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September 19. Next Academic Year Begins.
September 20–23. Matriculation Examinations.
September 26. Instructions Resumed.

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MEETINGS OF SOCIETIES.

Scientific. First Wednesday of each month, at 8 P. M. Next meeting, October 4.
S. H. Freeman, Secretary.

Philological. First Friday of each month, at 12 M. Next meeting, October 6.
M. Warren, Secretary.

Metaphysical. Second Tuesday of each month, at 8 P. M. Next meeting, October 10.
B. I. Gilman, Secretary.

Historical and Political Science. Third Friday of each month, at 8 P. M. Next meet-
ing, October 20.
H. B. Adams, Secretary.

Mathematical. Third Wednesday of each month, at 8 P. M. Next meeting, October 18.
O. H. Mitchell, Secretary.

Naturalists' Field Club. Excursions each Saturday during the Spring and Autumn. Regular meetings for the reading and discussion of papers once a month.
H. P. Reid, Secretary.
On the Geometrical Interpretation of Certain Formulae in Elliptic Functions, by Professor A. Cayley.

I have given in my Elliptic Functions expressions for the $sn^2$, $cn^2$, $dn^2$ of these combinations respectively, and to write the formula thus:

$$dn^2(u+ik) = (1-k^2)\text{sn}^2(u+ik) = k^2 - k^2x - (1-k')y$$

$$sn^2(u+ik') = 1 + (1+k)\text{cn}^2 + (1+k'+ik')y$$

$$cn^2(u+ik) = k(1+ik)\text{sn}^2 + \text{cn}^2 = k(1+ik) - y$$

where in the last set of values, $x$, $y$ are used to denote $\text{sn}^2$ and $\text{cn}^2$ respectively; and the formulae are thus brought into connexion with the cubic curve $y^2 = x(1-x)(1-k^2)$. The curve has an inflexion at infinity on the line $x = 0$; and the three tangents from the inflexion are:

$x = 0$, $x = 1$, $x = \frac{1}{k^2}$.

The tangents and the cubic curve become coincident in points such that the line joining them passes through the point of inflexion; in particular for the first mentioned pair the equation of the line joining the points of contact is $1+kk' = 0$. The linear functions belonging to a pair of tangents are precisely those which present themselves in the formulae, thus if $T_1$ is a pair of tangents to the curve, then $T_2 = y = 0$.

The second of the three formulae is $sn^2(u+ik) = \frac{1}{k}T_2$, and the other two formulae correspond in like manner to pairs of tangents from the sextactic points of theta-functions.

On Sinapine, a Constituent of Mustard; a preliminary notice, by R. Dorsey Coale.

A full account of this investigation will be published in the American Chemical Journal.

On Certain Recent Observations relating to the so called "Granules" of the Solar Surface, by C. S. Hastings.

The Dialectical Peculiarities of the Kentish Charters, by H. Wood.

The following seven Charters were considered in this paper: 1. Alfred Aldorman, 871-880 A. D.; 2. Wulfred, Oswald and Berhtsdi, 805-810; 3. Ethelred, 880-881; 4. Ethelred, 881; 5. Laes, 882; 6. Abba, 885; 7. Badan, 837. The dates are Kombler's, as revised by Thorpe. No. 1 was tested by all the laws of vowel change that apply, and was found to agree closely in dialect with the Interlinear Version of the Psalter (ed Stevenson 1843-47 for the Surtsey Soc.). Both differ in a marked manner, and in the same particulars, from the Kentish Glosses (Spr. des Kent. Psalters 2), that the Psalter is closely related to Northumbrian, partly through the influence of Bede, and, in the absence of vocalized s, from the Epinal Glosses. The conclusion was reached, in opposition to Sweet (Past. Care xxi., and 42 Diacrit. 634), that the Charter is neither West-Saxon nor Kentish, but rather Northumbrian-Meridian. Siévers' recent statement (Aeg. Gram. 2), that the Psalter is closely related to Northumbrian, partly through the influence of Bede, and, in the absence of vocalized s, from the Epinal Glosses. The conclusion was reached, in opposition to Sweet (Past. Care xxi., and 42 Diacrit. 634), that the Charter is neither West-Saxon nor Kentish,
the disciples in Gethsemane, his seizure by the Jews, Jesus before Calaphas, mocking by the Jews and the decision to conduct him to Pilate. The second day is contained on pp. 174–429; it shows Pilate in his office of governor, the proceedings before him, his acquittal of Jesus, Mary, the removal from the cross, and his burial. Finally the third day is contained on pp. 439–629: it begins with the conference respecting a guard of soldiers at the grave and the bargain with them about their reward, then the conversation of the soldiers with each other at the grave, the resurrection, parish, descent into hell, Mary Magdalen at the grave with Jesus, the ascension, the descent of the Holy Spirit, the descent of the Holy Ghost upon the followers, the sending forth of the disciples, and the ascension of Jesus, which is, however, a natural consequence of the exact identity of source and dramatic aim. Especially is this true of the Marien-Kings, which is made up of Latin songs thinly interlarded with German dialogue. The language of the MS. shows upon the most cursory examination its South German origin; its dialectic peculiarities, furthermore, prove it to be Bavarian-Austrian,—it was probably written a little previous to the year 1500. Its most marked phonetic characteristics are: the usual retention of Ohg. p in anlaut: pin, piut, pers, verpierpet, geporen, unzerprochen. The usual apocope of e in anlaut: pott (bode), palt (bald), truytt (leide), sue and au. For Mhgr. the MS. has throughout to: swecgen, guet, ruuef, muehlessen.

For Mhgr. ei the MS. has throughout ait: paysgen, ain, kain, soheyna, getoogen (y interchange with i both when alone and as a member of a diphthong) for Mhgr. i, a, ia, in, the MS. has as in Nhg. ei, eu, au, au. O works for b in offenwo, offenwartch.

Historical and Political Science Association.

May meeting.

Parish Institutions of Maryland, by Edward Ingle.

By an Act of Assembly passed in 1692 the Church of England was established in Maryland. The Province was divided into thirty-one parishes from ten to eighty miles long, and Vestries were chosen. The Act of 1702 remedied the imperfections of former Acts, and was the basis for church government until the revolution.

In each parish the freeholders chose six vestrymen and two churchwardens. The Vestry, composed of “sober and discreet” persons, was the guardian of parish funds and interpreted the By-Laws of the Anglican Church. The Parish Church was usually the first parish building. There the Vestry-men met and transacted the business of the parish. When there was no incumbent, the goods in the Vestry’s possession were expended in building or repairing churches, or in paying the salaries of clergymen. The church buildings were generally built of wood, with little or no attempt at ornamentation. At one time the Vestry chose counters of tobacco for the parish, and nominated inspectors of tobacco, out of which nominations the Governor made his appointments.

When the tax was imposed upon bachelors, the Vestry made out the list and sent it to the sheriff. Adulterers, &c., were presented for convictions. When the tax was imposed upon bachelors, the Vestry made out the list and sent it to the sheriff. Adulterers, &c., were presented for convictions. When the tax was imposed upon bachelors, the Vestry made out the list and sent it to the sheriff. Adulterers, &c., were presented for convictions.
April meeting.


In this paper general terms were considered as of two kinds: the intensively definite, connoting a fixed group of qualities, and the extensively definite, denoting a fixed group of objects. Six kinds of propositions involving such terms were described, viz.: Verbal Propositions, asserting that two groups of qualities have components in common (Propositions of Definition) or that two groups of objects have components in common (Propositions of Division); and Real Propositions, asserting (1) that two groups of qualities are sometimes found in the same object (Propositions of Concomitance), or (2) that two groups of objects possess qualities in common (Propositions of Resemblance), or (3) that, in some cases, components of a group of objects possess a group of qualities (Propositions of Possession), or (4) that, in some cases, components of a group of qualities are common to a group of objects (Propositions of Inherence). Each of these propositions may be denied as well as asserted, the affirmative species being particular and the negative universal; and each of these latter gives rise by negating the terms in all ways to four forms. Three of the six kinds of propositions, those of Definition, Resemblance, and Inherence, are the reciprocals of the other three, referring to qualities as the latter do to objects; and take a negative similarly reciprocal to the ordinary negative. The syllogistic of these forty-eight propositions consists of arguments following either the particular or universal type of ordinary syllogism, and in the case of Real Propositions consists of twelve such arguments, six universal and six particular.

From Propositions of Concomitance, signifying the assertion or denial of the existence of a class, a complex propositional system was developed containing propositions asserting or denying more than one class. Such a system contains seventy-five varieties, or eighty if the possibility is allowed of the non-existence of the Universe of Discourse. These may be reduced to eighteen types, or twenty on the supposition just made.

For the expression of these propositions a special notation was employed. The syllogistic of these eighteen types embraces thirty-four forms of complex argument. A similar complex syllogistic may be developed from either one of the other five kinds of propositions named above.

Remarks on the above paper, by C. S. Peirce.

Mr. Peirce remarked that the propositional system of Dr. Morgan supposes the universe of things to be limited (in this sense, that there is some logically possible combination of characters which does not occur in any existing thing), but supposes the universe of characters to be unlimited (in the sense that there is no aggregate of things which does not have some common mark). Mr. Peirce undertook to show what propositional system is necessary in case both universes are permitted to be limited, so that nothing of a general nature can be assumed respecting the relations of things and of characters. There will, in the first place, be universal propositions asserting that two classes of objects have no common breadth. These are purely extensive propositions. There will also be purely intensive, or (better), comprehensive propositions, asserting that two groups of marks have or have not a common depth.

Next there will be propositions asserting some relation between a group of things and a group of marks. These will be of twelve intransmutable species, as follows:

First, affirmative propositions, asserting the possession of characters by things.

a. Every one of a named class of things is said to possess every one of a named group of characters.

b. Some one or more (without saying what), of a class of things is said to possess every one of a group of characters.

c. Every one of a named group of characters is said to be possessed by some one or other of a named class of things. (y follows strictly from y.)

d. Some one or more (without saying what), of a group of characters is said to be possessed by every one of a named class of things.

e. Every one of a class of things is said to possess some one or other of a named group of characters. (x follows from y.)

f. Some one of a class of things is said to possess some one of a group of characters.

Second, negative propositions, denying the possession of characters by things will correspond exactly to the affirmative forms. These may be called propositions of the second order, because the relative term "possessing as a character" enters into them once. A proposition of the second order will be such as this. "Every S possesses every character not possessed by some T." There will be eighty-eight species of this order of propositions in all.

Propositions of even orders are evidently two families, the extensive and the comprehensive.

In immediate inferences, the order of the conclusion agrees with that of the premises, and the inference is unaltered in character. In simple immediate inferences the order is either unchanged or increased or diminished by two. An immediate inference from a universal to a particular proposition is impossible.

In syllogisms, it is necessary and sufficient that there should be a distributed middle term, and the order of the conclusion is the sum of the orders of the premises. Of course, immediate Inference from the conclusion is often possible. [What Dr. Morgan calls spurious propositions may be inferred from two premises having an undistributed middle].

The treatment here is that of the subject, and they have been identified with the relatives. To obtain an inference the premises are to be relatively multiplied together, and then all inferences conform to one or other of these forms:--

\[(a + b) \leftrightarrow (b + c)\]
\[a(b + c) \leftrightarrow b(c + a)\]

The dagger here denotes the operation of "relative addition." If denoted "lover of" and a "servant of," then is denoted "lover of a servant of," and \(l + s\) denotes "lover of everything but a servant of." A universal proposition stating that one relation is a special case of another is most naturally written in the form \(l < s\), which particular example means that to be a lover is to be a servant. But we have the general form:

\[l<s\] when \(n\) means 'not,' or 'other than.' By means of these formulae we bring the proposition \(l < s\) into the forms:

\[l < s\]
\[l < s\]
\[l < s\]

We now apply one of the rules for transposition. These rules are, first, that the proposition \(xy < z\) is equivalent to \(xy < y\) and \(yz < x\) (where the straight line over a term negates it and the curved line converts the relation), and second, that the proposition \(x y + z\) is equivalent to \(y x + z\) and to \(y z + x\). The application of these rules to the four forms just given yield the following equivalents of \(l<s\):

\[l<s\]
\[l<s\]
\[l<s\]

A particular proposition asserting that there is a pair of objects such that the first is at once in two relations to the second, cannot, in general, be expressed by the algebra of dual relations without the use of a negative copula. But this can be done in the special case in which the relatives have every object in the universe for correlate to each relate. Now a non-relative term such as 'man' may be considered as a relative term of which the relatives are the different men and the correlates all objects in the universe; so that whatever is a man is a man for every object in the universe. With that understanding, if \(m\) denote 'man' and \(a\) 'honor,' we can express that some man is honorable by writing \(1 < mh\) or \(1 < \text{hon}\).

Suppose now that we have given the two premises \(1 < a + b\) and \(1 < b + c\). Multiplying them we have

\[1 < (a + b) (b + c)\]
\[1 < (a + b) (b + c)\]

Thus we infer

\[1 < a + b\]

But

\[1 < a + b\]

so that we have

\[1 < a + c\]

which is the syllogistic conclusion. In like manner from the two premises

\[1 < a + b\] and \(1 < b + c\), we get

\[1 < (a + b) b\]

and thence, successively,

\[1 < (a + b) b\]

which is the syllogistic conclusion.

But from the two premises \(1 < ab\) and \(1 < bc\) we only get

\[1 < (ab) (bc)\]

which is a spurious proposition.

The extension of this method to the syllogistic of the higher orders of propositions affords no difficulty.
May meeting.

Consciousness and Reality, by M. I. Swift.

The aim of physical science is to account for all things by means of mechanical principles. How are we to determine whether there is any limit in the application of this method? Formerly there was a gulf between the activity of organic and inorganic matter, but it is now believed that this has been practically bridged over. The gulf between consciousness and the physical world still remains. Can these also be united upon physical principles? Clifford's "mind-stuff" theory is typical of various recent attempts that have been made with this end in view. Consciousness is regarded as made up of many "elementary feelings" not in themselves conscious. These feelings are the ultimate reality, and are termed "mind-stuff." "Mind-stuff is the reality which we perceive as matter." By this theory reality is placed beyond consciousness, and the physical is treated as phenomenal. The real nature of consciousness is therefore not explained, and we have no warrant for applying the laws of external phenomena to it, so that the supposed bridge turns out to be illusory. The true importance of the theory is its indirect reduction of the mechanical to the psychical, instead of the reverse, in its attempt to connect the two.

Efforts more strictly physical in their nature have likewise failed to explain consciousness mechanically, but science does not pronounce such an explanation impossible. In opposition to this view of the role to uphold the theory of "vital principles," and "forces" acting upon matter from without. Not only is it impossible to prove this, but nothing would be gained by its proof, for we should be plunged into the difficulties of a clearly established dualism. The true problem rests upon a wider basis. The error of supposing that consciousness can be physically explained arises largely from the habit of regarding it as of like nature with physical phenomena. Consciousness does not belong to the physical world, but is its reality, for that reason, in any way dependent upon consciousness? It was shown that consciousness is entirely different in its nature from the physical. If the former is unreal, the physical, as a construction in it, also loses its reality. The integrity of consciousness in its nature must be preserved, and apart from it we cannot hope to find reality.


At the last meeting Mr. Peirce developed, by means of the Algebra of Relatives, the syllogistic of the two fundamental propositions of common logic 'All a is b' and 'Some a is b'; in the notation of relatives $1 \prec a \bowtie b$ and $1 \prec \sim a b$, besides the propositional forms on which it was founded, this syllogistic gave two other conclusions of the forms $1 \preceq a \bowtie \sim b$ and $1 \prec \sim a b$, in which $\sim$ denotes the relative 'other than.'

An examination of the different possible values which the relative $\bowtie n$ may assume, enables us to make the following analysis of the meaning of these propositions. The former is a universal, the latter a particular proposition. $1 \prec a \bowtie \sim b$ is always true when there is more than one $b$, while if there is but one $b$ it is not so, and if $b$ does not exist neither does $a$. $1 \prec \sim a b$ asserts the existence of both $a$ and $b$, and if either is plural is always true, while if both are singular they are different objects. The universal proposition may be expressed in words, any given $a$ is other than some $b$, or, more shortly, Any $a$ is not some $b$. The particular may be expressed, some determinate $a$ is other than some determinate $b$, or, Some $a$ is not some $b$. The latter form is the same as Hamilton's proposition $a \bowtie n$, called spurious by De Morgan, and the former is what Hamilton's proposition $A = n$ becomes, instead of interpreting 'any' collectively as he does, and reducing the proposition to $O$ read backward, 'any' is given a distribution meaning. With this difference the two propositions are those of Hamilton's scheme, called $a$ and $b$ by Thomson and rejected by him.

Regarding the relative $n$ in combination with others as the mark of spurious propositions, they may exist in an indefinite succession of higher degrees in $n$. The proposition $1 \prec \bowtie a \bowtie \sim b$ is spurious in the second degree. It asserts that both terms exist, and that one is a singular, and that if the other is a singular the two are not the same object.

From two spurious propositions of the first order a genuine conclusion may be syllogistically drawn by the elimination of the relative $n$. This may be effected by propositions of either of the following forms,

1. $1 \prec \Delta \bowtie \sim a + e$
2. $1 \prec (\Delta + 1) e$

for which the name anti-spurious was suggested by Mr. Peirce. The first of these propositions asserts as follows, viz: that if one term includes the whole universe the other does not; again, that if one term includes everything but one object, the other includes at least everything but one; while if one term includes less than everything but one object, the other includes everything. Further, if the two terms are singulars the universe consists of only these two different objects.

The latter, or particular anti-spurious proposition asserts that if there is no $b$, $c$ must exist, while if there is but one it is, and if there is more than one, $c$ cannot exist.

Mathematical Society.

May meeting.

Note on the Formulae of Trigonometry, by Professor A. Cayley.

The equations $a = \cos B + b \cos C, b = \cos C + c \cos A, b = \cos A + d \cos C$, which connect together the sides $a, b, c$ and the angles $A, B, C$ of a plane triangle, may be presented in an algebraical rational form, by introducing in place of the angles $a, b, e$ the functions $A + b \sin A, b \cos b + b \sin b$, $c + b \sin b$, $c + b \sin c$; viz: calling these $\cos x, \sin x, \cos y, \sin y$ respectively, or what is the same thing, writing $2 \cos A = \frac{\pi}{4} + \frac{\pi}{4}$, $2 \cos B = \frac{\pi}{4} + \frac{\pi}{4}$, $2 \cos C = \frac{\pi}{4} + \frac{\pi}{4}$ then the foregoing equations may be written

$2 \cos C = \frac{\pi}{4} + \frac{\pi}{4}$
$2 \cos B = \frac{\pi}{4} + \frac{\pi}{4}$
$2 \cos C = \frac{\pi}{4} + \frac{\pi}{4}$

That is to say, we have a system of bipartite equations linear in $(a, b, c)$ and cubic in $(a, b, c, d)$ respectively.

Similarly in Spherical Trigonometry, writing as above for the angles, and for the sides writing in like manner $2 \cos a = \frac{\pi}{4} + \frac{\pi}{4}$, $2 \cos b = \frac{\pi}{4} + \frac{\pi}{4}$, $2 \cos c = \frac{\pi}{4} + \frac{\pi}{4}$, $2 \cos d = \frac{\pi}{4} + \frac{\pi}{4}$, we have a system of bipartite equations separately homogeneous in regard to $(a, b, c, d)$ and $(\alpha, \beta, \gamma, \delta)$ respectively.

A Word on Nonions, by J. J. Sylvester.

In my lectures on Multiple Algebra I showed that if $u, v$ are two matrices of the second order, and if the determinant of the matrix $(z + yv + xu)$ be written as $z^2 + 2xyz + y^2z + x^2z + y^2t + x^2t$ then the necessary and sufficient conditions for the equation $uv + wv = 0$ are the following, viz: $b = 0, e = 0, c = 0, d = 0$.

If these conditions we superadd $a = 1, f = 1, 1 = 1, 1 = 1, 0 = 0$, $u = 0, v = 0, w = 0$, and $u, v, w$ form a quaternion system. The conditions stated above will be satisfied if $z + yv + xu = z + y^2 + z^2$, which will obviously be the case if $w = 0, f = 0, f = 0$, where $e = 0, d = 0$.

For then $z + yv + xu = x + y + z$ Hence the matrices

$\begin{bmatrix} z & y & x \\ y & z & x \end{bmatrix}$. Hence the matrices

$\begin{bmatrix} z & y & x \\ y & z & x \end{bmatrix}$

are constructed as complex quantities are a linear transformation of the ordinary quaternion system 1, i, j, k; that is to say, if we form the multiplication table

<table>
<thead>
<tr>
<th>$\lambda$</th>
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Since $u, v$ contain between them 8 letters subject to the satisfaction of 5 conditions, the general most values of $\lambda, \mu, \nu, \tau$ ought to contain 5 arbitrary constants; but it is well known that any particular $(i, j, k)$ system may be superseded by a $(i', j', k')$ system, where $(i', j', k')$ are orthogonally related linear functions of $(i, j, k)$; and as this substitution introduces just 3 arbitrary constants, we may, by aid of it, pass from the system of matrices above given, to the most general form. The general expression

$\lambda + r = 1, -\mu + \nu = i, \nu + \mu = j$. Since $u, v$ contain between them 8 letters subject to the satisfaction of 5 conditions, the general most values of $\lambda, \mu, \nu, \tau$ ought to contain 5 arbitrary constants; but it is well known that any particular $(i, j, k)$ system may be superseded by a $(i', j', k')$ system, where $(i', j', k')$ are orthogonally related linear functions of $(i, j, k)$; and as this substitution introduces just 3 arbitrary constants, we may, by aid of it, pass from the system of matrices above given, to the most general form.
Just as in the preceding case the 8 terms may be found to be
1, p, p^2 will form a closed group. The values of the 9 matrices will
hence there will be a system of Nonions (precisely analogous to the known
system of quaternions) represented by the 9 matrices
\[ u_1^2 + u_2 u_3 + u_3^2 \]
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just as in the preceding case the 8 terms may be found to be
1, p, p^2 will form a closed group. The values of the 9 matrices will
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SYNOPSIS OF THE RECENT SCIENTIFIC JOURNALS

Published here.


The name of Nonius Marcellus is associated with dulness and ignorance, and yet his work De Compendiosa Doctrina is so important that no student of Latin can afford to ignore it. Nonius belonged to Thubursicu in Africa, and has been identified by Mommsen with the Nonius of a Thubursicuan inscription of the year 323 A.D. Very few of his quotations come from any author later than the Augustan age. This remarkable fact is to be explained by a curious reason in favor of the past, which is a notable phenomenon in the history of the later Latin literature. This reason is found in the latter half of the second century B.C., where we find on the pedestal of a statue of a man named Nonius, a tablet inscribed in Latin; and yet the name of Nonius has been preserved so long. This is a direct proof that the name of Nonius has been preserved for us in a living connexion many centuries after its origin.

The ancient Nonius is also of some importance in connection with the modern Nonius. He is the immediate historic precursor of the modern Nonius, and the fact that he has been preserved for us is a notable phenomenon in the history of the later Latin literature. The name of Nonius has been preserved so long for us in a living connexion many centuries after its origin.

In his school encyclopedia called De Compendiosa Doctrina, Nonius ignores Christianity persistently, styles himself a Peripatetic, and justifies us in classing him as a product of the reactionary Roman feeling which meets us again in Macrobius. After this general introduction Professor Net- tleship gives the titles of the twenty books of Nonius, some of which are connected with his romances, reserving a detailed examination of the first book of Nonius for the next number.

Article II.—On the Separation, by a Word or Words, of to in the Infinitive Mood. By Fitzedward Hall.

Our infinitive with to was old dative-gerundial, so that "able to thoroughly bake bread" stands in connexion with "conducive to thoroughly baking bread." In the discussion of this separation of to from the infinitive mood, Dr. Hall criticises the dogmatism of certain writers on English, such as Mr. Richard Taylor and Dean Alford, and shows that so far as the age of the separation is concerned, he has the warrant of Wycliff's conditers and first disciples. Bishop Pecock's Repressor (about 1456) is thickly strewn with expressions like forte first gene, and while Dr. Hall has nothing in point to produce for the next fifty years, he has presented the reader with a catena of examples covering the period from Lord Berners (1525—1525) to Mr. Leslie Stephen and Mr. Mallock. Dr. Hall sees in this usage a legitimate extension of the principle which has given us backside, foretell, and the like, and we are under no necessity of setting up the account of "affection" the choices of locutions like fully appro- priate. Closer notional incompleteness and greater clearness are sufficient justifications in Dr. Hall's judgment, although he does not fail to notice that Dr. Johnson, Lord Blessington, Mr. De Quincey, all voluminous authors, furnish only one example each and thus justly curtail this type.

Article III.—Final as before Sonants in Sanskrit. By Maurice Bloomfield.

"The main purpose of this paper is the explanation of the change of final as into ə. The ə before sonant consonants is not a diphthong; it is long ə, the result of short ə plus the voice of the sonant sibilant, which has fallen out, but has left its traces in the lengthening of the preceding short vowel. Short Indo-European ə is then not entirely dead upon Indian ground any more than short ə. E. ə has been cut off into certain long ə and ə; the euphonic change in a complex ə dhi only in the quality of the short vowel which has pre- ceeded the change; *apos dravati is the immediate historic precursor of apos dravati precisely as it ə is of ə-əə."
Article IV.—The Change of θi into τi in the Oramulum. By F. A. Blackburn.

Mr. Blackburn's study of the Oramulum has led him to the following conclusion: "1. That in the twelfth and thirteenth centuries the two sounds of initial θi were already in existence as they now are, and in the same words. 2. That monosyllable words of pronominal derivation were subject to a weakening and assimilation of the initial θi sound to τ after τ and τ, less often after σ; the result of a kind of inclination and consequent loss of accent. 3. That the extension of this change to all pronominal words in the Oramulum is artificial and the result of the author's desire for regularity; a desire shown also in his grammar, spelling and metre."  


Although scarce a decade has passed since the appearance of Umpf-enbach's edition of Terence, the need of more exhaustive work, with more complete and accurate collations and a sharper discrimination between the three families of Terence MSS., has already made itself felt. So the collation of the Perilus, the leading representative of the pure Caligullian recension, is unsatisfactory to the writer of this paper, and to substantiate his strictures Dr. Warren cites his own readings in some passages of the Andria. After this general statement of the necessity of more careful collations, Dr. Warren considers the MSS. used by Bentley, and endeavors to determine definitely what were the Codices Regii used by that illustrious critic. 8 D XVII is a fragment, the orthography is poor, too corrupt, and there is no evidence of Bentley's having consulted this MS. On the other hand, he does quote from each of the four remaining Regii. Regius 15 A VIII has been followed by Bentley in nine out of twelve passages, in which it is referred to, but in no case has his reading been accepted by recent editors and in four of the most important passages Bentley changed his mind. 15 B VIII is quoted by Bentley in twenty-two passages; in fifteen Bentley based his own reading upon this MS., in six of which, however, he withdrew his own emendation. On the readings of Regius 15 A XI Bentley seems to have set a high value. Regius 15 A XII, which is assigned by the catalogue to the tenth century, is the one most frequently cited by Bentley, and a careful collation of this MS. shows many points of agreement with DG. After thus identifying by actual examination the Codices Regii used by Bentley, Dr. Warren consulted the copy of Terence in which Bentley recorded his MS. collations. One of the oldest MSS. M (Cod. Jo. Mon Episc. Eliensis) has not yet been identified, but as the driedimata, called by Bentley vettorimata, has been brought to light, there is room for hope that M will also be forthcoming. The article closes with some specimens of Bentley's MS. readings.


Article II.—On Substituted Acrylic and Propionitic Acids. By Henry B. Hill.

Article III.—On the Determination of so-called Renvier Phosphoric Acid. By Clifford Richardson.


Article VII.—Protection of a Group containing Two Carbon Atoms. By Ira Remsen and W. A. Noyes.

Article VIII.—On a New Fat Acid. By J. M. Stillman and E. O'Neill.

Article IX.—On the Precipitation of Tilaric Acid. By P. T. Austin and F. A. Wiberg.


The Manufacture of Steel and Ingot Iron from Phosphoric Iron Ore. Notes.

American Journal of Chemistry. Edited by Professor Remsen. Contents of Vol. IV, No. 3.


Article II.—On Substituted Acrylic and Propionitic Acids. By Henry B. Hill.

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Article VIII.—On a New Fat Acid. By J. M. Stillman and E. O'Neill.

Article IX.—On the Precipitation of Titularic Acid. By P. T. Austin and F. A. Wiberg.

Article X.—On the Counter-Pedal Surface of the Ellipsoid. By J. J. Story.


Article XII.—On the Determination of so-called Renvier Phosphoric Acid. By Clifford Richardson.

Article XIII.—On the Precipitation of Tilaric Acid. By P. T. Austin and F. A. Wiberg.


Article XV.—Alhazen's Problem. By Marcus Baker.


Article XVII.—On Mechanical Inversion. By J. J. Sylvester.

Article XVIII.—On certain Metrical Properties of Surfaces. By Thomas Craig.


Article XX.—On the Determination of so-called Renvier Phosphoric Acid. By Clifford Richardson.

Article XXI.—On the Precipitation of Tilaric Acid. By P. T. Austin and F. A. Wiberg.


Article XXIII.—On Mechanical Inversion. By J. J. Sylvester.

Article XXIV.—On the Determination of so-called Renvier Phosphoric Acid. By Clifford Richardson.

Article XXV.—On the Precipitation of Tilaric Acid. By P. T. Austin and F. A. Wiberg.
THE CHESAPEAKE ZOOLOGICAL LABORATORY.

The establishment within the last ten years of marine observatories in Europe and elsewhere, for the study of Zoology, indicates a recognition of the dependence of naturalists upon aids to scientific investigation, similar to the astronomical observatories, equipped with books, instruments, and apparatus, for the prosecution of research, which have long been recognized as essential to advancement in astronomical knowledge.

Since 1872, the marine station at Naples has been organized and opened by Dr. Dohrn; a marine laboratory has been opened at Kiel by the “Association of German Naturalists and Physicians;” two stations have been established in Southern Russia by the “Association of Russian Naturalists;” the University of Vienna has opened a marine laboratory at Trieste under the direction of Prof. Claus; the University of Lille, one at Wimeraux under Prof. Giard; the Sorbonne, one at Roscoff under Prof. Lacaze-Duthiers; and others have been opened by the University of Aberdeen and the University of New South Wales.

In the United States the only opportunities for thorough study of marine zoology upon the thousands of miles of sea coast of the United States have been those afforded by the private laboratory of Mr. Alexander Agassiz at Newport, and that of the United States have been those afforded by the private laboratories in Europe and elsewhere, for the study of Zoology, indicates to show a demand here for facilities like those afforded by the educational institutions in all parts of the country, and seems itself of its facilities includes Instructors and Professors from any educational institution.

This summer a marine zoological station is to be organized on the sea coast of Japan by the University of Tokio, under the direction of Prof. Mitsukuri, a naturalist who has spent two seasons at the Chesapeake Zoological Laboratory.

The Chesapeake Zoological Laboratory of the Johns Hopkins University was opened in 1878, and its fifth session is now in progress. The following list of persons who have availed themselves of its facilities includes Instructors and Professors from educational institutions in all parts of the country, and seems to show a demand here for facilities like those afforded by the marine stations of the Universities of Europe.

ROLL OF MEMBERS OF MARINE LABORATORY, 1878-82.

SESSION OF 1878. (Fort Wool, June 24 to August 21, eight weeks.)

W. K. Brooks, Director.
H. J. Rice, Fellow, J. H. U.
H. Sewall, Assistant in Biology, J. H. U.
C. Shihler, Fellow, J. H. U.
August Schmidt, Teacher of Natural Science, Baltimore.
N. B. Webster, Principal, Military Academy, Norfolk, Va.
T. B. Webster, Teacher, Military Academy, Norfolk, Va.

SESSION OF 1879. (Grisfield and Fort Wool, June 25 to September 15, twelve weeks.)

W. K. Brooks, Director.
B. W. Barton, M. D., Baltimore.
Emil Bessels, M. D., Smithsonian Institute.
E. A. Birge, Professor of Zoology, University of Wisconsin.
S. P. Clarkso, Fellow, J. H. U.
H. C. Evarts, M. D., Philadelphia.
K. Mitsukuri, Fellow, J. H. U.
E. A. Nunn, Professor of Biology, Wellsley College, Mass.
H. J. Rice, Cazenovia, N. Y.
August Schmidt, Teacher of Natural Science, Baltimore.
C. Shihler, Fellow, J. H. U.
E. B. Wilson, Fellow, J. H. U.

SESSION OF 1880. (Beaufort, N. C., April 23 to September 30, twenty-three weeks.)

W. K. Brooks, Director.
H. G. Evans, M. D., Philadelphi.
J. W. King, Professor of Natural Sciences, Wisconsin State Normal School.
K. Mitsukuri, Professor of Zoology, University of Tokio, Japan.
Henry P. Osborn, Fellow, College of New Jersey.
E. B. Wilson, Fellow, J. H. U.

SESSION OF 1881. (Beaufort, N. C., May 1 to September 1, eighteen weeks.)

W. K. Brooks, Director.
E. B. Wilson, Assistant.
S. F. Clarke, Assistant.
Buel P. Colton, Teacher Natural Science, Princeton (Il.) High School.
H. Garman, Assistant, Illinois State Laboratory of Natural History.
J. Playfair McMurrough, Assistant in Biology, University of Toronto.
W. L. Norris, Arlington, Ill.
Fernando Sanford, Prof., Natural Science, Mount Morris College, Ill.
H. Sewall, Associate in Biology, J. H. U.
P. R. Uhler, Associate in Natural History, J. H. U.

SESSION OF 1882. The laboratory was opened for work at Beaufort, N. C., on May 1st, 1882, and will continue in session until the end of September.

W. K. Brooks, Director.
E. B. Wilson, Assistant.
H. W. Conn, J. H. U.
Henry L. Osborn, Fellow, J. H. U.
J. Pillsbury, Principal, Springfield (Mass.) High School.
John M. Tyler, Professor of Zoology, Amherst College.
Francis Winslow, Lieut., U. S. N., Washington, D. C.

PUBLISHED RESULTS OF SCIENTIFIC RESEARCH AT THE MARINE LABORATORY, 1878-82.

W. K. Brooks, Ph. D.:
The Development of Lingula and the Systematic Position of the Brachiopoda. (Scientific Results, Chesapeake Zool. Lab., 1878.)
Du développement de la Lingula et de la position Zoologique des Brachiopodes. (Arch. f. Zool. exp., 1881.)
The Larval Stages of Squilla empusa. (Scientific Results, Chesapeake Zool. Lab., 1879.)
The Artificial Fertilization of Oyster Eggs and the Propagation of the American Oyster. (Am. Jour. of Science, 1879.)
The Development of the American Oyster. (Report of the Maryland Fish Commissioners, and Studies from the Biol. Lab., J. H. U., 1880.)
The Acquisition and Loss of a Food Yolk in Molluscan Eggs. (Studies from the Biol. Lab., J. H. U., 1880; 2 plates.)
The Development of the Cephalopoda and the Morphology of the Cephalopod Foot. (Am. Jour. of Science, 1880.)
The Rhythmic Character of Segmentation. (Am. Jour. of Science, 1880.)
Budding in Free Medusae. (Am. Nat., Sept., 1880.)
Embryology and Metamorphosis of the Scorpioidea. (Zool. Anzeiger, Nov., 1880.)
The Young of the Crustacean Lucifer, A Nauplius. (Am. Nat., Nov., 1880.)
Alternation of Periods of Rest with Periods of Activity in the Vertebrates. (Studies from the Biol. Lab., J. H. U., 1881; 1 plate.)
The First Zoa of Porcellana. (With E. B. Wilson; Studies from the Biol. Lab., J. H. U., 1881; 2 plates.)
List of the Molluscs of Beaufort, N. C. (Studies from the Biol. Lab., J. H. U., 1882.)
Origin of the Eggs of Salpa. (Studies from the Biol. Lab., J. H. U., 1882; 1 plate.)
The Development of Lucifer. (Phil. Trans. Royal Soc. London, 1882; 11 plates.)
Handbook of Invertebrate Zoology. (Boston, Casella, 1882.)
The Metamorphosis of Alpheus. (Univ. Circular, No. 17.)

The Metamorphosis of Peneus. (In press.)

S. F. Clarke, Ph. D.:
New Hydroids from Chesapeake Bay. (Boston Soc. Nat. Hist., 1882.)

H. Garman and B. P. Colton:
Development of Arbacia punctulata. (Studies from the Biol. Lab., J. H. U., 1882.)

J. P. McMurrich:
Origin of the so-called Test Cells in the Ascidian ovum. (Studies from the Biol. Lab., J. H. U., 1882.)

K. Mitsukur:

P. R. Uhler:
List of Animals observed at Fort Wool, Va. (Studies from the Biol. Lab., J. H. U., 1879.)

N. B. Webster:
Partial List of Land Plants at Fort Wool, Va. (Studies from the Biol. Lab., J. H. U., 1879.)

E. B. Wilson, Ph. D.:
The Early Stages of Renilla. (Zool. Anzeiger, in press; Univ. Circular, No. 17.)


A New Species of Pilidium. (Studies from the Biol. Lab., J. H. U., 1882.)


—Also see J. M. Wilson.

H. L. Osborn:
On the Growth of the Shell of the Oyster. (In press.)

—Also see J. M. Wilson.

H. W. Conn:
Development of Tubularia cristata. (Zool. Anzeiger, in press; Univ. Circular, No. 17.)

J. M. Wilson with E. B. Wilson and H. L. Osborn:
Variation in the Segmentation of the Egg of Renilla. (Zool. Anzeiger, in press.)

PRELIMINARY REPORTS OF WORK OF MARINE LABORATORY—MAY-JULY, 1882.

The following extracts from the informal reports of the Director, addressed to the President of the University during the current session, exhibit the character of the work now in progress:

BEAUFORT, JUNE 2, 1882.

Our first month's work this season has been unusually fortunate, and the accomplished results which I have to report would make a good showing as the work of a whole season, instead of a single month. I have never before had so many workers here for the first few weeks, and, as we are now pretty familiar with our fauna and know where to look for things, I have more to tell you than I have ever before had at such an early date. Mr. Conn came with us from Baltimore on May 1st, and undertook for his special work the study of the development, structure, and general zoology of the crabs of Beaufort. The work will occupy him for several seasons, but he has already made satisfactory progress. As the fauna includes a long list of species of crabs, it is very desirable that they should be thoroughly studied, and a history of the metamorphosis of a number of forms will be a very important contribution to general embryology. My special reason for advising him to select this subject, however, is this. The crabs are geologically a comparatively modern group, and, as they are unusually well adapted for preservation as fossils, I know of no group of animals more favorable for tracing the resemblance between the young stages of recent animals and their sub-fossil allies. Mr. Conn's chief aim is to accumulate facts which will ultimately form a basis for this comparison, although this is only one of the important aspects of his subject.

Beside working at the crabs, Mr. Conn has obtained very important results, showing intra-cellular digestion in hydroids. Unicellular animals, such as Amoebæ, draw their solid food directly into the protoplasmic substance of the body before they digest it, while most other animals receive it and digest it in a digestive cavity, which is, in a strict sense, outside the body, before it is assimilated by the growing cells. The division of the animal kingdom into two great groups—Protozoa and Metazoa—rests in great part upon this difference; but, as each cell in the wall of the digestive tract of a Metazoon is homologous with the entire body of a Protozoa, we must, on theoretical grounds, suspect that there exist, or have existed, animals with a digestive cavity, and also with the power of intra-cellular digestion. The manner in which the gap between the Protozoa and the Metazoa has been bridged is a question of the utmost scientific importance, and intra-cellular digestion has recently been demonstrated in several Metazoa embryos: (for instance, by Dr. Wilson, in the Renilla embryo), and it has been satisfactorily shown in two adult Metazoa, a barn worm and a jelly fish.

By feeding specimens of a large hydroid with finely powdered carmine for several days, and then hardening them and staining their bodies into thin microscopic sections, Mr. Conn has obtained beautiful preparations, which show the solid particles of carmine inside the protoplasm of the cells of the digestive tract. He has thus shown, more satisfactorily than it has ever been shown before, the existence of the power of intra-cellular digestion in an animal which also has a true stomach-digestion. Mr. Conn has also obtained results of great interest and importance regarding the embryology of Hydroids. A few years ago, Ciamiciani published a very elaborate and fully illustrated paper on the embryology of Tubularia; but, as his history of the very early stages would, if true, be very difficult to harmonize with certain established generalizations of embryologists, naturalists have given it only a guarded acceptance, and a return to the subject has been very desirable. Mr. Conn has undertaken this, and, although the thorough study of the subject may require several months, he has already shown that Ciamiciani's account rests upon serious errors of observation, and that the development of Tubularia is in many respects different from the development of the Bryozoa. For the last few days Dr. Wilson has been engaged upon an extremely interesting subordinate subject connected with the development of Renilla. He finds that these animals, during the very earliest stage of their life—the period of segmentation—present very considerable individual variation, so that they might be acted upon, and modified by, natural selection even at this time. Nothing of the kind has ever been recorded, except by me in the case of the oyster, although I do not believe that it is very unusual in segmenting eggs. At any rate, it has entirely escaped notice. It is an extremely difficult thing to study, as a single egg must be kept under continuous observation for six or eight hours, and must be accurately drawn at short intervals. Then, in order to show that it is a natural, and not an abnormal egg, it must be kept under observation until it develops into a normal embryo. (See statement of results, p. 247.)

The tax upon Dr. Wilson for the last few days has been so great that I have had to recall a party of my students to his collection, in order to relieve him, and also to secure the examination of a greater number of eggs.

The work of my own work, I have made fair progress in my study of the Medusæ of Beaufort, although I have no particular features to mention, and must wait until the whole is finished.


PROPAGATION OF THE OYSTER.

I have not yet succeeded in doing all that I hoped in oyster propagation, although I feel that my results are of sufficient importance to be a good return for my month's labor. I pointed out four years ago, that as the growth of an animal is limited by the supply of the least abundant of the necessary ingredients of its food, the supply of oysters is in all probability determined by the amount of carbonate of lime available for shell-formation.

I now find that by placing the oyster eggs in a vessel of water, with a good supply of such shells as decompose readily, I can hasten the formation of the shell, and carry the young together in thirty-six hours, instead of the eighty hours which they have ever before been carried in eight days; at the same time the young are much more healthy and vigorous than those reared without a supply of lime.

After the shell is formed, the young oyster can be kept alive for several days, but it gradually starves to death. The only point which now remains for solution, in practical oyster propagation from the egg, is the duration of the same method of rearing the young oysters. I hoped before this date to be able to report this discovery to you, but, while I have so far failed, I feel that the subject demands nothing more than a little patience. The spawning season is now nearly over, and I may make a further attempt in thirty-six hours, but I have a plan of the way to reduce the most critical period in the life of the oyster from eight days to thirty-six hours, is itself of enough value to compensate for the time I have given to the subject.

Dr. Wilson, U. S. Fish Commission, joined our party about two weeks ago. He is a well-known authority in all that relates to the oyster, and he is devoting all his time at present
ABSTRACTS OF RESULTS OF RESEARCHES AT MARINE LABORATORY—MAY-JULY, 1882.

Development of Tubularia cristata, by HERBERT W. CONN.

The Tubularian hydroids have always been considered to present anomalies in their embryology. The great groups of the animal kingdom agree in general quite closely in their early stages of development. The exceptions are few, and are consequently of peculiar interest. The hydroida, as a rule, develop as follows: The egg undergoes a total segmentation, which is usually quite regular, and leads to a morula stage. This morula becomes converted into a two-layered planula by delamination. Tubularia and hydra present exceptions. Allman, who first described Tubularia, noted that in this case no stages of segmentation were reached. According to him, a mass of embryonic tissue becomes separated from the spadix of the gonophore and directly converted into the embryo. This mass is considered as homologous with an egg, or possibly a segmented egg. It is therefore probable that there was an error of some kind in Packard's statement, and as I wish to trace the development of all the hydropians by the natural method, I am now working on this point. In my first paper I described the stages of development, and noted the absence of segmentation. Later, Claparède studied the same, and, while he traced the early stages of segmentation, he left the development in a peculiarly exceptional form. He describes an irregular segmentation which results in an epibolic gastrula. From the fact that an epibolic gastrula occurs in no other hydroid, its presence in this one hydroid form, although Claparède's figure seems very clear, has been open to much doubt and even denial. As nothing definite seemed to be known on the subject, I have worked out the development of Tubularia cristata. I find that while Claparède's figures are partially correct, his conclusions are wholly erroneous. The segmentation is somewhat irregular, but no epibolic gastrula is formed. A solid morula stage is reached, which becomes converted to the regular manubrium layer by delamination into a two-layered planula. The embryology of Tubularia then presents no deviations from the ordinary hydroid type. Its development is quite primitive, perhaps the most primitive of all hydroid forms; its metamorphosis is not complete. It becomes converted into a peculiar actinula form, which shows relationship to both hydroid and medusoid forms. But in its early stages, in its segmentation of germinal layers, it agrees completely with all other hydroids, except hydra.

Abstract of Observations on the Structure and Development of Renilla and Leptogorgia, by EDMUND B. WILSON.

Since the beginning of the present season the eggs of Rennilla have been procured in abundance, and a very complete study of the development has thus been rendered possible. This has brought to light a number of new and interesting points, of which I will mention only one. The eggs of Rennilla are at first free and in the water, but they soon become aggregated on the surface of the shell, from which they obtain the name of Rennilla. The eggs of Leptogorgia, on the other hand, are attached to the shell. The eggs of Rennilla are free and in the water, but they soon become aggregated on the surface of the shell, from which they obtain the name of Rennilla. The eggs of Leptogorgia, on the other hand, are attached to the shell.

The Metamorphosis of Alphea, by W. K. BROOKS.

Our only information on the metamorphosis of this genus is contained in a short paper which was published about a year ago in the American Naturalist, by Dr. Packard. He had an opportunity, several years ago, to study, at Fort Macon, two miles from Beaufort, the eggs and young of Alphea heterochela (Say), and he states that there is no metamorphosis but that the young hatches from the egg in the adult form. Before I received this paper, I had made several drawings of the young stages of a closely related species, Alphea minus (Say), and I found that there is a metamorphosis. In this form the young hatches from the egg in the juvenile form. Before the next moult, which takes place within a few hours, the buds representing the sixth pair of walking legs, but these are not functional but rudimentary, and they are biramous. All the abdominal segments are present, and all the abdominal appendages except the sixth pair are represented by biramous buds. The mandibles are simple, and the eyes are not functional.

After the next moult, which takes place within a few hours, the buds representing the sixth pair of abdominal appendages are present but in other respects the larva is the same as it was before the moult. Within twenty-four hours it mouls again, and then it has the full number of functional appendages, and at first appears to resemble the adult in every respect. The eyes are nearly covered by the carapace, the mandible is bloated and twisted, and the general shape is that of the adult. Careful examination shows, however, that the larva is now a true schizopod, since the three pairs of maxillipeds, and the five pairs of walking legs are all furnished with long, hairy movable swimming exopods.

After the next moult, which takes place within about the same period, the mouth mandibles become rudimentary, although they are still present as buds. In other respects the young now has the characteristics of the genus. After the next moult, the exopods disappear, and the adult form is assumed. The coloring at this period is very different from that of the adult in the previous period, and is very similar to that of Alphea minus. The differences in the claws do not appear until several months later.
RESULTS ACCOMPLISHED IN THE MANUFACTURE AND THEORY OF GRATINGS FOR OPTICAL PURPOSES, A PRELIMINARY NOTICE.

By H. A. ROWLAND.

It is not many years since physicists considered that a spectroscope constructed of a large number of prisms was the best and only instrument for viewing the spectrum, where great power was required. These instruments were large and expensive, so that few physicists could possess them. Professor Young was the first to discover that some of the gratings of Mr. Rutherford showed more than any prism spectroscope which had then been constructed. But all the gratings which had been made up to that time were quite small, say one inch square, whereas the power of a grating in resolving the lines of the spectrum increases with the size. Mr. Rutherford then attempted to make as large gratings as his machine would allow, and produced some which were nearly two inches square, though he was rarely successful above an inch and three-quarters, having about thirty thousand lines. These gratings were on speculum metal and showed more of the spectrum than had ever before been seen, and have, in the hands of Young, Rutherford, Lockyer and others, done much good work for science. Many mechanisms in this country and in France and Germany, have sought to equal Mr. Rutherford's gratings, but without success.

Under these circumstances, I have taken up the subject with the resources at command in the physical laboratory of the Johns Hopkins University.

One of the problems to be solved in making a machine is to make a perfect screw, and this, mechanics of all countries have sought to do for over a hundred years and have failed. On thinking over the matter, I devised a plan whose details I shall soon publish, by which I hoped to make a practically perfect screw, and so important did the problem seem that I immediately set Mr. Schneider, the instrument maker of the university, at work on it. The operation seemed so successful that I immediately designed the remainder of the machine, and have now had the pleasure since Christmas of trying it. The screw is practically perfect, not by accident, but because of the new process for making it, and I have not yet been able to detect an error so great as one one-hundred-thousandth part of an inch at any part. Neither has it any appreciable periodic error. By means of this machine I have been able to make gratings with 45,000 lines to the inch, and have made a ruled surface with 160,000 lines on it, having about 29,000 lines to the inch. The capacity of the machine is to rule a space 6\(\frac{1}{2}\) inches long and 4\(\frac{1}{2}\) inches with any required number of lines to the inch, the number only being limited by the wear of the diamond. The machine can be set to almost any number of lines to the inch, but I have not hitherto attempted more than 45,000 lines to the inch. It ruled so perfectly at this figure that I see no reason to doubt that at least two or three times that number might be ruled in one inch, though it would be useless for making gratings.

All gratings hitherto made have been ruled on flat surfaces. Such gratings require a pair of telescopes for viewing the spectrum; these telescopes interfere with many experiments, absorbing the extremities of the spectrum strongly; besides, two telescopes of sufficient size to use with six inch gratings would be very expensive and clumsy affairs. In thinking over what would happen were the grating ruled on a surface not flat, I thought of a new method of attacking the problem, and soon found that if the lines were ruled on a spherical surface the spectrum would be brought to a focus without any telescope. This discovery of concave gratings is important for many physical investigations, such as the photographing of the spectrum both in the ultra-violet and the ultra-red, the determination of the heating effect of the different rays, and the determination of the relative wave lengths of the lines of the spectrum. Furthermore it reduces the spectroscope to its simplest proportions, so that spectrosopes of the highest power may be made at a cost which can place them in the hands of all observers. With one of my new concave gratings I have been able to detect double lines in the spectrum which were never before detected.

The laws of the concave grating are very beautiful on account of their simplicity, especially in the case where it will be used most. Draw the radius of curvature of the mirror to the center of the mirror, and from its central point with a radius equal to half the radius of curvature draw a circle; this circle thus passes through the center of curvature of the mirror and touches the mirror at its center. Now if the source of light is anywhere in this circle, the image of this source and the different orders of the spectra are all brought to focus on this circle. The word focus is hardly applicable to the case, however, for if the source of light is a point the light is not brought to a single point on the circle but is drawn out into a straight line with its length parallel to the axis of the circle. As the object is to see lines in the spectrum only, this fact is of little consequence provided the slit which is the source of light is parallel to the axis of the circle. Indeed it adds to the beauty of the spectra, as the horizontal lines due to dust in the slit are never present, as the dust has a different focal length from the lines of the spectrum. This action of the concave grating, however, somewhat impairs the light, especially of the higher orders, but the introduction of a cylindrical lens greatly obviates this inconvenience.

The beautiful simplicity of the fact that the line of focus of the different orders of the spectra are on the circle described above leads immediately to a mechanical contrivance by which we can move from one spectrum to the next and yet have the apparatus always in focus; for we only have to attach the slit, the eye-piece and the grating to three arms of equal length, which are pivoted together at their other ends and the conditions are satisfied. However we move the three arms the spectra are always in focus. The most interesting case of this contrivance is when the bars carrying the eye-piece and grating are attached and end thus forming a diameter of the circle with the eye-piece at the centre of curvature of the mirror, and the rod carrying the slit alone movable. In this case the spectrum as viewed by the eye-piece is normal, and when a micrometer is used the value of a division of its head in wave lengths does not depend on the position of the slit, but is simply proportional to the order of the spectrum, so that it need be determined once only. Furthermore, if the eye-piece is replaced by a photographic camera the photographic spectrum is a normal one. The mechanical means of keeping the focus is especially important when investigating the ultra-violet and ultra-red portions of the solar spectrum.

Another important property of the concave grating is that all the superimposed spectra are in exactly the same focus. When viewing such superimposed spectra it is a most beautiful sight to see the lines appear colored on a nearly white ground. By micrometric measurement of such superimposed spectra we have a most beautiful method of determining the relative wave lengths of the different portions of the spectrum, which far exceeds in accuracy any other method yet devised. In working in the ultra-violet or ultra-red portions of the spectrum we can also focus on the superimposed spectrum and so get the focus for the portion experimented on.

The fact that the light has to pass through no glass in the concave grating makes it important in the examination of the extremities of the spectrum where the glass might absorb very much.

There is one important research in which the concave grating in its present form does not seem to be of much use, and that is in the examination of the solar protuberances; an instrument can only be used for this purpose in which the dust in the slit and the lines of the spectrum are in focus at once. It might be possible to introduce a cylindrical lens in such a way as to obviate this difficulty. But for other work on the sun the concave grating will be found very useful. But its principal use will be to get the relative wave lengths of the lines of the spectrum, and so to map the spectrum; to divide lines of the spectrum which are very near together, and so to see as much as possible of the spectrum; to photograph the spectrum so that it shall be normal; to investigate the portions of the spectrum beyond the range of vision; and lastly to put in the hands of any physicist at a moderate cost such a powerful instrument as could only hitherto be purchased by wealthy individuals or institutions.

To give further information of what can be done in the way of gratings I will state the following particulars:

The dividing engine can rule a space 6\(\frac{1}{2}\) inches long and 4\(\frac{1}{2}\) inches wide. The lines, which can be 4\(\frac{1}{2}\) inches long, do not depart from a
straight line so much as \( \frac{1}{400} \) inch, and the carriage moves forward in an equally straight line. The screw is practically perfect and has been tested to \( \frac{1}{400} \) inch without showing error. Neither does it have any appreciable periodic error, and the periodic error due to the mounting and graduated head can be entirely eliminated by a suitable attachment.

For showing the production of ghosts by a periodic error, such an error can be introduced to any reasonable amount. Every grating made by the machine is a good one, dividing the 1,474 line with ease, but some are better than others. Rutherford's machine only made one in every four good, and only one in a long time which might be called first-class. One division of the head of the screw makes 14,438 lines to the inch. Any fraction of this number in which the numerator is not greater than say 20 or 30 can be ruled. Some exact numbers to the millimetre, such as 400, 800, 1200, etc., can also be ruled. For the finest definition either 14,438 or 28,876 lines to the inch are recommended, the first for ordinary use and the second for examining the extremities of the spectrum. Extremely brilliant gratings have been made with 43,814 lines to the inch, and there is little difficulty in ruling more if desired. The following show some results obtained:

- Flat grating, 1 inch square, 43,000 lines to the inch. Divides the 1,474 line in the first spectrum.
- Flat grating, 2 X 3 inches, 14,438 lines to the inch, total 43,814. Divides 1,474 in the first spectrum, the E line (Ångström 5,209.4) in the second and is good in the fourth and even fifth spectrum.
- Flat grating, 2 X 3 inches, 1,200 lines to one millimetre. Shows very many more lines in the B and A groups than were ever before seen.
- Flat grating, 2 X 2 inches, 14,438 lines to the inch. This has most wonderful brilliancy in one of the first spectra, so that I have seen the 2 line, wave length 8,240, (see Abney's map of the ultra-red region), and determined its wave length roughly, and have seen much further below the A line than the B line is above the A line. The same may be said of the violet end of the spectrum. But such gratings are only obtained by accident.

- Concave grating, 2 X 3 inches, 14,438 lines to the inch, radius of curvature 7 feet. Divides the 1,474 line in the first spectrum, the E line in the second, and is good in the third or fourth.
- Concave grating, 3 X 5 inches, 17 feet radius of curvature, 28,876 lines to the inch, and thus nearly 100,000 lines in all. This shows more in the first spectrum than was ever seen before. Divides 1,474 and E very widely and shows the stronger component of Ångström 5,275 double. Second spectrum not tried.
- Concave grating, 4 X 6 inches, 3,610 lines to the inch, radius of curvature 5 feet 4 inches. This grating was made for Professor Langley's experiments on the ultra-red portion of the spectrum, and was thus made very bright in the first spectrum. The definition seems to be very fine notwithstanding the short focus and divides the 1,474 line with ease. But it is difficult to rule so concave a grating as the diamond marks differently on the different parts of the plate. These give illustrations of the results accomplished, but of course many other experiments have been made. I have not yet been able to decide whether the definition of the concave grating fully comes up to that of a flat grating, but it evidently does so very nearly.

Baltimore, May 25, 1882.

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**LETTER OF CHARLES DARWIN.——ANIMAL MIMICKRY.**

The death of Charles Darwin has awakened so much interest in his personal character, as well as in his scientific attainments, that the following letter which he recently addressed to one of the workers in zoology in this university, is here printed as an excellent illustration of the qualities which were characteristic of the departed naturalist.

The letter was written in reply to a description, sent Mr. Darwin, of a mollusk which closely resembled in color and form the sea-weed upon which it habitually lives. This sea-weed is the well known *Scorposum*, or Gulf-weed, which is found floating at the surface of the sea, sometimes several lines to the inch, and there is little difficulty in ruling more if desired. The following show some results obtained:

- Flat grating, 1 inch square, 43,000 lines to the inch. Divides the 1,474 line in the first spectrum.
- Flat grating, 2 X 3 inches, 14,438 lines to the inch, total 43,814. Divides 1,474 in the first spectrum, the E line (Ångström 5,209.4) in the second and is good in the fourth and even fifth spectrum.
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- Concave grating, 4 X 6 inches, 3,610 lines to the inch, radius of curvature 5 feet 4 inches. This grating was made for Professor Langley's experiments on the ultra-red portion of the spectrum, and was thus made very bright in the first spectrum. The definition seems to be very fine notwithstanding the short focus and divides the 1,474 line with ease. But it is difficult to rule so concave a grating as the diamond marks differently on the different parts of the plate. These give illustrations of the results accomplished, but of course many other experiments have been made. I have not yet been able to decide whether the definition of the concave grating fully comes up to that of a flat grating, but it evidently does so very nearly.

Baltimore, May 25, 1882.

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**BRIEF NOTICES.**

**LETTER OF CHARLES DARWIN.**

The death of Charles Darwin has awakened so much interest in his personal character, as well as in his scientific attainments, that the following letter which he recently addressed to one of the workers in zoology in this university, is here printed as an excellent illustration of the qualities which were characteristic of the departed naturalist.

The letter was written in reply to a description, sent Mr. Darwin, of a mollusk which closely resembled in color and form the sea-weed upon which it habitually lives. This sea-weed is the well known *Sargassum*, or Gulf-weed, which is found floating at the surface of the sea, sometimes in immense quantity. It has long, narrow, leaflike fronds of a peculiar form, with serrated margins, and is of an olive or reddish brown color, with darker blotches and spots.

The mollusk, which is somewhat like a common garden slug, is provided with three pairs of appendages which exactly resemble in form and color the fronds of the *Sargassum*. The body is also colored like the sea-weed and the whole animal is so similar in appearance to the plant on which it lives as almost to defy detection.

This resemblance is an instance of what is called "protective mimicry," many cases of which have been noted in other groups of animals. The mimicry is "protective" because the organism which "mimics" the other is concealed from view, and thus protected from the attacks of enemies. Thus in the present case the mollusk is not distinguished from the plant by fish or other predatory animals, is therefore passed by, and escapes destruction. Some idea of the perfection of the resemblance may be gained from the fact that the mollusks escaped discovery for several hours during which the *Sargassum* was kept in a large, clear glass jar in the laboratory and examined several times in the presence of other animals.

The phenomena of mimicry are of interest on account of their clear illustration of the action of natural selection. Obviously there must be a tendency toward the survival of those individuals which are most effectually hidden—that is, those which most nearly resemble the objects with which they are constantly associated—while other individuals will tend to be weeded out. From this tendency has very commonly resulted general resemblances between organisms and their environments, such as the prevailing white color of arctic animals or the tawny colors of desert animals; and now and then have arisen resemblances so special and detailed as to merit the name of mimicry.

**DOWN, BERKSHIRE, KENT, DEC. 21, 1881.**

*Dear Sir:*—I thank you much for having taken so much trouble in describing fully your interesting and curious case of mimicry. I am in the habit of looking through many scientific journals, and though my memory is now not nearly so good as it was, I feel pretty sure that no such case as yours has been described amongst the nudibranch molluscs.

You perhaps know the case of a fish allied to *Hippocampus* (described some years ago by Dr. Günther in Proc. Zool. Soc.) which clings by its tail to sea-weeds, and is covered with waving filaments so as itself to look like a piece of the same sea-weed. The parallelism between your and Dr. Günther's case makes both of them the more interesting, considering how far a fish and molluse stand apart. It would be difficult for anyone to explain such cases by the direct action of the environment.

I am glad that you intend to make further observations on this mollusc, and I hope that you will give a figure, and if possible a colored figure.

With all good wishes from an old brother naturalist, I remain, dear sir,

Yours faithfully,

(Signed,) CHARLES DARWIN.
PUBLIC LECTURES.

Among the arrangements for public lectures in the Johns Hopkins University for the coming year are the following:

Professor James A. Harrison, of Washington and Lee University, will deliver a course on Anglo Saxon Poetry. He is well known as the author of several volumes: "A Group of Poets," "Spain," etc.

William H. Carpenter, Ph. D., will give a course of lectures on the Eddas. His schedule includes the following topics: Old Norse literature; Iceland; the ancient literature of the Scandinavian North; the elder Edda; the younger Edda; other poetical literature; the Sagas; Old Norse historical literature; other prose literature.

Richard T. Ely, Ph. D., will give a course on French and German Socialism.

AMERICAN CHEMICAL JOURNAL.

At a general meeting of the German Chemical Society, December 17, 1881, Dr. A. W. Hofmann, Vice-President of the Society, spoke of the falling off in the number of original communications to the Society, as follows:

"On the other hand, the Society notes a falling off in original communications in comparison with former years, as the following figures show:

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<th>Year</th>
<th>Communications</th>
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<td>1878</td>
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This loss may mainly be referred to two causes. In the first place, a new chemical periodical, The American Chemical Journal, has been founded in America, which offers to chemists on that side of the Atlantic a prompt and convenient medium of publication; and thus many papers which formerly were sent directly to the Berichte, now reach it only at second-hand. Of late, chemical research in America has increased to a very gratifying extent; and we may state with confidence that from twenty to thirty original papers have been lost to the Society from the cause above indicated."

MARYE MINERALOGICAL COLLECTION.

"This University is much indebted to Mr. George T. Marye, Jr., of San Francisco, for the effective interest which he is taking in its welfare and means of usefulness. Mr. Marye has declared his intention to provide the University with the most complete and representative collection, which can be obtained, of the mineral resources of the whole Pacific Coast. He is now very actively engaged in carrying out this purpose, and has already forwarded a large number of fine specimens, collected from Alaska, Oregon, Idaho, Wyoming, California, Nevada, New Mexico, Arizona, and Mexico. These specimens, for the most part, the occurrence and associations of gold, silver, mercury, copper, and native sulphur."—Extract from a report of Dr. H. N. Morse on the Courses in Mineralogy.

ANNOUNCEMENT AS TO ADDITIONAL MINOR COURSE.

The additional minor course to be hereafter required of all under-graduate students (see page 35 of University Register, 1881-'82) may be made up as follows:

1. Ethics and Psychology. Lectures and class exercises. One hour a week through the year.
2. History. Introductory course, embracing lectures on Oriental History and exercises in Classical and early European History. Two hours a week through the year.
3. English. Course in modern English Prose, including exercises in grammar and style, lectures on the art of expression, and outlines of the History of English Literature. Two hours a week through the year.

Total, five hours weekly.

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