fruit as it arrived at its destination. The Hon. W. Fawcett read a paper on the banana industry in Jamaica, which gave general information on the habits of the plant and its method of cultivation. Statistics show that at present the exports to England are small in proportion to those shipped to America. Mr. A. Howard brought forward evidence to show that epiphytes do harm to cacao trees mainly by blocking up the lenticels. He advised spraying with copper sulphate or rosin compound to kill off the smaller plants. Other papers were, "Insect Pests," by Mr. H. Maxwell-Lefroy; "Barbados Aloes," by Mr. W. G. Freeman; and "Essential Oils," by Mr. J. H. Hart.

THE issue of the *Elektrochemische Zeitschrift* for August contains a useful reference article by Dr. H. Lienau on bauxite. This mineral is the chief source of the commercial aluminium produced by the electrolytic processes, and although many attempts have been made, and are still being made, to replace it by some cheaper raw material, these attempts hitherto have been unsuccessful. Natural deposits of bauxite occur in France, Germany, Ireland and the United States, those of the department Var in southern France being at present the most extensively worked. In 1896 this district produced 29,620 tons and in 1901 65,000 tons, of which total 55,000 tons were exported to other countries. After a reference to the geological formation in which bauxite occurs and to the varying composition of the deposits, the author describes the various processes which have been worked at one time or another for extracting aluminium or its compounds from this source. The first patented process dates from 1858, and had for its object the extraction of aluminium hydrate from red bauxite. The demand by paper and colour manufacturers for a cheaper source of aluminium sulphate than the alums turned attention to the direct production of aluminium sulphate from bauxite, but the efforts to produce this salt, free from iron, from red bauxite have not been completely successful. The utilisation of bauxite for the electrometallurgical production of aluminium is a comparatively recent development, but very large quantities of the mineral are now being used in aluminium reduction works. The author surmises from this fact that bauxite is being employed directly in the electrolytic baths, and that the troublesome and costly process by which alumina was first extracted from the raw bauxite is now being dispensed with.

MR. F. KROHN sends from Funchal, Madeira, some notes on sunset glows observed by him during June, July and August, in continuation of those previously described by him (p. 199). On a number of occasions, even when the sky above and to the west was overcast at sunset, a pink glow could be seen on the eastern horizon just before sunset, and then just immediately after or at the time of sunset a pink glow would suffuse the cloud screen above. Mr. Krohn was under the impression that the phenomenon was rather more marked about July 6-7, 12-16 and 26-27, but these dates, especially the last two, are uncertain. Since the end of July, clear weather has prevailed, and during August 1-3 a well-marked maximum was observable, the phenomenon being particularly well marked on August 2, when both sunrise and sunset displays were very fine, the sky at the time being quite clear. The latter sunsets, however, were very far from equalling the displays of June 10-11. The rays or spokes in the pink haze, mentioned in Prof. A. S. Herschel's letter of July 10 (*NATURE* of July 24), have been observed by Mr. Krohn four or five times. From the observations it is concluded that the volcanic dust and moisture cloud is travelling at an average rate of about thirty miles an hour in the latitude of Funchal. This does not seem an improbable rate if Prof. Herschel's estimate of the height of the present cloud is correct, for the rate at which the Krakatoa cloud travelled was about seventy-two miles an hour; but this cloud was travelling at a much greater height.

WHEN well marked, the phenomena observed by Mr. Krohn at sunset followed the course described by Prof. Herschel. In Mr. Krohn's words, "A pink glow appears in the east in the form of a broad band above a broad greenish-grey band down on the horizon. The pink band gradually extends upwards and disappears as the glow begins to form a pink arc in the western horizon, which until then shows a white hazy area above the sun's point of setting. Gradually the white area contracts and assumes a more golden hue. The pink arc also contracts and assumes a more intense colour; at the outer edge it is more purple where the pink mixes with the blue of the sky. A dirty greenish-grey haze now begins to spread upwards from the eastern horizon and finally replaces the pink halo in the west as a purplish-grey arc around a whitish halo. This faint purplish halo or arc is visible for some time after dusk has set in. At sunrise the phenomena are practically the same, but the order is reversed and the colours near the horizon seem to be purer."

THE director of the Philippine Weather Bureau, the Rev. Fr. José Algué, S.J., has issued the first part of a report containing an account of the climate of Baguio (Benguet), as gathered from a complete year's observations. The report is very thoroughly made and is the first of its kind, and one of its main objects is to draw attention to climatological conditions of certain regions of the archipelago which might be advantageously chosen as health resorts. In the case of each of the meteorological elements here discussed, a comparison of the facts is made with the data already recorded at and published by the Manila Observatory. The meteorological station at Baguio is of quite recent date, having been in operation since August, 1900, and its equipment was made more complete after the establishment of the Philippine Weather Bureau in May, 1901. The present report contains the observations of pressure, temperature, relative humidity, fog, clouds, rainfall, wind, and in most cases curves of the daily and yearly variations are given. The concluding chapter is devoted to a comparison of the climate of this station with those of other tropical stations at similar altitudes.

THE trustees of the British Museum at Bloomsbury have issued a capital "Guide to the Antiquities of the Stone Age in the Department of British and Mediæval Antiquities," which is

accompanied by ten plates and 142 other illustrations. It has been prepared by Mr. Charles H. Read, who observes that his work is to some extent rendered incomplete owing to the fact that many objects essential to a full understanding of the Stone Age are at the Natural History Branch in Cromwell Road, while some localities and some classes of implements are not so well represented as they should be in the national collection. Although he groups the antiquities under those of Palæolithic and Neolithic ages, he figures and describes certain Eolithic implements, recognising that the existence of an earlier and ruder type is in itself not improbable. His reference to the occurrence of "early Palæolithic" implements in beds older than the chalky boulder clay, though based on a statement in a Geological Survey memoir, requires qualification, as the evidence is far from satisfactory. The text is, however, so full of information and the illustrations are so excellent, exhibiting the chipped and polished stone-implements from all parts of the world, as well as engraved stones, bones and horns, and pile-dwellings, that the work will be highly appreciated by all who take an interest in the antiquity of man.

MR. T. MELLARD READE has given an account of the Glacial and post-Glacial features of the River Lune and its estuary (*Proc. Liverpool Geol. Soc.*, vol. ix. 1902). The lower part of the valley is a pre-Glacial excavation that was filled with Boulder-clay and other glacial drift, and since to a large extent removed by river denudation, the various stages being recorded by terraces cut in the drift. The later deposits include thick sands and clayey sands rich in foraminifera, of which lists have been furnished by Mr. Joseph Wright.

A FULL account of a recent peat and forest bed at Westbury-on-Severn has been contributed by Mr. Mellard Reade, Mr. A. S. Kennard and others to the *Proceedings* of the Cotteswold Naturalists' Field Club (vol. xiv. part 1). The deposits include blue clays containing foraminifera, an intermediate peat bed with branches and roots of trees, and an overlying mass of tidal alluvium. The foraminifera appear to have lived in the locality and probably in brackish water. The peat bed has yielded many land and fresh-water mollusca, which with other remains indicate climatic conditions similar to those of the present day. The deposits are recent, and the indications they furnish of changes of level prior to the Roman occupation are briefly discussed.

A PAPER by E. Guyou, entitled "La Méthode des Distances Lunaires, le Présent, le Passé, l'Avenir," has reached us. The author considers that the publication of lunar distances of certain stars in the national ephemerides has had a bad effect in that it has concentrated observation upon those stars all of which at the moment of observation are possibly too far from the moon for accurate observation, and that therefore repeated failure to obtain accurate results has led to the abandonment of the method. The author expects now to see the method revive, observers being no longer biassed in their choice and taking the most convenient star. We think he is too sanguine.

THE chemical composition of tubercle bacilli derived from various sources, especially in regard to the amount of ash and of phosphoric anhydride, and of the alcoholic, ether and chloroform extracts, has been investigated by De Schweinitz and Dorset. There is a distinct difference in the composition of the various bacilli; the alcoholic extract of avian bacilli is very much greater than that of any other variety, but the chloroform extract of bovine and of human virulent bacilli is almost the same. There is also a greater difference between the virulent and non-virulent human bacilli than between the virulent human, bovine and equine bacilli. (*Amer. Med.*, July 19, p. 93.)



IN the August number of the *American Chemical Journal* is an interesting paper by Messrs. Franklin and Stafford on reactions between acid and basic amides in liquid ammonia. Solutions of these amides in liquid ammonia are conductors of electricity, a fact presumably due to electrolytic dissociation of the dissolved substances. It would appear that these amides indeed bear a relation to liquid ammonia which in many respects is very similar to that borne by ordinary acids and bases to water. Complete or partial neutralisation of the dissolved amides takes place with the formation of one or more molecules of the solvent ammonia in which the reaction takes place. By bringing together liquid ammonia solutions of different acid and basic amides, the authors have prepared a large number of metallo-substituted acid amides; for example, monopotassium acetamide, mono- and di-potassium benzamide, mono- and di-potassium sulphamide, mono- and di-potassium urea, magnesium acetamide, &c.

IN a *Bulletin* of the Bussey Institution, vol. iii. No. 2, Prof. F. H. Storer describes the results of tests for mannose carried out on a large number of vegetable species. From these it would appear that mannan is fairly widely distributed in plant life. The amount of mannan in the trunk-wood of sugar-maple trees felled during the period of hibernation is considerably greater than that in maple trees felled at the beginning or end of May, that is, during or just after the formation of new leaves upon the trees. The author comes to the conclusion that mannan as well as starch is stored as reserve food in the wood of the sugar maple.

THE sixteenth number of the *Revue générale des Sciences*, issued on August 30, contains a short article, by Mr. P. Lemoult, on the new synthesis of indigo patented by Sandmeyer. The author points out that the Sandmeyer synthesis possesses several advantages, from a chemical point of view, over the two processes which are now used on the large scale for the artificial production of indigo. An estimate of the cost of production by the new process indicates that the indigo obtained should compete successfully on the market with the natural product and that of the older synthetic methods.

IN vol. xvii. of the *Journal* of the College of Science, Imperial University, Tokyo, Messrs. Divers and Ogawa show that it is possible to prepare sulphamide from ammonium amidosulphite with a 10 per cent. yield, whereas the older method of obtaining it from sulphuryl chloride and ammonia only gives 1 to 2 per cent. of the theoretical amount.

TO the September number of the *Zoologist*, Mr. R. C. J. Swinhoe contributes some important notes on prehistoric man in Burma. It will be remembered that in 1894 Dr. F. Noetling announced in the *Records* of the Geological Survey of India the discovery in a bed of ferruginous conglomerate at the oil-fields of Yenangyoung of worked flints in association with the remains of *Hipparion antilopinus* and *Rhinoceros beringensis*, thus carrying back the existence of man in that country to the older Pliocene or upper Miocene. A year later, Mr. R. D. Oldham expressed the opinion that, in the first place, the flints are not confined to the ferruginous conglomerate and, secondly, that they are not chipped by man. As the result of a recent visit to the locality, Mr. Swinhoe confirms Dr. Noetling's view that the chipped flints, and likewise certain faceted bones, are the works of men's hands; but, on the other hand, he regards them as of Palæolithic age, the place where they were found being apparently a workshop of that period.

THE September issue of the *Quarterly Journal of Microscopical Science* contains four articles of a highly technical nature, for the most part interesting only to specialists. In the first of the four, Dr. T. H. Bryce treats of the maturation of the

egg in the common sea-urchin; he is followed by Mr. R. I. Pocock, who discusses the "entosternite" of spiders and scorpions. The third article, by Dr. S. F. Harmer, is devoted to the morphology of polyps allied to the common sea-mat, while in the fourth, Mr. L. Doncaster describes the development and anatomy of the annelid sagitta.

Nos. 1275 and 1276 of the *Proceedings* of the U.S. Museum are respectively devoted to a list of the beetles of the Columbia district, by Mr. H. Ulke, and to the description of some new South American birds, by Mr. H. C. Oberholser.

THE additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Mrs. O'Connor; a Rhesus Monkey (*Macacus rhesus*) from India, presented by Miss Faulkner; a Lesser White-nosed Monkey (*Cercopithecus petaurista*) from West Africa, presented by Mr. C. W. Woodhouse; a Black-headed Lemur (*Lemur brunneus*) from Madagascar, presented by Dr. H. C. Hilliard; a Grey Parrot (*Psittacus erithacus*) from West Africa, presented by Captain Paget J. Bourke; a Carrion Crow (*Corvus corone*) British, presented by Miss N. Simmons; a Great Barbet (*Megaloema virens*) from the Himalayas, presented by Mr. R. Phillips; eighteen Green Tree Frogs (*Hyla arborea*) European, presented by Dr. E. L. Gough; a Common Marmoset (*Hapale jacchus*), an All-green Tanager (*Chlorophonia viridis*), a Blue Sugar-bird (*Dacnis cayana*) from Brazil, a Suricate (*Suricata tetradactyla*) from South Africa, a Prairie Marmot (*Cynomys ludovicianus*) from North America, a Crab-eating Opossum (*Didelphys cancrivorus*) from Tropical America, a Levaillant's Amazon (*Chrysotis levaillanti*) from Mexico, three Asiatic Quails (*Perdica asiatica*) from India, deposited; an Axis Deer (*Cervus axis*) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN OCTOBER:—

- Oct. 10. 0h. 41m. to 5h. 34m. Transit of Jupiter's Sat. IV.
- 12. 2h. 7m. to 5h. 49m. Transit of Jupiter's Sat. III.
- 13. 11h. 24m. Minimum of Algol ( $\beta$  Persei).
- 15. Venus. Illuminated portion of disc = 0.981, of Mars = 0.930.
- 16. 8h. 13m. Minimum of Algol ( $\beta$  Persei).
- 16. 10h. 17m. to 11h. 18m. Moon occults  $\zeta^1$  Piscium (mag. 4.2).
- 16. 16h. 17m. to 19h. 50m. Total eclipse of the moon partly visible at Greenwich. The moon sets at 18h. 32m. when totally eclipsed.
- 19. 5h. 58m. to 9h. 40m. Transit of Jupiter's Sat. III.
- 19. 17h. 8m. to 18h. 13m. Moon occults  $\delta^1$  Tauri (mag. 4.0).
- 19. 17h. 43m. to 18h. 43m. Moon occults  $\delta^2$  Tauri (mag. 4.7).
- 19-21. Epoch of Orionid meteoric shower. Radiant  $91^\circ + 15'$ .
- 22. 12h. 53m. to 13h. 44m. Moon occults  $\lambda$  Geminorum (mag. 3.6).
- 23. 9h. Mercury in conjunction with Venus. Mercury,  $1^\circ 20' S$ .
- 26. 9h. 54m. to 13h. 36m. Transit of Jupiter's Sat. III.
- 30. 6h. Venus in conjunction with moon. Venus,  $0^\circ 54' N$ .
- 30. Partial eclipse of the sun slightly visible at Greenwich. The eclipse ends at 19h. 1m., or 8 minutes after sunrise at Greenwich on the morning of Oct. 31.

REPORT OF THE MELBOURNE OBSERVATORY FOR 1901.—New buildings are being added at a cost of 1500l., and, with the repairs that have already been done, this will add considerably to the efficiency of the Observatory.

The third Melbourne catalogue for the epoch 1890 has been in the printer's hands since last December. 336 plates have been exposed in connection with the astrographic chart, and of these, 320 have been passed as satisfactory.

6327 stars have been selected from the catalogue plates, and roughly reduced for observation with the Melbourne transit circle, to serve as standard stars for the reduction of the Melbourne regions, and of these 3944 have already been completely observed with the meridian circle three times or more.

There are now 760 meteorological stations in communication with the Observatory, and all the records for the last forty years are, at present, being completely rearranged and classified in convenient forms for easy reference. The terrestrial-magnetism work has been carried on as hitherto, and the special observations in connection with the Antarctic expeditions are being made at the required intervals. In the reduction of the magnetograph curves for the past thirty years, 21,877 curves had been measured up to March 31.

NEW MINOR PLANETS.—The following five minor planets, with their positions, are recorded by Prof. Max Wolf in No. 3815 of the *Astronomische Nachrichten*:—

1902. Sept. 3d. 12h. 55m. '8 (Heid).	Sept. 7d. 10h. 38m. '9 (Heid).			
$\alpha$	$\delta$	$\alpha$	$\delta$	Mag.
1902 J.O. 23h. 54m. '7	-0° 13'	23h. 51m. '7	-0° 44'	13
1902 J.P. 23h. 56m. '7	+1° 14'	23h. 54m. '5	+0° 47'	12
1902 J.Q. oh. 13m. '4	+1° 20'	oh. 11m. '3	+0° 44'	12.5
1902 J.R. oh. 9m. '2	-1° 21'	oh. 6m. '6	-1° 36'	12
1902 J.S.		oh. 10m. '3	-0° 13'	13

### THE RETURN OF THE ARCTIC EXPEDITIONS.

SINCE we went to press with our last issue, the Arctic expeditions of Lieut. Peary and Captain Sverdrup have returned, and accounts of their work, as well as of that of the Baldwin-Ziegler expedition, have appeared in the daily papers. The following brief account of the scientific results obtained by the three expeditions is obtained from telegrams received through Reuter's Agency, and from the personal narrative of Captain Sverdrup which is to be found in the *Times* of Monday last.

Lieut. Peary reached Payer Harbour on September 16, 1901, and within a week the Eskimos with the expedition began to sicken, and not one escaped illness. Of the number, six adults and a child died. Further sickness among the Eskimos occurred in the following January.

An advance party, in charge of Hensen, started for Conger on March 3. On March 6, the main party started, leaving Peary in charge at Payer Harbour. Conger was reached in twelve marches, shortly after the advance party had arrived there. The Eskimos supporting the expedition went back on reaching Conger. Eight marches more took the expedition to Cape Hecla, at the north end of Robinson Channel, which was all open across to Greenland, while there were lakes of water extending northward as far as could be seen, from Black Cape to Cape Ransome. On April 1, Lieut. Peary started northward over the Polar Sea with Hensen, four Eskimos and six sledges. The old floes were covered deeply with snow and intersected by rubble ridges, and lanes of young ice were encountered.

The travelling, except for the lanes of young ice, was similar in character to that experienced by the English expedition of 1876. After a number of difficult marches, which became more and more perilous, the pack, in latitude 84° 17', to the north-west of Cape Hecla, became impracticable, and further efforts to advance had to be abandoned. New leads and the pressure ridges, with fogs, made the return in some respects more trying than the advance. Cape Hecla was regained on April 29 and Cape Sabine on May 15. The ice broke up earlier than in 1901, and Payer Harbour was blockaded almost continuously. The *Windward* bored through, entered the harbour on August 8, and left the same afternoon.

The leader of the expedition states that he has a deep-rooted conviction that it is possible to reach the North Pole. In all his attempts during the last four years, he points out, he has not had a suitable starting-point, but he believed that the Pole can be reached on sledges by any adequately equipped expedition which makes latitude 83 its winter quarters. If he had means of his own to continue the work, he would certainly not give it up, but he must now bow to circumstances. It has been demonstrated to his satisfaction, he declares, that there is no open ocean in the voyage to the Far North. On the other hand, there is no foundation for the idea that there is an eternally frozen sea, though the waters are practically always

covered with ice. He has shown, he thinks, that Greenland's shore is the most northerly land of the earth's surface, and that all beyond it on the other side is ocean.

Lieut. Peary made a close study of the Eskimos living on Whale Sound, the most northerly people in the world. Their complete isolation has differentiated them from every other race. They are a small tribe, not exceeding 200 in number, and are being rapidly destroyed by an unknown disease, apparently a malignant slow fever. He collected specimens of everything pertaining to their habits, knew every man, woman and child personally, learned their characters and capacities, and taught them to work.

The first intimation of the return of Capt. Sverdrup in the *Fram* came in the shape of the following telegram (dated Stavanger, September 19) from Captain Sverdrup to the secretary of the Royal Geographical Society:—

"Arrived here to-day with the *Fram*. Our exploring work consists in the southern and the western shores of Ellesmere Land and other unknown fields to the westward. Braskerud died autumn 1899, otherwise all well."

The *Fram*, it will be remembered, left Christiania in June, 1898, its principal geographical object being to ascertain the extension of Greenland towards the north, to determine the yet unknown configuration of the mainland, and, if possible, to discover whether this great Arctic land finally breaks up into groups of islands in the north. It was also understood that, if circumstances were favourable, Captain Sverdrup, like Lieut. Peary, would make an attempt to reach the North Pole.

The personal narrative of the leader of the expedition, already referred to, gives an interesting account of the work accomplished and the way in which the great difficulties which presented themselves were overcome. As so much care and attention had been paid to the scientific equipment of the expedition, valuable scientific results may be expected to accrue from it, particulars of which will be eagerly awaited. The narrative, however, gives information as to some of the work done in the interests of science. Hayes Sound was completely mapped. The unknown west coast of Ellesmere Land was explored. Between Ellesmere and North Kent, a large bay was seen to extend eastward and to be about 100 miles broad. On the northern side of the same, some large, complicated fjords were found. The land extended about fifty miles westward from these, after which it ran in a north and north-westerly direction. Part of the land which was traversed was very hilly and intersected by large fjords, several of which were from fifteen to twenty miles broad at the mouth.

Much other new land was explored and the numerous fjords investigated. All the members of the expedition appear to have worked heartily and harmoniously together, and returned safely to Stavanger on Friday last, with the exception of the surgeon, who was to have taken charge of the meteorological observations and who died in the course of the expedition.

Mr. Baldwin, in the course of an interview, claimed to have accomplished, in the course of nearly a year and a half's incessant work, more than the unfavourable conditions which surrounded his expedition really warranted, and to have brought back data which ought materially to assist subsequent explorers. For the first time in the history of North Polar exploration, a photographic record had been secured of the ice and snow conditions of the Arctic and of the animal life of those regions. The kinematograph had been for the first time successfully employed in the far North, and as a result there were more than 1000 perfect photographic representations of their work, and in addition more than 200 drawings and paintings had been made.

The main object of the expedition was to plant the American flag at the North Pole, and the result being what it was, the explorer is naturally somewhat disappointed. He maintains, however, his belief that his objective can be reached in accordance with his original plan. He attributes his non-success to the condition of the ice in the Franz Josef Land Archipelago in the autumn of 1901, which prevented the navigation of the *America* far enough north to be of practical advantage in establishing headquarters so as to facilitate sledge-work in the winter and spring of the present year, and to the sickening and death of many of the dogs from internal parasites, which ultimately proved fatal to more than half the pack.

A hut was found by the party, and in it a small brass cylinder

3 inches in length containing a record of Dr. Nansen's work, dated May 19, 1896, the hut proving to be that in which Nansen had stayed. In the place of the document, Mr. Baldwin left a record by himself of his own work and visit.

During the period spent by the expedition in the far north, some fifteen balloons were released containing messages, addressed to the nearest American Consul, respecting both air and sea currents.

After an adventurous and trying journey, the expedition, on July 17, reached a place of safety to the southward of Cape Flora, and eventually home. In Mr. Baldwin's opinion, the old idea of an open Polar sea is baseless. "We know," he says, "that land extends as far as the 82nd degree on the Franz Josef Land side, and it is from here that I believe the Pole will be reached. I quite agree with Lieutenant Peary that the most practical way of attaining the Pole is by sledging from this point."

CONVENTION OF WEATHER BUREAU OFFICIALS.

ON August 27, 28 and 29 of last year, the second Convention of Weather Bureau Officials took place at Milwaukee, Wisconsin, and we have recently received the report of the proceedings, which has been published by the U.S. Department of Agriculture (*Bulletin* No. 31), being edited by Messrs. James Berry and W. F. R. Phillips under the direction of the chief of the Weather Bureau, Prof. Willis L. Moore. The report, which covers no less than 246 pages, will be found most interesting

Amongst other papers of particular interest are those referring to "the forecaster and the newspaper," by Mr. Harvey Maitland Watts, who points out the great value newspapers can be in publishing popular and accurate meteorological information and timely warnings to their readers. Dr. Oliver Fassig gives the results of a study of the diurnal variations of the barometer, and demonstrates the westward movement of the daily barometric wave, portraying it excellently by means of a series of charts which accompany the paper. In the subsequent discussion, Prof. Moore refers to the paper as "quite unique and entitled to great consideration." "Lightning Recorders and their Utility in Forecasting Thunderstorms," "Meteorology in Colleges," &c., are among other subjects touched upon, and the volume concludes with a good index and a capital photograph of a group of the members present at this Convention. There seems no doubt that such gatherings are most useful and valuable, and Prof. Moore tells us that these two conventions have demonstrated their usefulness by affording exceptional opportunity for exchange of views and discussion of methods and means for advancing the work of the Weather Bureau.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE technical schools and colleges throughout London are now beginning their winter's work. An examination of a batch of prospectuses which has reached us shows that year by year there is an increasing amount of attention paid to the varied wants of students engaged throughout the day in different



FIG. 1.—Fog Pyramid. This photograph was taken by Prof. Alex. McAdie on July 30, 1900, at 7.15 p.m. The conditions were normal so far as temperature, humidity and wind are concerned at Mount Tamalpais. The view in the foreground is the town of Mill Valley. The apex of the fog pyramid was (it is estimated) about five miles from the camera. The fog in the background overlies the Golden Gate and the Bay of San Francisco. The formation is peculiar, and it should be noted that the land under the fog pyramid is level, and the uplifting of the fog is not due to the existence of foothills at this point.

reading to meteorologists, for the numerous papers included in the seven sections of the volume refer to widely varied branches of work. To enter into anything like detail in this note is out of the question, but brief references may be made to a few of the papers read at this Convention.

Prof. Moore in his presidential address gave a brief survey of the weather service since its inception in 1870, showing its rapid growth and pointing out its increasing efficiency. "Fog Studies" was the subject of Prof. Alex. McAdie's paper, the author emphasising the point that fog "may be considered as a problem in *air drainage*, just as frost may be so considered." We reproduce one of the numerous excellent reproductions in the report with which he illustrated his remarks. Mr. E. J. Glass describes and illustrates the "chinook" winds so well known to those who live near the Rocky Mountains and which serve the useful purpose of storing the snow that supplies the water to the rivers during the summer season.

industries. At the Battersea Polytechnic, for example, we notice that in addition to the lectures and laboratory work in inorganic, organic and physical chemistry, classes have been arranged in gas manufacture, in the manufacture of oils, fats, soaps and candles, in iron and steel analysis, in paper making and testing, and in the chemistry of the kitchen and laundry. The same thoroughness is shown in the departments concerned with the building, engineering and other trades. The prospectus of the Chelsea Polytechnic, over which Prof. Tomlinson, F.R.S., presides, is published in four volumes dealing respectively with the day colleges for men and women, the day school for boys and girls, and the evening classes. It would be difficult to name a subject, commercial or technical, in which no class is provided at Chelsea. Moreover, every stage is looked after; there are classes suitable for the apprentice, and yet arrangements have been made by which advanced students may engage in research work under the supervision of the principal.

The Sir John Cass Technical Institute at Aldgate is just entering upon its first full session. Intending students will find that complete chemical, metallurgical and physical courses of instruction have been provided, as well as classes in commercial and domestic subjects. Considerable attention appears to have been given to the preparation of candidates for examinations in connection with the University of London.

THE Report for the year 1901 on the museums, colleges and institutions under the administration of the Board of Education has been issued. Among other interesting items, it may be mentioned that the year was marked by a large falling off in the number of visitors to the western galleries of the Victoria and Albert Museum who received special assistance or facilities for the examination of the collections for scientific instruction and research. There was also a diminution in the total number of visitors to the Museum, the total in 1901 being 836,848 as compared with 1,017,314 in 1897, since which year there has been a steady decrease. The most important events in the history of the Royal College of Science during the year reported upon were the retirement of Sir Norman Lockyer after forty-four years' total service, and of Sir Arthur Rücker after fifteen years' service. Similarly the report of the Geological Survey is exceptional, since it records the retirement of Sir Archibald Geikie after a service of more than forty-five years. The South Physics Observatory was very busy during the fifteen months with which its report deals, viz. from October, 1900, to December, 1901. Bad weather entirely prevented observations of sun spots on 127 days throughout this period, and 171 nights during the same time were wholly bad for observing purposes, leaving 201 nights available, on which occasions the observers attended.

THE Report of the Board of Education for the year 1901-2 contains much interesting information concerning the amount and quality of the science teaching in schools working under the regulations of the South Kensington authorities. During the session 1900-1, the total number of students receiving instruction in science and art in such schools was 332,329, and the total number of such schools or institutions was 2288. The grants paid in respect of the instruction given, or of the examinations held at its close, amounted to 286,251*l.*, of which it is interesting to note 2687*l.* only was paid on the results of the annual examinations, by far the greater part being awarded upon attendances or in the form of capitation grants in "schools of science." The new regulations, under which fees became payable by candidates for examination in the elementary stage of science subjects, appear to have had a beneficial effect. The percentage of these papers which reached the first class rose from 27 in 1900 to 31 in 1901 under the new regulations, and of those which reached the second class from 32 to 37, the percentage of failures thus falling from 41 to 32. Up to the end of 1901, 78 schools in England and 65 in Wales applied for recognition under the new regulations, which offer grants to secondary day schools taking an approved scheme of instruction for a three or four years' course in science. Of the English schools, 58 were endowed schools, 6 were county or municipal schools, 9 were established by articles of association and 5 by religious bodies. As these regulations only came into force in August, 1901, none of the schools had, at the time of drawing up the report, completed the first year's course, so that no account of the way in which the new arrangements work is yet available.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 15.—M. Bouquet de la Grye in the chair.—The cultivation of the yellow lupin (*Lupinus luteus*), by MM. P. P. Dehérain and E. Demoussy. The poor yield of this plant on calcareous soil appears to be due to the effect of the lime in preventing the assimilation of phosphoric acid, since if considerable quantities of phosphate are added, the plant will grow in soils containing a fair proportion of lime. The tubercles containing bacteria capable of fixing atmospheric nitrogen do not, however, appear under these conditions, not even when the yellow lupins are inoculated from the tubercles of white lupins. The growth is best in non-calcareous soils.—On the principal focal surface of the objective of the photographic equatorial of the Observatory of Toulouse, by

MM. B. Baillaud and Montangerand.—On the rocks thrown out by the actual eruption of Mont Pelée, by M. A. Lacroix. From the external appearances, three classes of rocks can be distinguished, compact vitreous blocks of a greyish-black colour, rocks of a clearer colour than these, and angular blocks of white pumice, sometimes as large as a cubic metre. All these have proved to be of the same petrographical type; they consist of hypersthene andesites rich in phenocrystals, the latter consisting of plagioclases of the andesine and bytownite series. The principal coloured element is hypersthene, accompanied by titanomagnetite and small quantities of augite, hornblende and olivine. The products of the eruption have the same general character as the rock mass of Mont Pelée formed in the course of previous eruptions.—On the differences of contact potential, by M. Pierre Boley. A study of the electromotive forces of the cell constructed of the saturated amalgams of two metals, with two electrolytes.—On the electrical resistance of slightly conducting bodies at very low temperatures, by M. Edmond van Aubel. The electrical resistance of iron pyrites was measured for a temperature range of from 60° C. to -181° C. The resistance increases considerably as the temperature is lowered, but there is still an appreciable conductivity at the temperature of liquid air. The curve showing the variation of the electrical resistance of iron pyrites with temperature shows that  $\frac{AR}{\Delta t}$

increases as the temperature approaches the absolute zero. Experiments on other metallic sulphides are being carried out.—On a note of M. Th. Tommasina, on the mode of formation of cathode and Röntgen rays, by M. Jules Semenov.—On the formation of liquid drops and the laws of Tate, by MM. Ph. A. Guyé and F. Louis Perrot. With other conditions fixed, the weight of a drop falling from the end of a tube is a function of the time of formation of the drop. It follows that any attempt to verify Tate's law, in which the time of formation is not taken into account, is wanting in precision. It is essential that the conditions of experiment should be so arranged that the weight of the drop should be independent of the time of formation. In view of these facts, the authors consider that the experiments of MM. Leduc and Sacerdote do not furnish even an approximate proof of the law in question.—On the production of india-rubber in the forests of the French Congo, by M. Aug. Chevalier. Observations on *Landolphia Klainii*, the chief india-rubber-producing tree in the French Congo.

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