PROCEEDINGS

OF THE

ROYAL IRISH ACADEMY

VOLUME XXIV

DUBLIN

PUBLISHED AT THE ACADEMY HOUSE, 19, DAWSON STREET

SOLD ALSO BY

HODGES, FIGGIS, & CO., LIMITED, 104, GRAFTON STREET

AND BY WILLIAMS & NORGATE, LONDON, EDINBURGH, AND OXFORD

1902–1904

35-132722—July 4

The Academy *desire it to be understood that they are not answerable for any opinion, representation of facts, or train of reasoning that may appear in any of the following Papers. The Authors of the several Essays are alone responsible for their contents.*

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SECTION A.—MATHEMATICAL, ASTRONOMICAL, AND PHYSICAL SCIENCE

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SECTION A.—MATHEMATICAL, ASTRONOMICAL, AND PHYSICAL SCIENCE

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DATES OF PUBLICATION

PART	1.	Pages	1	to	46.	August, 1902.
,,	2.	,,	47	,,	58.	April, 1903.
,,	3.	,,	59	,,	68.	September, 1903.
,,	4.	,,	69	,,	84.	January, 1904.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

PAPERS READ BEFORE THE ACADEMY.

I.

ON THE CREEPING OF LIQUIDS AND ON THE SURFACE TENSION OF MIXTURES.

By FREDERICK T. TROUTON, D.Sc., F.R.S.

[Read June 10, 1901.]

Certain liquids, as is well known, when left in the open air, will creep up over the sides of the containing vessel and escape. Ordinary commercial paraffin is a liquid which creeps in this way to a remarkable extent. The phenomenon is well known in connexion with domestic lamps, often producing inconvenient results.

The effect is readily observed by standing a beaker full of ordinary paraffin on paper in the open air, when in a few days a considerable quantity of the liquid will be seen to have crept out on to the paper.

Experiments were undertaken with the view of investigating the conditions necessary for this creeping to occur, and the conclusions ultimately arrived at from these may be summed up in the statement that *in order that a liquid should creep it must be a mixture, and the surface tension of this mixture must be less than that of its least volatile constituent.*

A simple form of experiment, to compare the creeping tendencies of different liquids, may be arranged as follows. A long metal strip is made to stand up in a beaker, by suitably forming its end into a base (fig. 1). The upper end of the strip is bent over and touches the interior of another vessel. The liquid is placed in the beaker and creeps over, and is collected in the second vessel. The phenomenon divides itself naturally into two parts: (1) The initial stage, while the liquid is forming a layer over the surface of the strips; and (2) when the continuous transport of liquid across to the second vessel takes place. Passing by for the present the initial stage, it will abundantly appear from what follows that a mixture is necessary for continuous creeping.

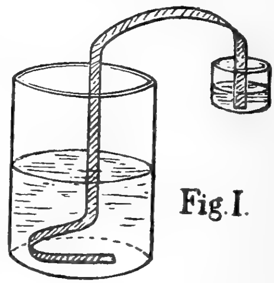

Fig.I.

Fig. 1.

Though many attempts were made, no pure liquid could be found which would creep. Various mixtures, however, were found which did so actively. For instance, a pure paraffin (or rather what was sold as such) did not creep, but the addition of a small quantity of a lighter paraffin enabled it to do so actively. Again, ordinary paraffin, which is, as is well known, a mixture of a number of different members of the paraffin series, when left in the open air, loses much of its lighter constituents and at the same time it is found to lose its power of creeping in a like proportion. The power of creeping may be restored by the addition now of a small quantity of a lighter oil. Thus a liquid which has once crept over will not creep again nearly so actively, if at all. If the surface-tension of the portion of liquid which has crept over and been collected in the experiment described above be determined, it will be found to be always greater than that of the original liquid, and it also naturally consists of the less volatile constituents of the mixture. This suggests that evaporation, in conjunction with change in surface tension, plays an important rôle in the phenomenon of creeping. This is easily verified by covering the whole arrangement with a bell-jar. Evaporation being thus prevented, creeping ceases likewise.

We now can see where the energy comes from to enable liquid, as shown in fig. 1, to be *continuously* elevated and carried into the upper vessel. Evaporation of the liquid lowers the temperature, and in consequence energy can be obtained from the environments. The effect is brought about, it must be observed, through the loss into the surrounding atmosphere of the more volatile portions of the liquid, and the process is consequently an irreversible one. The condition necessary to enable this influx of energy to produce a directed effect of the kind required is that the surface-tension of the liquid remaining after the loss of the more volatile constituents shall be greater than before. In this way, as the liquid passes along the strip, its surface tension increases, and more liquid is enabled to be drawn up and ultimately to pass over.[1]

In accordance with this view of the phenomenon, the creeping activity of paraffin should be increased by the addition of any liquid which is more volatile and which has a lower surface tension. The addition of benzoline, ether, and of a number of other liquids, was found to increase the rate of creeping immensely.

On the other hand, the addition of a more volatile liquid, with a higher surface-tension, which, on mixing with the paraffin, increases its surface-tension, should tend to prevent creeping. Various liquids, such as benzene and chloroform, which are more volatile, but have a higher surface-tension, were tried with this view. These were found, however, not to prevent, but to actually increase, the creeping activity.

On account of these unexpected results, experiments were made with the object of ascertaining the effect produced on the surface-tension of paraffin by the addition of these liquids, and afterward experiments were made with mixtures of various liquids to investigate the law of the surface-tension of mixtures in general.[2]

The curve in fig. 2 exhibits the determinations made of the surface-tension of mixtures of paraffin and chloroform; and on examining the curve, the reason becomes obvious why the addition of chloroform does not prevent but rather facilitates the creeping of paraffin, for the value of the surface-tension is there seen to be diminished by the addition of small quantities of chloroform. The like was found to hold good for benzene.

Mixtures, then, of various liquids were examined, and it was invariably found that the surface-tension of a given mixture was

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[1] A single liquid might conceivably creep through a similar gradient in surface-tension, brought about by the cooling due to evaporation alone increasing the surface tension.

[2] Since then the author has had the opportunity, through the courtesy of Prof. W. Ramsay, of consulting a hitherto unpublished paper of his on the surface-tension of mixtures of liquids.

less than would be calculated from the percentage present in the mixture, on the supposition that the surface-tension was proportional to the composition. The following liquids were used:—benzene, chloroform, turpentine, paraffin, alcohol, benzolene, and ether. These were examined, two and two, in nearly all those cases where mutual

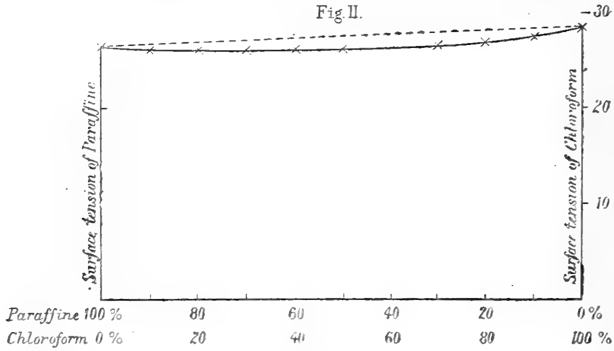

FIG. 2.

solution occurs. In addition, water and alcohol, water and glycerine, aniline and chloroform, olive oil and benzene, were examined, all with like results.

The curve shown, as in fig. 3, typically exhibits the results obtained in general for mixtures of liquids. The dotted line gives the value the surface-tension would have for all percentage-mixtures if the surface-tension were proportional to the composition. The ordinates to the full line represent the observed values.

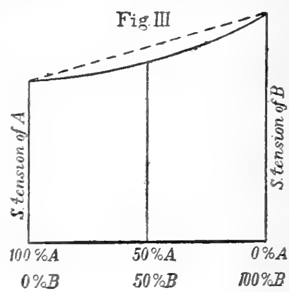

FIG. 3.

When the surface-tensions of the pure liquids are the same or not very different from each other, the surface-tension of mixtures in all or in some proportions may be less than either of the given substances.

The depression of the surface-tension of mixtures of liquids below the calculated value seems to be but a particular case of a general principle which underlies the character of the effect produced on physical properties by admixture or solution, and which ranges from things so far asunder as melting points and electrical conductivities.

No simple relation, however, could be found connecting the depression with the properties of the pure substances. In some few cases, it should be remarked, it was found that the effect of one substance on another was roughly in inverse proportion to their molecular weights. Thus, the depression produced on the surface-tension of chloroform below the calculated value by the addition of small quantities of alcohol is at the rate of about 1·7 for each percentage added, while the corresponding depression produced by chloroform on alcohol is only about ·7. These are in the ratio of about 2·4, which is also nearly the ratio of their molecular weights, $59{\cdot}5/23 = 2{\cdot}5$. The effects produced are, in this case at all events, simply proportional to the number of molecules added, and the failure in general to find similar relationships holding with other liquids may perhaps be due to the masking of the effect through molecular association.

A number of experiments have been made to ascertain if there is any specific effect produced by the kind of material over which the creeping takes place : this both in the initial stages and for continuous creeping. No consistent quantitative results have been so far reached. This is probably to be attributed to the difficulty of presenting clean and unaltered surfaces for the liquids to creep over. The experiments, however, undoubtedly point to a decided difference between different metals, both in the rate the creeping goes on at in the continuous stage, as well as in the initial stage.

That the latter should be the case is not surprising, but it is not easy to see how the kind of material the surface is made of can have effect once the layer of liquid has become established, for its thickness is found to be great compared to molecular distances.

It is possible, however, that the effect may be wholly due to specific roughness or corrugosity incident or natural to surfaces prepared from different materials, for the state of roughness of a given metal is found to have a great influence on the effect.

Attraction between the solid and liquid is a necessary condition for creeping to occur at all; thus, that the rate the liquid in the first instance establishes the layer should be dependant upon the material over which the creeping occurs, is not surprising.

II.

INTEGRALS DEPENDING ON A SINGLE QUATERNION VARIABLE.

By CHARLES JASPER JOLY, M.A., D. Sc., F.T.C.D., Royal Astronomer of Ireland, and Andrews' Professor of Astronomy in the University of Dublin.

[Read April 28, 1902.]

TABLE OF CONTENTS.

Introduction.

In the "Lectures on Quaternions," Hamilton devotes a brief series of Articles (625–630) to the investigation of quaternion integrals. It does not seem to have been observed that his results lead directly to the fundamental theorems of Green and Stokes and to the extensions of these theorems due to Tait and proved by him and other writers in various ways. Indeed, Hamilton regards the subject as one of great difficulty and dismisses it rather abruptly; but his method is of wide scope and merits further developments.

I propose therefore to sketch some of the consequences of Hamilton's method in relation to quaternion integrals depending on a single quaternion variable, and from certain general results I shall deduce as particular cases the extensions of the theorems of Stokes and Green. It is not my object to furnish short proofs of these theorems; they can be readily supplied from the results of this Paper by substituting from the commencement vectors instead of quaternions and by integrating round closed curves or over closed surfaces.

In the concluding articles it is shown that the quaternion integrals are capable of physical applications, and the more concrete character of these articles may assist in forming a clearer conception of the nature of the general integrals considered in the earlier portion.

As the integrals discussed in this Paper depend essentially on the combinatorial functions which I have called *quaternion arrays* (Trans. R.I.A., vol. xxxii., p. 17), it may be useful to recapitulate the formulæ which we shall require. (Compare "Elements of Quaternions," Art. 365 (6)). If a, b, c and d are any quaternions, the arrays are

$$(ab) = \mathrm{V}b\,\mathrm{S}a - \mathrm{V}a\,\mathrm{S}b\,; \quad [ab] = \mathrm{V}\cdot\mathrm{V}a\,\mathrm{V}b\,; \quad (abc) = \mathrm{S}a[bc]\,;$$

$$[abc] = (abc) - [bc]\,\mathrm{S}a - [ca]\,\mathrm{S}b - [ab]\,\mathrm{S}c$$

and

$$(abcd) = \mathrm{S}a[bcd].$$

Transposition of contiguous symbols changes the sign of an array, and an array vanishes if its constituents are linearly connected. Also for any fifth quaternion e,

$$a(bcde) + b(cdea) + c(deab) + d(eabc) + e(abcd) = 0$$

and

$$e(abcd) = [bcd]\,\mathrm{S}ae - [acd]\,\mathrm{S}be + [abd]\,\mathrm{S}ce - [abc]\,\mathrm{S}de.$$

Art. 1.—If $F(q, r)$ is any function of two quaternions, distributive with respect to the second, so that

$$F(q, r + s) = F(q, r) + F(q, s)\,, \tag{1}$$

the integral considered by Hamilton is

$$Q = \int_{q_0}^{q_1} F(q, \mathrm{d}q), \tag{2}$$

in which the variable quaternion q changes by a determinate *mode of passage* from one fixed limit q_0 to the other q_1. He supposes the mode of passage to undergo a slight variation while the limits remain fixed, and he denotes the corresponding variation in the integral by

$$\delta Q = \delta \int_{q_0}^{q_1} F(q, \mathrm{d}q) = \int_{q_0}^{q_1} \delta F(q, \mathrm{d}q). \tag{3}$$

Now

$$\delta F(q, \mathrm{d}q) = \delta_q F(q, \mathrm{d}q) + F(q, \delta \mathrm{d}q) \tag{4}$$

in which δ_q is a symbol of partial differentiation and relates to q alone and not to δq. Similarly

$$\mathrm{d} F(q, \delta q) = \mathrm{d}_q F(q, \delta q) + F(q, \mathrm{d}\delta q), \tag{5}$$

and because the differentials $\mathrm{d}q$ and δq are independent

$$\delta \mathrm{d}q = \mathrm{d}\delta q. \tag{6}$$

Therefore, subtracting (5) from (4) we find

$$\delta F(q, \mathrm{d}q) - \mathrm{d}F(q, \delta q) = \delta_q F(q, \mathrm{d}q) - \mathrm{d}_q F(q, \delta q), \tag{7}$$

and when we integrate this between the fixed limits we obtain Hamilton's result

$$\delta Q = \int_{q_0}^{q_1} \{\delta_q F(q, \mathrm{d}q) - \mathrm{d}_q F(q, \delta q)\}, \tag{8}$$

because δq vanishes at the limits.

Art. 2.—Hamilton contents himself with observing that the elements of the integral (8) do not generally vanish, and therefore the value of the integral (2) depends in general on the mode of passage. We shall suppose that it is possible to pass by continuous variation of the mode of passage from one given mode to another without the introduction of infinite terms. In this case we shall have the integral $Q_{\prime}$ for the second mode connected with the integral Q for the first by the relation

$$Q_{\prime} = Q + \int \delta Q = Q + \iint_{q_0}^{q_1} \{\delta_q F(q, dq) - d_q F(q, \delta q)\}. \quad (9)$$

The limits of the double integral are fixed and prescribed by the modes of passage for the single integrals; and if the single integrals are single-valued (their modes of passage being given) the value of the double integral is independent of the manner in which the variation has been performed: in other words, the double integral is independent of its mode of passage, provided always that no infinite terms arise. More generally even if the single integrals are multiple-valued, the double integral is independent of its mode of passage provided that mode is included in a determinate domain.

Art. 3.—Introducing a quaternion operator D, analogous to ∇, which operates on q alone, we may write symbolically

$$\delta_q = \mathrm{S}\,\delta q\,\mathrm{D}, \qquad d_q = \mathrm{S}\,dq\,\mathrm{D}; \quad (10)$$

and therefore we may may replace (9) by

$$Q_{\prime} = Q + \iint F(q, dq\,\mathrm{S}\,\delta q\,\mathrm{D} - \delta q\,\mathrm{S}\,dq\,\mathrm{D}), \quad (11)$$

in which we repeat D operates on q alone. It will be noticed that

$$dq\,\mathrm{S}\,\delta q\,\mathrm{D} - dq\,\mathrm{S}\,dq\,\mathrm{D}$$

vanishes for $\delta q = dq$ and is consequently expressible in terms of the arrays[1]

$$(dq\,\delta q) = \delta q\,\mathrm{S}\,dq - dq\,\mathrm{S}\,\delta q \quad \text{and} \quad [dq\,\delta q] = \mathrm{V}\mathrm{V}\,dq\,\mathrm{V}\,\delta q. \quad (12)$$

In fact

$$dq\,\mathrm{S}\,\delta q\mathrm{D} - \delta q\,\mathrm{S}\,dq\mathrm{D} = -(dq\delta q)\mathrm{SD} + \mathrm{SVD}(dq\delta q) - \mathrm{VVD}[dq\delta q], \quad (13)$$

and in order that the integral (2) should be independent of the mode of passage we must have

$$-F(q, \beta - \alpha)\,\mathrm{SD} + F(q, \mathrm{SD}(\beta - \alpha)) - F(q, \mathrm{VVD}\,\mathrm{V}\alpha\beta) = 0 \quad (14)$$

for all constant vectors α and β as we see by replacing the *vectors*

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[1] Trans. R.I.A., vol. xxxii., p. 17.

$(\mathrm{d}q, \delta q)$ and $[\mathrm{d}q, \delta q]$ by $\beta - \alpha$ and $V\alpha\beta$ respectively. (Compare *Trans. R.I.A.*, xxxii., p. 5.) It is easy to see that the terms in $\beta - \alpha$ and $V\alpha\beta$ in (14) must vanish separately, so we may replace this condition by the pair

$$SD \cdot F(q, \gamma) - S\gamma D \cdot F(q, 1) = 0, \qquad F(q, V\gamma VD) = 0, \quad (15)$$

in which γ is any constant vector.

In particular if we write $q = t + \rho$ so that D becomes

$$D = \frac{\partial}{\partial t} - \nabla \quad (16)$$

the conditions for an exact differential are

$$\frac{\partial}{\partial t} F(q, \gamma) + S\gamma\nabla \cdot F(q, 1) = 0, \qquad F(q, V\gamma\nabla) = 0; \quad (17)$$

and for a scalar integral, or if $F(q, \mathrm{d}q) = Sp\,\mathrm{d}q$, the conditions reduce at once to

$$\frac{\partial}{\partial t} Vp + \nabla Sp = 0, \qquad V\nabla Vp = 0 \quad (18)$$

Art. 4.—When the variable is a vector ρ, equations (2) and (11) become

$$Q = \int_{\rho_0}^{\rho_1} F(\rho, \mathrm{d}\rho); \qquad Q_{,} = Q + \iint F(\rho, V\nabla V\,\mathrm{d}\rho\,\delta\rho) \quad (19)$$

because on replacing q by ρ and D by $-\nabla$ we have

$$\mathrm{d}q S\delta q D - \delta q S \mathrm{d}q D = -\mathrm{d}\rho S\delta\rho\nabla + \delta\rho S\mathrm{d}\rho\nabla = V\nabla V\mathrm{d}\rho\delta\rho.$$

The double integral is consequently taken over the surface generated by the motion of the path of integration from the first to the second mode of passage or path of integration.

For a closed circuit

$$Q = \int F(\rho, \mathrm{d}\rho) = -\iint F(\rho, V\nabla V\mathrm{d}\rho\delta\rho); \quad (20)$$

and for a scalar integral we have Stokes's theorem

$$Q = \int S\sigma\,\mathrm{d}\rho = -\iint S\sigma V\nabla V\,\mathrm{d}\rho\,\delta\rho = \iint SV\nabla\sigma V\,\mathrm{d}\rho\,\delta\rho. \quad (21)$$

Art. 5.—The results of Art. 2 may be extended to a class of integrals not considered by Hamilton,

$$Q = \iint F(q, \mathrm{d}q, \mathrm{d}'q) \quad (22)$$

in which the limits are fixed while $F(q, \mathrm{d}q, \mathrm{d}'q)$ is distributive with respect to the two independent differentials $\mathrm{d}q$ and $\mathrm{d}'q$ and satisfies the general condition [1]

$$F(q, r, s) + F(q, s, r) = 0. \tag{23}$$

The limits being fixed, a variation of the two-spread mode of passage gives

$$\delta Q = \iint \delta F(q, \mathrm{d}q, \mathrm{d}'q); \tag{24}$$

and writing as before (4)

$$\begin{aligned} \delta F(q, \mathrm{d}q, \mathrm{d}'q) &= \delta_q F(q, \mathrm{d}q, \mathrm{d}'q) + F(q, \delta\mathrm{d}q, \mathrm{d}'q) + F(q, \mathrm{d}q, \delta\mathrm{d}'q) \\ \mathrm{d}F(q, \mathrm{d}'q, \delta q) &= \mathrm{d}_q F(q, \mathrm{d}'q, \delta q) + F(q, \mathrm{d}\mathrm{d}'q, \delta q) + F(q, \mathrm{d}'q, \mathrm{d}\delta q) \\ \mathrm{d}'F(q, \delta q, \mathrm{d}q) &= \mathrm{d}'_q F(q, \delta q, \mathrm{d}q) + F(q, \mathrm{d}'\delta q, \mathrm{d}q) + F(q, \delta q, \mathrm{d}'\mathrm{d}q) \end{aligned} \tag{25}$$

we find on addition by (6) and (23),

$$\begin{aligned} &\delta F(q, \mathrm{d}q, \mathrm{d}'q) + \mathrm{d}F(q, \mathrm{d}'q, \delta q) + \mathrm{d}'F(q, \delta q, \mathrm{d}q) \\ &\qquad = \delta_q F(q, \mathrm{d}q, \mathrm{d}'q) + \mathrm{d}_q F(q, \mathrm{d}'q, \delta q) + \mathrm{d}'_q F(q, \delta q, \mathrm{d}q). \end{aligned} \tag{26}$$

The limits being fixed, integration gives in place of (24) the relation

$$\delta Q = \iint \{\delta_q F(q, \mathrm{d}q, \mathrm{d}'q) + \mathrm{d}_q F(q, \mathrm{d}'q, \delta q) + \mathrm{d}'_q F(q, \delta q, \mathrm{d}q)\}. \tag{27}$$

Art. 6.—By Article 3, as a consequence of the relation (23), the function $F(q, r, s)$ must involve r and s combinatorially, that is in terms of the arrays (rs) and $[rs]$. We may therefore write

$$F(q, r, s) = F_1(q, (rs)) + F_2(q, [rs]), \tag{28}$$

the functions being distributive with respect to (rs) and $[rs]$ respectively. Or for the sake of brevity if we use the notation

$$F(q, r, s) = F(q, \{rs\})$$

instead of the expanded relation (28), we may by (10) replace (27) by

$$\delta Q = \iint F(q, \{\mathrm{d}q\,\mathrm{d}'q\}\mathrm{S}\delta q\mathrm{D} + \{\mathrm{d}'q\,\delta q\}\,\mathrm{S}\mathrm{d}q\mathrm{D} + \{\delta q\,\mathrm{d}q\}\mathrm{S}\mathrm{d}'q\mathrm{D}). \tag{29}$$

As in Article 3 the element under the signs of integration must be

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[1] It is apparently impossible to assign any meaning to an expression of the type of (22) in which this condition is not satisfied.

a function of the three-symbol arrays[1] $[\delta q, dq, d'q]$ and $(\delta q, dq, d'q)$. In fact the relations

$$\begin{aligned} (bc)\,S\,ap + (ca)\,S\,bp + (ab)\,S\,cp &= [p, [abc]] \\ [bc]\,S\,ap + [ca]\,S\,bp + [ab]\,S\,cp &= -(p, [abc]) \end{aligned} \qquad (30)$$

may be proved without any difficulty, so that we have

$$\delta Q = \iint F_1\{q, [D, [\delta q\, dq\, d'q]]\} - \iint F_2\{q, (D, [\delta q\, dq\, d'q])\}. \quad (31)$$

Art. 7.—Thus, given any two modes of passage for the variable of the double integral (22) between the fixed limits, if it is possible to pass from the first to the second by continuous variation without introducing infinite terms, the difference of the values of the double integral is expressible as a triple integral whose limits are prescribed by the two modes of passage, and, except in cases of multiple values of the double integrals, the value of the triple integral is independent of its three-spread mode of passage.

If the double integral (22) is independent of the mode of passage, the element of the integral (31) must vanish, or replacing $[\delta q\, dq\, d'q]$ by an arbitrary quaternion a we must have

$$F_1\{q, [D\,a]\} - F_2\{q, (D\,a)\} = 0, \qquad (32)$$

or separately for the scalar and vector part of a,

$$F_2(q, VD) = 0, \qquad F_1(q, VVD\,a) - SD \cdot F_2(q, a) = 0 \qquad (33)$$

a being an arbitrary vector. Or in terms of ∇ and $\frac{\partial}{\partial t}$ by (16) this is

$$F_2(q, \nabla) = 0, \qquad F_1(q, V\nabla a) + \frac{\partial}{\partial t} F_2(q, a) = 0. \qquad (34)$$

The general scalar double integral is of the form

$$\iint S\,\sigma_1 (dq\, d'q) + \iint S\,\sigma_2 [dq\, d'q], \qquad (35)$$

and for this the conditions reduce to

$$S\nabla\sigma_2 = 0, \qquad \frac{\partial \sigma_2}{\partial t} = VD\,\sigma_1. \qquad (36)$$

---

[1] These arrays are defined by the relations

$$(abc) = S\,Va\,Vb\,Vc\,; \quad [abc] = (abc) + [cb]\,Sa + [ac]\,Sb + [ba]\,Sc,$$

in which a, b and c are any quaternions, and as $(abc) = S\,[abc]$ any three-symbol array can be expressed in terms of $[abc]$.

For a vector variable ρ, (22) reduces to

$$Q = \iint F_2(\rho, \mathrm{V}\,\mathrm{d}\rho\,\mathrm{d}'\rho) \tag{37}$$

and (31) to

$$\delta Q = -\iint F_2(\rho, \nabla)\,\mathrm{S}\,\delta\rho\,\mathrm{d}\rho\,\mathrm{d}'\rho\,, \tag{38}$$

so that

$$Q_{\prime} = Q - \iiint F_2(\rho, \nabla)\,\mathrm{S}\,\delta\rho\,\mathrm{d}\rho\,\mathrm{d}'\rho\,; \tag{39}$$

but a direct proof of the relation (38) by Hamilton's method is probably quite as short for anyone not thoroughly familiar with the notation of this paper as the process of deduction from the general result. This last result includes Green's theorem.

Art. 8.—Finally, so far as quaternions are concerned, we have triple integrals of the type

$$Q = \iiint F(q, [\mathrm{d}q, \mathrm{d}'q, \mathrm{d}''q]) \tag{40}$$

in which (compare Arts. 5 and 6) the three independent differentials $\mathrm{d}q$, $\mathrm{d}'q$, $\mathrm{d}''q$ enter combinatorially or in terms of the three-symbol array $[\mathrm{d}q\,\mathrm{d}'q\,\mathrm{d}''q]$. The limits of this integral being fixed, exactly as in Art. 5, we may reduce δQ to the form

$$\begin{aligned}\delta Q = \iiint \{&\delta_q F(q, [\mathrm{d}q, \mathrm{d}'q, \mathrm{d}''q]) - \mathrm{d}_q F(q, [\delta q, \mathrm{d}'q, \mathrm{d}''q]) \\ &+ \mathrm{d}'_q F(q, [\mathrm{d}q, \delta q, \mathrm{d}''q]) - \mathrm{d}''_q F(q, [\mathrm{d}q, \mathrm{d}'q, \delta q])\}\,;\end{aligned} \tag{41}$$

and because for any quaternions[1] we have identically

$$p\,(abcd) = [bcd]\,\mathrm{S}\,ap - [acd]\,\mathrm{S}\,bp + [abd]\,\mathrm{S}\,cp - [abc]\,\mathrm{S}\,dp \tag{42}$$

we obtain in terms of D by relations such as (10) the simple equivalent of (41),

$$\delta Q = \iiint F(q, \mathrm{D}) \cdot (\delta q\,\mathrm{d}q\,\mathrm{d}'q\,\mathrm{d}''q)\,. \tag{43}$$

The conclusions of Art. 2 and of the last Article apply to this case, the difference of two triple integrals corresponding to two different modes of passage between fixed limits being expressible as a quadruple integral. The condition that the triple integral (40)

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[1] Here $(abcd) = \mathrm{S}\,a\,[bcd]$ &c. is the single four-symbol array for four given quaternions.

should be independent of the mode of passage is simply (compare (15) and (33))

$$F(q, \mathrm{D}) = 0 \tag{44}$$

or in terms of ∇, (compare (17) and (34))

$$\frac{\partial}{\partial t} F(q, 1) - F(q, \nabla) = 0. \tag{45}$$

For the general scalar triple integral having for its element $\mathrm{S}p[\mathrm{d}q\mathrm{d}'q\mathrm{d}''q]$, the condition (45) is

$$\frac{\partial}{\partial t} \mathrm{S}p - \mathrm{S}\nabla \mathrm{V}p = 0. \tag{46}$$

Art. 9.—At the commencement of the last Article we stated that the triple integral completed the list for quaternions. A quadruple quaternion integral has a four-spread mode of passage; in other words the quaternion variable receives every possible value included within the given limits, and the mode of passage is incapable of variation. The methods of the present Paper apply however without formal modification to integrals of a variable

$$q = x + x_1 i_1 + x_2 i_2 + \ldots + x_n i_n \tag{47}$$

where the units $i_1, i_2 \ldots i_n$ obey the laws

$$i_s^2 = -1, \quad i_s i_t + i_t i_s = 0 \tag{48}$$

and where multiplication is associative.

Art. 10.—Analytically the conception of the modes of passage for single, double and triple quaternion integrals presents no difficulty. We have only to conceive the variable quaternion to be a function of one, two or three variable parameters. The limits are defined when a single restriction is imposed on the group of parameters for each limit. Thus the limits for a double integral are defined by two quaternions each of which is a function of a single parameter, and for a triple integral the limits are two quaternions, functions of two variable parameters.

It is worth while inquiring whether we cannot assign useful interpretations for the modes of passage and for the limits when we replace q by $t + \rho$ and regard t as the time measured from a fixed epoch and ρ as the vector to a variable representative point at the time t. For a single integral taken between fixed limits, the representative point is obliged to leave a fixed position at a given time and to reach another fixed position at another given time. The path it describes and the rate at which it traverses that path are fully specified by the mode of passage.

Art. 11.—To give an illustration, take the case of the scalar integral

$$Q = \int \mathrm{S}(E+\sigma)(\mathrm{d}t+\mathrm{d}\rho) = \int E\,\mathrm{d}t + \int \mathrm{S}\sigma\,\mathrm{d}\rho\,. \tag{49}$$

We have seen (18) that the conditions that this integral should be independent of the mode of passage are

$$\frac{\partial\sigma}{\partial t} + \nabla E = 0\,, \qquad \mathrm{V}\nabla\sigma = 0\,. \tag{50}$$

The form of these equations suggests an example from fluid motion, so we suppose σ to be the velocity of the fluid which the second condition requires to be irrotational. To see what interpretation we may assign to the scalar E, we write down the equation of motion, the suffix denoting that σ_0 is not operated on by ∇, (compare the Appendix to vol. II. of the "Elements of Quaternions," p. 547),

$$\dot{\sigma} = \frac{\partial\sigma}{\partial t} - \mathrm{S}\sigma_0\nabla\cdot\sigma = -\nabla P - \frac{1}{c}\nabla p \tag{51}$$

in which P is the potential of the impressed force, c the density and p the pressure. But we have identically

$$\mathrm{V}\sigma_0\mathrm{V}\nabla\sigma = \mathrm{S}\sigma_0\nabla\cdot\sigma - \nabla\,\mathrm{S}\sigma_0\sigma = \mathrm{S}\sigma_0\nabla\cdot\sigma + \nabla\,\tfrac{1}{2}\mathrm{T}\sigma^2 = 0\,, \tag{52}$$

and therefore

$$\frac{\partial\sigma}{\partial t} = -\nabla P - \frac{1}{c}\nabla p - \tfrac{1}{2}\nabla\,\mathrm{T}\,\sigma^2. \tag{53}$$

Thus we may take

$$E = P + \int\frac{1}{c}\,\mathrm{d}p + \tfrac{1}{2}\mathrm{T}\,\sigma^2 \tag{54}$$

so that E is the energy of the fluid per unit mass.

In general in the case of fluid motion when E is the energy per unit mass and σ the velocity of the fluid at the representative point during its motion from one limit to the other, the time integral of the energy diminished by the time integral of the component of the velocity along the path of the representative point into the element of that path ($-\,S\sigma d\rho$), depends on the manner in which the point moves in the given interval of time from one limit to the other; but when the fluid motion is irrotational the difference of these integrals (49) is independent of the mode of passage of the representative point.

It should be observed that $\int S\sigma d\rho$ is not now the *flow*, for the velocities σ are taken successively in time and not at the same instant along the path.

When we do not suppose the motion irrotational, the difference of the integrals (Art. 3.) for two different modes of passage is given by

$$Q_{,} = Q + \iint S(\delta t\, d\rho - dt\, \delta\rho)\left(\frac{\partial\sigma}{\partial t} + \nabla E\right) - \iint S\, V\nabla\sigma V\, d\rho\, \delta\rho\,. \quad (55)$$

In this case by (51) and (52)

$$\frac{\partial\sigma}{\partial t} + \nabla E = V\sigma_0 V\nabla\sigma\,, \quad (56)$$

and this relation may be employed to simplify (55). But the double integral admits of further simplification, for if in the variation of the mode of passage we suppose the curves $\delta\rho$ to be instantaneous or to pass through the loci of representative points at every instant during the passage, we shall have $\delta t = 0$, so that

$$Q_{,} = Q - \iint dt\, S\, \delta\rho\, V\sigma_0 V\nabla\sigma - \iint S\, V\nabla\sigma V\, d\rho\, \delta\rho\,. \quad (57)$$

Art. 12.—To illustrate the meaning of the double integral we take the simple case (35) which becomes in terms of t and ρ

$$Q = \iint S\sigma_1 (dt\, d'\rho - d't\, d\rho) + \iint S\sigma_2 V\, d\rho\, d'\rho \quad (58)$$

because

$$(dq\, d'q) = dt\, d'\rho - d't\, d\rho\,, \qquad [dq\, d'q] = V\, d\rho\, d'\rho\,. \quad (59)$$

The limits being fixed must consist of a closed curve composed of pairs of corresponding points of departure and arrival, the times being prescribed for every point. There is now a singly infinite system of representative points, each of which leaves its point of departure at a definite instant and reaches its point of arrival at another definite instant, and when the mode of passage is given the path and the rate of description of that path is given for every representative point. We may therefore conceive a curve connecting the series of representative points to sweep across the closed curve in a manner prescribed by the mode of passage. Let us suppose the differentials chosen so that $d\rho$ is an element of this instantaneous curve while $d'\rho$ is an element of the path of a representative point. We shall then have $dt = 0$, and the integral becomes

$$Q = -\int d't \int S\sigma_1 d\rho + \iint S\sigma_2 d\rho\, d'\rho \tag{60}$$

and $-\int S\sigma_1 d\rho$ is now (compare Art. 11) the flow of the vectors σ_1 along the instantaneous curve from one extremity to the other. In like manner $\int S\sigma_2 d\rho\, d'\rho$ is the flux of the vectors σ_2 through the elementary strip between two consecutive instantaneous curves, the integration being performed along an instantaneous curve; but for the reason stated in Art. 11, $\iint S\sigma_2 d\rho\, d'\rho$ is not the flux of the vectors σ_2 through the surface generated by the instantaneous curve, being rather the integral of the fluxes at successive intervals of time through the strips determined by successive positions of the instantaneous curve.

Art. 13.—We have seen (36) that the conditions that this integral should be independent of the mode of passage are

$$S\nabla\sigma_2 = 0, \qquad \frac{\partial\sigma_2}{\partial t} = V\nabla\sigma_1. \tag{61}$$

Now these are precisely the equations which the electric displacement $\left(\frac{1}{4\pi}\sigma_2\right)$ in a dielectric and the corresponding magnetic force (σ_1) satisfy. It is therefore possible to give a physical illustration of the integral (60). Any closed curve being taken in the dielectric, if a variable curve is subject to the conditions that its extremities shall move in a determinate manner along the fixed curve; then the time integral of the flows of the magnetic force from one extremity of the variable curve to the other in every position of the curve added to 4π times the integral of the displacement through the strips between successive positions of the variable curve, is independent of the nature of the variable curve.

Art. 14.—When the double integral is independent of the mode of passage, it may be expressed as the difference of two single integrals.

Replacing Q by P in (49) and (55) for the sake of greater clearness and choosing the differentials so that δt is zero, we have

$$P = \int \mathrm{S}\,(E+\sigma)\,(\mathrm{d}t + \mathrm{d}\rho)\,; \quad P_{,} - P = -\iint \mathrm{d}t\,\mathrm{S}\,\delta\rho\left(\frac{\partial\sigma}{\partial t} + \nabla E\right)$$
$$- \iint \mathrm{S}\,\mathrm{V}\,\nabla\sigma\,\mathrm{V}\,\mathrm{d}\rho\,\delta\rho\,. \qquad (62)$$

Comparing the second of these with (60) and observing that δ and d correspond respectively to d and d$'$, we may write

$$\sigma_1 = \frac{\partial\sigma}{\partial t} + \nabla E\,; \qquad \sigma_2 = \mathrm{V}\,\nabla\,\sigma\,, \qquad (63)$$

and the conditions (61) are identically satisfied. Now $-\sigma$ is the vector potential of the magnetic current, and $-E$ is the scalar magnetic potential,[1] so that if

$$p = -E - \sigma\,, \qquad (64)$$

we shall have the integral (60) equal to the difference of the two values of the integral

$$P = -\int \mathrm{S}\,p\,\mathrm{d}q \qquad (65)$$

corresponding to the two modes of passage which together form the limit for the integral (60). The quaternion p may be called the quaternion magnetic potential; and the magnetic force σ_1 and the electric displacement $\frac{1}{4\pi}\sigma_2$ are derived from p by the combinatorial operations with D,

$$\sigma_1 = -(D, p)\,, \qquad \sigma_2 = [D, p]. \qquad (66)$$

Art. 15.—When the integral is not independent of the mode of passage (31) gives

$$\delta Q = \iint \mathrm{S}\left(\frac{\partial\sigma_2}{\partial t} - \mathrm{V}\,\nabla\sigma_1\right)(\delta t\,\mathrm{V}\,\mathrm{d}\rho\,\mathrm{d}'\rho + \mathrm{d}t\,\mathrm{V}\,\mathrm{d}'\rho\,\delta\rho + \mathrm{d}'t\,\mathrm{V}\,\delta\rho\,\mathrm{d}\rho)$$
$$- \iint \mathrm{S}\,\nabla\,\sigma_2\,\mathrm{S}\,\delta\rho\,\mathrm{d}\rho\,\mathrm{d}'\rho\,;$$

or supposing the differentials chosen so that $\mathrm{d}\rho$ and $\delta\rho$ are along

[1] Oliver Heaviside: *Electrical Papers*, vol. i., p. 467.

instantaneous curves (so that dt and δt are zero), while $d'\rho$ is an element of a path of a representative point, this reduces to

$$\delta Q = \int d't \int S\left(\frac{\partial \sigma_2}{\partial t} - V \nabla \sigma_1\right) V \delta\rho \, d\rho - \iint S \nabla \sigma_2 S \delta\rho \, d\rho \, d'\rho. \quad (67)$$

The difference between two integrals for different modes of passage is therefore

$$Q_, = Q - \int d't \iint S \sigma_3 \delta\rho \, d\rho - \iiint S \nabla \sigma_2 S \delta\rho \, d\rho \, d'\rho \quad (68)$$

if

$$\frac{\partial \sigma_2}{\partial t} - V \nabla \sigma_1 = - \sigma_3. \quad (69)$$

In the variation from one mode of passage to the other, the instantaneous curve corresponding to a given value of t traces out a surface—the instantaneous surface. The integral $\iint S \sigma_3 \delta\rho \, d\rho$ is the flux through this surface, supposed momentarily fixed, and the time integral of this is $\int d't \iint S \sigma_3 \delta\rho \, d\rho$. In the electro-magnetic illustration σ_3 is the conduction current when the medium is not a perfect non-conductor. $S \nabla \sigma_2$ is the electric volume-density. (Clerk Maxwell, *Electricity and Magnetism*, Art. 619).

Art. 16.—Finally for the triple integral (40), we take as an example

$$Q = \iiint S p [dq \, d'q \, d''q], \quad (70)$$

or in terms of ρ and t since

$$[dq \, d'q \, d''q] = S \, d\rho \, d'\rho \, d''\rho - dt \, V \, d'\rho \, d''\rho - d't \, V \, d''\rho \, d\rho - d''t \, V \, d\rho \, d'\rho, \quad (71)$$

and since we may choose the differentials so that dt and $d't$ are zero, we have

$$Q = - \int d''t \iint S V p V d\rho \, d'\rho + \iiint S p S d\rho \, d'\rho \, d''\rho. \quad (72)$$

The limits now consist of a closed surface composed of pairs of points of departure and arrival corresponding to prescribed times. We may imagine a surface drawn through the representative points to sweep through the closed surface. This variable instantaneous surface must at every instant cut the limiting surface in a definite curve corresponding to that instant, but the shape of the instantaneous surface is otherwise arbitrary until the mode of passage is prescribed.

If the integral is independent of the mode of passage, the condition (46) is

$$\frac{\partial}{\partial t} \mathrm{S} p - \mathrm{S} \nabla \mathrm{V} p = 0 , \tag{73}$$

and the simplest physical illustration seems to be to take $\mathrm{S} p = c$ to be the density of a fluid and $\mathrm{V} p = c\sigma$ to be the product of the density and the velocity. The equation of continuity being

$$\frac{\partial c}{\partial t} - \mathrm{S} \nabla (c\sigma) = 0 , \tag{74}$$

the condition is satisfied, and the integral

$$Q = - \int \mathrm{d}'' t \iint c \, \mathrm{S} \sigma \, \mathrm{d}\rho \, \mathrm{d}'\rho + \iiint c \, \mathrm{S} \, \mathrm{d}\rho \, \mathrm{d}'\rho \, \mathrm{d}''\rho \tag{75}$$

is independent of the mode of passage.

The integral $\iint c \, \mathrm{S}\sigma \, \mathrm{d}\rho \, \mathrm{d}'\rho$ is the flux of the fluid through the surface with which the variable instantaneous surface momentarily coincides, and the integral $- \int \mathrm{d}''t \iint c \, \mathrm{S}\sigma \, \mathrm{d}\rho \, \mathrm{d}'\rho$ is the negative of the time integral of this flux corresponding to the motion of the instantaneous surface. The integral $\iiint c \, \mathrm{S} \, \mathrm{d}\rho \, \mathrm{d}'\rho \, \mathrm{d}''\rho$ is simply the negative of the quantity of fluid which has passed through the instantaneous surface in its motion.

III.

SOME EXPERIMENTS ON DENUDATION BY SOLUTION IN FRESH AND SALT WATER.

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[Read February 24, 1901.]

The following experiments are directed to throw light on the much-neglected question of the solvent effects of sea-water on rocks and rock-forming silicates.

Materials dealt with.—Four substances are dealt with in these preliminary experiments—basalt, hornblende, obsidian, and orthoclase. The basalt is a typical specimen, black, fine-grained, compact, with specks of olivine, from the Giant's Causeway, Ireland. The hornblende is the dark-green aluminous variety, well crystallized, cleavable, from Friedrickshaabe. The obsidian is a typical rhyolite glass from Monte Pelato, Lipari. The orthoclase is highly cleavable, fresh, pale pink in colour.

Mode of Experiment.—The experiments are all comparative, equal amounts being exposed to solution in distilled water and in sea-water under like conditions. The sea-water used was taken from the rocky coast of Killiney, County Dublin, a part of the coast sufficiently far removed from any stream or river discharge.

The experiments are of two distinct types. In the one it was sought to secure to the full the effects of aeration upon the rate of solution.

To this end ten grammes of the mineral, finely powdered, are placed along with 1000 c.cs. of the solvent in a Jena-glass flask of the conical Erlenmeyer shape, the flask having a capacity of 1100 c.cs. A continuous stream of air is directed by a Jena-glass tube to the bottom of the flask, the air escaping in bubbles which rise through the liquid, and with the help of occasional shaking preserve the sediment in suspension. The entering air is filtered from dust by passage through cotton wool, and damped by passage through towers of pebbles, wetted with salt water in the case of the salt-water experiments, and fresh water in the case of the fresh-water experiments. Eight flasks were exposed in this manner, each to an equal stream of air, four containing fresh water, and four sea-water. The duration of the experiments was three months, during which time the current of air continued, with only a very few days intermission, both during night and day. On each occasion upon which the flasks were shaken it was found that the salt-water solutions had almost cleared before the next day, whereas the fresh-water solutions remained turbid, a natural effect, which in nature is of much importance.

The second mode of experiment was applied to a specimen of the basalt only. In this case the material in coarse grains and fragments, to the weight of about 180 grammes, is placed in a U-tube, and by a cup-of-Tantalus arrangement, which will be described in the appendix, the solvent (which in this case also was 1000 c.cs. in volume) was compelled to travel in opposite directions through the tube, passing from an Erlenmeyer Jena-glass flask placed beneath to one placed above, and gravitating back again, continuously during the daytime. The air from the room enters through damping tubes into the upper and lower flasks alternately with the withdrawal of the solvent.

The action upon the material in the U-tube may be considered as much like what goes on upon the sea beach or in the wash of a river, for at the completion of each upward passage of the water through the U-tube one limb of the tube is to a considerable extent drained of water, air entering freely between the coarser particles. On the completion of the downward movement the other limb of the tube is drained out to a large extent. The particles are thus exposed to the wash of the solvent in both directions, and to its periodic partial withdrawal from around them. There is, however, no attrition.

The time occupied in the upward passage of the water is from seven to eight minutes; in the downward from about eight to nine minutes. The flasks and U-tubes are in duplicate, the U-tubes being attached side by side, the one holding basalt traversed by salt water, and the other basalt traversed by fresh water, and the current is maintained through each by the one hydraulic arrangement.

The duration of this experiment was four months. At night the active motion of the water was stopped, but during this period the particles remained submerged.

Surface Area exposed to Solution.—It is very certain that the rate of motion of the solvent in such experiments has within limits only a minor influence on the ultimate results. It is even doubtful if the quantity of the solvent within wide limits, so long as the solid is maintained immersed, seriously effects the results. The primary factor appears to be the stability of the solid material, and hence the extent of surface which this exposes to the solvent is the most important quantitative measurement involved. It is too often the practice to state in such experiments the amounts gone into solution as a percentage of the mass of the entire solid. The latter quantity is in itself of little importance.

In the case of the last described experiment the materials introduced into the U-tubes were sifted through sieves of measured mesh. Thus in each U-tube the following quantities of basalt were inserted :—

25 grammes,	passed	0·55 m.m.,	stopped by	0·45	mm.	mesh.
40 ,,	,,	0·45 ,,	,,	,, 0·35	,,	,,
20 ,,	,,	0·35 ,,	,,	,, 0·20	,,	,,

To each of these, 103 grammes of coarse fragments having a mean diameter of about 5 mms. were added. A minimum value for the total surface area is arrived at by assuming the particles spherical in form, and having diameters of the mean values of the mesh which admits and the mesh which stops. The assumption is also applied to the 103 grammes of larger fragments. Making the requisite calculations, we arrive at the result that the area exposed is not less than 0·509 square metres. The actual area lies above this minimum value. The particles are rarely rounded, more often rectangular or wedge-shaped and rough. The assumption that the particles were cubical would leave the area still below one square metre. We are probably not far from the actual value in assuming, therefore, one square metre as approximately the total surface area exposed within each tube.

In the case of the ten-gramme charges, on the conclusion of the experiments, each was separated by suspension in water into five degrees of coarseness. These parts were carefully weighed, and the mean diameters estimated by micrometric measurements (from ten to twenty measurements being applied to each assortment), and the total areas calculated, on the assumption that the particles are cubic in form.

The following are the results in square metres :—basalt, 1·209; orthoclase, 1·799; obsidian, 1·163; hornblende, 0·791.

On the foregoing data the table which follows further on is calculated representing the amounts of material removed in each case per annum from an area of one square metre, according to the experiments.

Such calculations can of course give only approximate evaluation of surface. We possess no definite knowledge as to the depths to which solutions might in such cases penetrate beneath the surface of the various minerals and exert a solvent action. If this depth is considerable, which does not appear probable, the gain in surface obtained by reducing the material to very fine particles is more apparent than real. Doubtless, the rate of abstraction of dissolved material is in any case much greater at the actual surface. If we assume such abstraction of material to only go on for molecular distances beneath the surface, or at least distances small compared with the diameters of the particles, the calculations afford at least a definite basis of comparison with purely solvent processes in Nature, for here also a similar penetration of solvent influences occurs. In each case, too, we may assume a somewhat similar protective effect due to residual materials. The conclusion to be drawn is that *under*-estimate of the surfaces exposed—even on the assumption of cubic particles—is more probable than *over*-estimate.

As regards chemical attack over the surface of glass exposed in each vessel, it may be stated here that this can only cause small error. The glass used throughout (save the U-tubes in the basalt experiments) was Jena glass. This glass has been the subject of tests made at the Technical Institute of Charlottenburgh, which the makers have published, and which apply to the amount of Na_2O liberated under various conditions. These show that the area of 500 sq. cms. exposed in the flask, even if the full rate of solution for water at 20° C. continued for three months, would only liberate 0·00017 grammes of Na_2O. As it is not to be supposed that the primary rate of extraction would continue, and as the mean temperatures were not higher than 12° C., in any case the error may be considered negligible. The fact is the area of glass exposed is small compared with the areas of the mineral particles.

The Chemical Results.—The chemical analyses were carried out in the Chemical Laboratory of the Royal Dublin Society, under the supervision of, and in part by, Mr. R. J. Moss, F.C.S., Chemical Analyst to the Society, to whom my best thanks are due. Mr. Stone, the assistant, bestowed the utmost pains on the very difficult task of evaluating the small quantities available for estimation.

Unfortunately the estimate of the alkalies in the case of the sea-water solutions, owing to the indirect methods available and the overwhelming amounts of sodium and potassium already present, could not be effected with sufficient accuracy. The lime was in those cases estimated where the nature of the mineral rendered its solution probable. A partial analysis of the sea-water used was also carried out under like conditions to those obtaining in the case of the salt-water analyses.

The procedure in analyses was the usual one. The lime was weighed as oxide by ignition of the oxalate, no attempt being made to separate further possible impurities, which may in the case of sea-water, as pointed out by Dittmar, amount to as much as 9 per cent. of MgO, Na_2O, &c. The presence of TiO_2 in the silica precipitate was not sought for, the weighing after the usual precipitation with HCl and ignition being entered as silica.

The columns headed I. refer to the basalt dealt with according to the second method of experiment as described, the substance being comparatively coarse-grained, and subjected to an alternate flow of water in opposite directions. In all cases the quantities in the columns headed "Salt" have already been reduced by the amounts of dissolved silica, alumina, and lime detected in the unused sea-water, as given in the last column.

The mean temperature prevailing during the progress of Experiments II., III., IV., and V., was 7° C.; and during Experiment I., 12° C. At the conclusion of the experiments the sea-water, in each case, showed a distinctly increased alkaline reaction towards litmus; the fresh water also showed a very faint alkaline reaction towards litmus.

Consideration of Results.—The principal issue which led to the foregoing experiments is the broad and somewhat complex one, as to whether the water of the sea is a more active solvent denuding agent than fresh water. It seems to have been left an open question up to the present. Daubrée's well-known experiments[1] with chloride of sodium and water acting on orthoclase exposed to violent attrition in a rotating vessel admittedly applies to the activity of the one dissolved substance only. Moreover, the negative result which Daubrée apparently obtained is not in agreement with the results obtained by Beyer,[2] that the felspars decompose rapidly in water containing sodium chloride. But Daubrée does not appear to have gone beyond investigating the final reaction, whether alkaline or not. Further direct

[1] "Geologie Expérimentale," vol. i., p. 237.

[2] Quoted by G. P. Merrill in "Rocks, Rock-Weathering, and Soils," p. 178.

TABLE I.

Weights dissolved in 1000 c.cs.

	I. Basalt.		II. Basalt.		III. Orthoclase.		IV. Obsidian.		V. Hornblende.		VI. Sea-Water.
	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.	
SiO_2, ...	·01581	·01189	·01181*	·00364	·00905	·20819	·00356	·00151	·00406	·00589	·00100
Al_2O_3, ...	abs.	·00027		abs.	abs.	·00101	abs.	·00109	trace.	·00884	·00130
Fe_2O_3, ...	abs.	abs.	trace.	abs.	abs.	—	abs.	abs.	abs.	trace.	abs.
CaO, ...	·03210	·16437	—	·22062	—	—	abs.	·01962	trace.	·13161	·59701
MgO, ...	·00909	—	—	—	—	—	trace.	—	abs.	—	—
Na_2O, ...	·01127	—	—	—	—	—	·00159	—	·01592	—	—
K_2O, ...	trace.	—	—	—	·00594	—	abs.	—	trace.†	—	—
	0·06827	0·17643		0·22426	0·01499	0·20920	0·00515	0·02222	0·01998	0·14635	

* The solution was, unfortunately, almost totally lost after this determination.

† Feeble spectrum of K and Li.

TABLE II.

Weights removed by solution per square metre per annum.

	I. Basalt.		II. Basalt.		III. Orthoclase.		IV. Obsidian.		V. Hornblende.	
	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.	Fresh.	Salt.
SiO_2, ..	·0474	·0357	·0295	·0091	·0151	·3470	·0089	·0039	·0152	·0222
Al_2O_3, ..	—	·0008	—	—	—	·0017	—	·0027	—	·0331
Fe_2O_3, ..	—	—	—	—	—	—	—	—	—	—
CaO, ..	·0963	·4931	—	·5514	—	—	—	·0490	—	·4936
MgO, ..	·0273	—	—	—	—	—	—	—	—	—
Na_2O, ..	·0338	—	—	—	—	—	·0040	—	·0597	—
K_2O, ..	—	—	—	—	·0099	—	—	—	—	—
	0·2048	0·5296		0·5605	0·0250	0·3487	0·0129	0·0556	0·0749	0·5489

evidence on the broad question at issue I have not found. Dana considered that basalt rocks were protected by sea-water, either where quite covered or merely washed with spray, relatively to the same rock exposed to the alternate wetting and drying of sub-aereal actions. Merrill,[1] commenting on this, remarks justly that erosive actions, in such cases, preserve a deceptive appearance of freshness to the rock. He, however, thinks that no exception can be taken to Dana's remarks regarding rocks wholly immersed.

Gustav Bischof in his well-known "Chemical and Physical Geology" has advanced reasons from the chemical point of view for believing that the alkaline silicates of felspars, &c., will experience more active dissolution in water containing dissolved salts of calcium and magnesium. This view is based on the fact that alkaline silicates are decomposed in presence of the sulphates and chlorides of calcium and magnesium, the sparingly soluble earthy silicates being precipitated.[2]

If this applies to the naturally occurring crystallized silicates, in which alumina forms part of the molecule, and which are, comparatively speaking, insoluble bodies, sea-water, containing $MgSO_4$, $CaSO_4$, and $MgCl_2$, in abundance, should accelerate the decomposition of felspars.

The results of the reaction with the alkaline silicates appear, according to Bischof, to be the formation of the silicates of lime and magnesium and the sulphates and chlorides of the alkalies. The latter will, of course, be dissolved. The silicate of lime will again be decomposed if carbonic acid is present, silica separating out and precipitating, and carbonate of calcium being formed. The silicate of magnesia will, however, not be decomposed by carbonic acid.

According to these reactions, wherever sea-water acts upon silicates containing alkaline silicates, and is, as in the experiments, freely exposed to the CO_2 of the atmosphere, decomposition will be accelerated, silicate of magnesia being precipitated, bicarbonate of calcium formed and retained in solution (or precipitated if the amount of CO_2 is deficient), silica precipitated, and soluble chlorides and sulphates of the alkalies formed. These reactions would alone not serve to explain the presence of the comparatively large amount of silica in solution revealed by the reaction with orthoclase (Ex. III.), unless soluble alkaline silicates remain in solution, or a hydrosol of silica is formed.

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[1] *Loc. cit.*, p. 253.

[2] "Geologie Expérimentale," vol. i., p. 12.

But they suggest forcibly that the final results in nature (or in the experiments), as regards bringing the rock materials into solution, represent but a part of the total reaction upon the rock. In other words, the amount of decomposition actually effected is indicated only by the liberation in solution of certain of the constituents. This fact—which could be instanced by many well-known phenomena of rock-weathering—involves a conservative effect of great importance in nature, and which must also be borne in mind in considering any such experiments as the present ones, effected on fresh material. The process of leaching out soluble constituents, and leaving insoluble ones, or those of secondary formation, behind, must lead to a rapid diminution of the surface activity of the solid.

With the conspicuous exception of the orthoclase the silica obtained in the salt water solutions is either about equalled or actually largely excelled in amount in the case of the fresh-water solutions—as in the experiments on basalt and obsidian.

The obsidian, it will be observed, proved to both solvents the most resistant of the materials dealt with. Daubrée records among his results that this same substance offered remarkable resistance to attack.[1] The final solutions in this case, he records, showed scarcely any alkaline reaction.

A conspicuous feature of the results is the much greater quantities of lime dissolved in the salt-water solutions. According to Bischof this might be explained, as we have seen, as the result of the secondary reaction attending the liberation of alkaline silicates. The result, which is more especially conspicuous in the case of the basalt (both in fresh and salt water), is in keeping with the well-known deposition of carbonate of calcium in some basic igneous rocks undergoing decay. Alumina in solution was only detected in the salt solutions, but in every case in minute quantity. The almost complete absence of iron in the solutions is remarkable, the delicate test by sulphocyanide of ammonium revealing no more in any instance than a trace.

Looking at the figures at the foot of the columns of Tables I. or II., we observe that in every case the total amount removed in solution by the salt water exceeds considerably what is removed by the fresh water. If the alkalies (and magnesia in some cases) taken up by the sea water were added, the preponderance would be still greater. As it stands the

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[1] *loc. cit.*, p. 275.

sea-water dissolves from twice (obsidian) to fourteen times (orthoclase) the mass dissolved by fresh water.

The main question at issue is undoubtedly answered by these experiments, incomplete though they be. They show, indeed, that under the conditions of experiment:—moderate temperature; fresh material; abundant aeration; active circulation; absence of attrition: marine solvent denudation exceeds in activity fresh-water denudation in the case of *basalt* not less than three times; in the case of *hornblende* not less than eight times; in the case of *obsidian* over four times; and in the case of *orthoclase* not less than fourteen times. In short, taking alkalies into account and some MgO (as we have seen there is some reason to believe MgO will not enter largely into solution in the case of sea water), the preponderance ranges from about four times (basalt) to seventeen or eighteen times (orthoclase). With the lapse of time, as the surface of the solids become exhausted of the more soluble constituents, a convergence and approximation of the two rates will probably occur.

It is interesting to place the figures applying to fresh-water solvent denudation side by side with estimates which have been based on river-water analyses.

Mr. T. Mellard Reade has estimated that solvent denudation in England and Wales is lowering the surface of the land at the rate of one centimetre in 430 years. This represents the removal of about 60 grammes per square metre per annum. The Mississippi, drawing its supplies from areas exposed to wide climatic extremes and from every variety of rock and soil, is lowering its basin at the rate of one centimetre in 833 years, which represents the removal of about 30 grammes per square metre per annum. Comparing these figures with the experimental figures, we see that even a brisk continuous washing of fresh rock-surface having the superficial area of the denuded region would not be competent to supply more than a small percentage of these amounts. The mean of the figures at foot of the columns applying to fresh-water denudation in Table II. is just 0·08 grammes removed per square metre per annum. This is 0·15 per cent. of the amount estimated by Mr. Mellard Reade, and 0·3 per cent. of the amount removed per square metre per annum by the Mississippi. Herein we see the influence primarily of the great surface areas exposed in the soils (as much as 500 square metres in the litre), as well as the solvent influence of the acids originating in vegetation, the more rapid solution of the calcareous rocks, effects of alternate wetting and drying, frost and sunshine.

Appendix.

A brief account of the apparatus used in the experiments on the solvent denudation of basalt (coarse grain) in fresh and salt water may be of value to anyone entering on such experiments. The arrangement is such as to utilize the motion of a continuous water supply from any source to produce a reciprocating passage of a given quantity of a liquid through a U-tube containing the substance being dealt with.

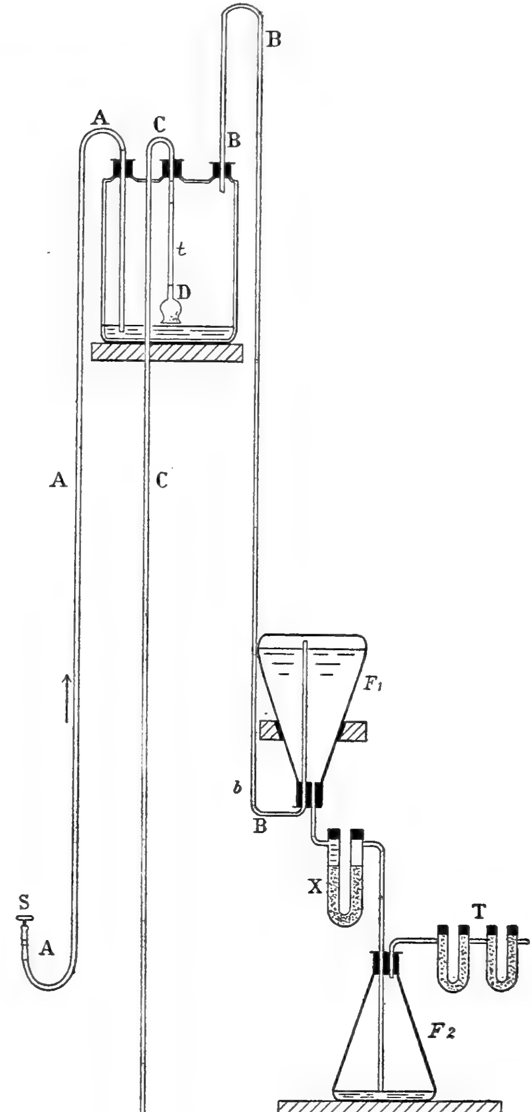
In the diagram for clearness one U-tube only is shown, *X*, containing the basalt. In the actual experiments there were two U-tubes attached side by side so as to be under like conditions of temperature, both containing basalt of same assortment of grain; but through the one salt water, through the other fresh water circulated. It will thus be understood that the flasks containing these solvents, F_1 and F_2, were four in number, the diagram showing those required for the one solvent only. Beyond them those for the other solvent may be supposed concealed. Similarly, behind *X* the second U-tube is concealed. The tube *B* bifurcates at *b*, one branch ascending to the top of F_1 as shown, the other ascending to the top of the flask concealed behind F_1.

At *S* is a stop-cock controlling the city water supply. A stout rubber connection, closed all but for a nearly capillary glass tube, admits from this a *continuous* small stream of water at high pressure into the tube *A*. It is thus conveyed in a slow continuous stream into the closed Wolf's bottle placed above the tap and above the flasks. If we imagine the Wolf's bottle just full of air, and water flowing into it from the tap, this air will escape by the second tube *B* into F_1 and at first pass through the mineral particles in *X*, and escape through the measured quantity of solvent in F_2, emerging by the damping tubes *T*. When the Wolf's bottle gets quite full the siphon *C* comes into operation and rapidly empties the bottle, like a cup-of-Tantalus, the siphon being in fact of sufficient bore to empty the bottle in about eight minutes, although the stream is entering by tube *A* all the time. During this emptying process evidently the solvent in F_2 is sucked up and passes through *X*, rising finally into F_1. When all is nearly drawn up the Wolf's bottle is quite empty. The siphon breaks, and the current from *A* gradually refills the Wolf's bottle, during which time the solvent flows back through *X*. This takes about nine minutes.

There is thus a tide upwards and downwards maintained through the U-tube X; and it is easy to arrange that the sand in each limb shall be alternately uncovered and exposed to the air when the supply of solvent from the attached flask fails. It is necessary for safety to take the tube B about 60 centimetres or thereabouts above the Wolf's bottle.

Where the siphon opens within the bottle a peculiar arrangement is adopted, absolutely essential to the succcss of the apparatus. This consists in forming the lower part, t, of the siphon of soft-rubber tubing, carrying at its lower end an open thistle funnel, D. The object of this is to obviate a well-known difficulty in the cup-of-Tantalus arrangements: viz. the failure of the siphon to "break" at end of its discharge and the consequent formation of a chain of gas-bubbles and water-bubbles, carrying off the water at the same rate as that at which it enters the bottle. Now the action of the thistle funnel and rubber tube is as follows:—as the water sinks in the bottle and at last begins to uncover the thistle funnel, the weight of the water in this funnel elongates the rubber tube a little, so that finally, when the lower lip of the funnel uncovers and the water spills out of it, the contraction of the rubber tube jerks the funnel completely out of the water beneath and lets the whole siphon fill with air.

This arrangement gave no trouble and worked with no more attention than that required to re-moisten the gravel contained in the damping tubes T. I may point out that the adjustment of the effective capacity of the Wolf's bottle is simply carried out by an adjustment of the length of the arm of the siphon within the bottle, that is, by adjusting the length of the rubber tube t.


B
A
C
B
t
D
A
C
F1
b
B
X
S
T
A
F2
C

IV.

SOME PROPERTIES OF A CERTAIN QUINTIC CURVE. By The Rev. W. R. WESTROPP ROBERTS, B.D., F.T.C.D.

[Read January 27, 1902.]

1.—The Curve, the properties of which I treat of in this Paper, is a special case of the class of quintic curves having a triple point. Such curves possess considerable interest, as many of their properties can be ascertained by the known properties of Abelian integrals and functions, and they thus afford us geometrical interpretations of complex mathematical formulæ.

The equation of a quintic curve having a triple point is readily seen to be of the form

$$Az^2 - 2Bz + C = 0; \quad . \quad . \quad . \quad . \quad . \quad (1)$$

the triple point, which we shall denote by O, being at the point of intersection of the axes x and y, A, being a binary cubic in x and y, B, a quartic and C a quintic in the same variables, and z a line which passes through the points in which the five lines through O whose equation is $C = 0$ meet the curve.

We shall now express the coordinates of a point on the curve in terms of a parameter θ. In order to effect this we shall seek expressions for the coordinates of the two points in which the line $x = \theta y$ meets the curve.

Introducing this value of x into the equation of the curve, we find, after dividing by y^3,

$$\overline{A}z^2 - 2\overline{B}zy + \overline{C}y^2 = 0, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where $\overline{A}$ is what A becomes when we put $x = \theta$ and $y = 1$, and, similarly, $\overline{B}$ and $\overline{C}$ are what B and C become for the same values of x and y.

If we now solve the above quadratic for the ratio $z : y$, it is plain we may write

$$\left.\begin{aligned} \rho x &= \overline{A}\theta \\ \rho y &= \overline{A} \\ \rho z &= \overline{B} \pm \sqrt{\overline{R}} \end{aligned}\right\} \quad \ldots\ldots\ldots \quad (3)$$

where $R \equiv \sqrt{B^2 - AC}$.

It follows thus that the line $x = \theta y$ meets the curve in two points P and P', which we call *corresponding points*, and further, if we denote their coordinates by x, y, z, and x', y', z', we shall have

$$\left.\begin{aligned} \rho x &= \overline{A}\theta & \rho x' &= \overline{A}\theta \\ \rho y &= \overline{A} & \rho y' &= \overline{A} \\ \rho z &= \overline{B} + \sqrt{\overline{R}} & \rho z' &= \overline{B} - \sqrt{\overline{R}}, \end{aligned}\right\} \quad \ldots \quad (4)$$

that is to say, θ being given, to one point P there corresponds a positive value of the radical $\sqrt{\overline{R}}$, and to the other point P' a negative value. It is evident that if $\overline{R} = 0$, the points P and P' coincide.

2.—The class of this curve is easily ascertained, since the triple point O is to be counted as equivalent to three double points in estimating the number of tangents which can be drawn from an arbitrary point to the curve; this number is then $5 \times 4 - 3 \times 2 = 14$; and if this point be on the curve the number of tangents which can be drawn from it will be 14 diminished by 2, or 12; but if the point be O, the triple point, the number of tangents which can be drawn from it to the curve will be $14 - 3 \times 2 = 8$: hence eight tangents can be drawn from O to the curve. Now, a line drawn through O meets the curve in corresponding points, and these points will coincide when the line touches the curve, the eight points of contact of tangents which can be drawn from O to the curve, are then points which coincides with their corresponding points. Their equation is consequently

$$\overline{R} = 0.$$

We shall call the roots of $R = 0$, $a_1, a_2, \ldots a_8$, and we shall sometimes write it in the form

$$R = D_1 D_2 D_3 D_4;$$

D_1, D_2, D_3, and D_4 being four quadratic factors whose roots are

$a_1, a_2;\ a_3, a_4;\ a_5, a_6;\ a_7, a_8$. We shall refer to these eight points as the R points.

3.—Let $z = lx + my$ be the equation of any line, and let us seek the equation which determines the parameters of the five points of section. Substituting for z, its value $lx + my$ in the equation of the curve, we obtain

$$A\,(lx + my)^2 - 2B\,(lx + my) + C = 0\,, \quad . \quad . \quad . \quad (1)$$

and consequently the five θs of the points of section of the curve with the line, which we shall denote by $\theta_1, \theta_2, \theta_3, \theta_4, \theta_5$, are found from the equation

$$\overline{A}\,(l\theta + m)^2 - 2\overline{B}\,(l\theta + m) + \overline{C} \equiv \phi(\theta) = 0\,. \quad . \quad . \quad (2)$$

If we now investigate the change in θ due to changes dl and dm in l and m, we obtain, by differentiating the above equation,

$$\frac{d\,\phi(\theta)}{d\theta}\cdot d\theta + 2\{\overline{A}\,(l\theta + m) - \overline{B}\}(\theta\,dl + dm) = 0\,.$$

Now,

$$\overline{A}\,(l\theta + m) - \overline{B} = \sqrt{R}\,,$$

and $\dfrac{d\,\phi(\theta)}{d\theta} = M\phi'(\theta)$, where M is a function of l and m; hence

$$\frac{d\theta_1}{\sqrt{R_1}} + 2\frac{(\theta_1)\,dl + dm)}{M\phi'(\theta_1)} = 0\,, \quad . \quad . \quad . \quad . \quad . \quad (3)$$

θ_1 being one of the five roots of the equation

$$\phi(\theta) = 0\,, \quad \text{and} \quad \phi'(\theta_1) \equiv (\theta_1 - \theta_2)(\theta_1 - \theta_3)(\theta_1 - \theta_4)(\theta_1 - \theta_5)\,.$$

We now write

$$\left.\begin{aligned}
&\Sigma\frac{d\theta_1}{\sqrt{R_1}} + 2\Sigma\frac{(\theta_1\,dl + dm)}{M\phi'(\theta_1)} = 0\,,\\
&\Sigma\frac{\theta_1\,d\theta_1}{\sqrt{R_1}} + 2\Sigma\frac{(\theta_1^2\,dl + \theta_1\,dm)}{M\phi'(\theta_1)} = 0\,,\\
&\Sigma\frac{\theta_1^2\,d\theta_1}{\sqrt{R_1}} + 2\Sigma\frac{(\theta_1^3\,dl + \theta_1^2\,dm)}{M\phi'(\theta_1)} = 0\,,
\end{aligned}\right\} \quad . \quad . \quad (4)$$

where Σ denotes summation from θ_1 to θ_5.

But, by the theory of partial fractions, we have

$$\Sigma \frac{1}{\phi'(\theta_1)} = 0, \quad \Sigma \frac{\theta_1}{\phi'(\theta_1)} = 0, \quad \Sigma \frac{\theta_1^2}{\phi'(\theta_1)} = 0, \quad \Sigma \frac{\theta_1^3}{\phi'(\theta_1)} = 0.$$

Consequently we obtain the following three relations connecting the five values of θ and their differentials which correspond to the points of section of a line with the curve,

$$\Sigma \frac{d\theta_1}{\sqrt{R_1}} = 0, \quad \Sigma \frac{\theta_1 d\theta_1}{\sqrt{R_1}} = 0, \quad \Sigma \frac{\theta_1^2 d\theta_1}{\sqrt{R_1}} = 0. \quad . \quad (5)$$

These differential equations we can integrate since they are true for every line which can be drawn to meet the curve.

If we now write $$\int \frac{\theta^r\, d\theta}{\sqrt{R}} \equiv I_r(\theta),$$

r being an integer, we obtain, by integration of the differential system (5),

$$\left.\begin{aligned} \Sigma I_0(\theta) &= c_0, \\ \Sigma I_1(\theta) &= c_1, \\ \Sigma I_2(\theta) &= c_2, \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Σ denoting summation from θ_1 to θ_5, and c_0, c_1 and c_2 being constants.

4.—We now proceed to determine the values of the constants c_0, c_1, and c_2.

By reference to equations (4), Art. 1, we see that to a given value of the parameter θ, corresponds but *one* point P, if we agree to affect the radical $\sqrt{R}$ with a positive sign, its corresponding point P' being determined by giving the radical a negative sign. To the triple point O will then correspond three values of the parameter θ, or, in other words, there are three different values of θ which will give us

$$x = 0, \qquad y = 0,$$

these values of θ corresponding to the different branches of the curve which pass through O. These values of θ are plainly the roots of the equation $\overline{A} = 0$, which we shall denote by n_1, n_2, n_3.

The constants c_0, c_1, c_2 being the same for all lines, their value will remain unaltered if we consider a line, $x = \theta y$, drawn through O. Now, such a line meets the curve in O counted three times, and whose parameters on each branch on which it lies are respectively n_1, n_2, and n_3, and in two corresponding points for which θ is the same but the radical is equal in value and opposite in sign. The sum, then, of the five integrals I_0 reduce to $I_0(n_1) + I_0(n_2) + I_0(n_3) \equiv N_0$ say. We find then

$$\left.\begin{aligned} c_0 &= N_0, \text{ and by parity of reasoning} \\ c_1 &= I_1(n_1) + I_1(n_2) + I_1(n_3) \equiv N_1, \\ c_2 &= I_2(n_1) + I_2(n_2) + I_2(n_3) \equiv N_2. \end{aligned}\right\} \quad . \quad . \quad (1)$$

Hence any line meets the curve in five points such that

$$\left.\begin{aligned} \Sigma\, I_0(\theta) &= N_0, \\ \Sigma\, I_1(\theta) &= N_1, \\ \Sigma\, I_2(\theta) &= N_2. \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In precisely the same way we may prove that any conic *through the triple point* O meets the curve in seven points, and so that

$$\left.\begin{aligned} \Sigma\, I_0(\theta) &= N_0, \\ \Sigma\, I_1(\theta) &= N_1, \\ \Sigma\, I_2(\theta) &= N_2. \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

As these three equations will, in all cases we shall discuss, always obtain together, we shall write them in the briefer form

$$\Sigma\, I(\theta) = N,$$

it being always understood that this equation $\Sigma\, I(\theta) = N$ implies *three* equations, connecting $\Sigma\, I_0(\theta)$, $\Sigma\, I_1(\theta)$, and $\Sigma\, I_2(\theta)$, with N_0, N_1, and N_2.

5.—To any point for which θ is given, and also the sign of the radical $\sqrt{R}$, correspond the three integrals $I_0(\theta)$, $I_1(\theta)$, and $I_2(\theta)$, which we shall refer to as the integrals of the point, to any three points whose parameters are θ_1, θ_2, and θ_3, will correspond three integrals $I_0(\theta_1)$, $I_0(\theta_2)$, and $I_0(\theta_3)$, three integrals of the class $I_1(\theta)$ and three of the class $I_2(\theta)$. If we write

$$\left.\begin{aligned} I_0(\theta_1) + I_0(\theta_2) + I_0(\theta_3) &= U_0 \\ I_1(\theta_1) + I_1(\theta_2) + I_1(\theta_3) &= U_1 \\ I_2(\theta_1) + I_2(\theta_2) + I_2(\theta_3) &= U_2, \end{aligned}\right\} \quad . \quad . \quad . \quad (1)$$

we might, not improperly, call U_0, U_1, and U_2, the arguments of the three points whose parameters are θ_1, θ_2, and θ_3.

For such quintic curves we have a theory of residuation analogous to Sylvester's *Theory of Residuation for the Cubic*; but as I have already discussed such a theory in a Paper published in the "Proceedings of London Mathematical Society" some years ago, and as the treatment for the quintic is almost exactly similar to that I adopted in the case of the uni-nodal quartic, I shall not do more than allude to it.

We consider the equation of a curve of the mth degree of the form

$$az - b = 0,$$

which we call an O curve, where a and b are binary forms of the $m - 1$th and mth degrees respectively. Such a curve has O for a point of the $m - 1$th order; and we find, by reasoning of a precisely similar nature to that we employed in discussing the relations of the parameters of the points of section of a line with the quintic, that the $2m + 3$ values of θ corresponding to the $2m + 3$ points of section are connected by three relations, viz.,

$$\Sigma I(\theta) = N.$$

If two systems of points on the quintic α and β together make up the complete intersection of an O curve and the quintic, these systems are said to be co-residual.

6.—We now turn to the equation of the curve

$$Az^2 - 2Bz + C = 0.$$

If we write for z, z_1+f, f being the equation of a line through O, we find

$$Az_1^2 - 2(B - Af)z_1 + C - 2Bf + Af^2 = 0,$$

or, $$Az_1^2 - 2B_1z_1 + C_1 = 0,$$

where $$B_1 \equiv B - Af, \quad C_1 = C - 2Bf + Af^2.$$

Now it is clear since f contained but two constants, it will not in general be possible to make C_1 contain the binary cubic A as a factor. The curve we discuss is that special case of the quintic with a triple point in which it is possible to transform the equation of the curve so that $C_1 \equiv AQ$, Q being a binary quadratic. This involves one condition. The equation of this curve can then be written in this form

$$Az^2 - 2Bz + AQ = 0 \quad \ldots \ldots \quad (1)$$

This being the case, suppose we transform the above equation to a new axis of z, which will be effected by writing $z+f$ for z. For this transformation we have

$$Az^2 - 2B_1z + C_1 = 0,$$

where $$B_1 = B - Af,$$

$$C_1 = AQ - 2Bf + Af^2.$$

Now, we say, since we have two constants at our disposal, that it is possible to determine f so that $B - Af$ may contain $Q - f^2$ as a factor. Let us write then

$$B - Af \equiv (Q - f^2)F, \quad \ldots \ldots \quad (2)$$

F being a binary quadratic.

Let us now see what C_1 becomes in this case. We have

$$C_1 = A(Q+f^2) - 2Bf$$

$$= A(Q+f^2) - 2f \cdot \{Af + (Q-f^2)F\}$$

$$= (Q-f^2)(A-2fF) \equiv (Q-f^2)H \text{ say},$$

where $$H \equiv A - 2fF.$$

The equation of our curve can consequently be written

$$Az^2 - 2(Q-f^2)Fz + (Q-f^2)H = 0. \quad . \quad . \quad (3)$$

Now the equation of the tangents from O to this curve will be the discriminant of the above equation considered as a quadratic in z.

Hence $\qquad R \equiv (Q-f^2)\{(Q-f^2)F - AH\} \equiv D_1D_2D_3D_4;$

we have, consequently,

$$Q - f^2 \equiv D_1,$$

D_1 being the equation of a pair of tangents from O to the curve multiplied by such a factor so that

$$Q - D_1 \equiv f^2.$$

There are eight R points as we have stated, and there are consequently twenty-eight ways of arranging the eight points in pairs; and consequently twenty-eight ways of reducing the equation of the curve to the form

$$Az^2 - 2DFz + DH = 0. \quad . \quad . \quad . \quad . \quad (4)$$

If we write $A \equiv a_1a_2a_3$, a_1, a_2 and a_3 being the tangents at triple point, we can show that our quintic can be regarded as the envelope of a certain cubic curve. Let k be so chosen that

$$k\,a_2a_3 + D \equiv \phi^2 \text{ say,}$$

then we have, multiplying the equation (4) by k and substituting for $k\,a_2a_3$ its value $\phi^2 - D$,

$$a_1(\phi^2 - D)z^2 - 2DFkz + kDH = 0;$$

or, $\qquad a_1(\phi z - D)^2 = D\{a_1z^2 + 2z(kF - a_1\phi) + a_1D - kH\}$

showing that the curve is the envelope of the cubic

$$a_1D(\rho-1)^2 - 2(\rho-1)(kF - \phi a_1) + \{a_1z^2 + 2z(kF - a_1\phi) + a_1D - kH\} = 0.$$

or, $\qquad a_1z^2 + 2z(kF - a_1\rho\phi) + \rho^2a_1D - kH = 0; \quad . \quad . \quad . \quad (5)$

and this cubic touches the curve in five points where it meets the conic

$$z\phi = D\rho.$$

7.—The equation of our quintic being

$$Az^2 - 2Bz + AQ = 0,$$

an equation which is obviously satisfied by $z = 0$, $A = 0$, it follows that the tangents at the triple point meet the curve again in three points which lie on a right line, this then is the characteristic of our quintic, *that the tangents at O meet the curve in three points which lie on a right line*; these points, we call the A points, and the line joining them meets the curve in two points which we call the Q points.

It is easy to see that each of the A points has O as a corresponding point, and consequently the arguments of the A points are seen to be $-N_0$, $-N_1$, and $-N_2$. If now we call Q and Q', the two points in which the line joining the A points meets the curve, and J and J' their integrals, as above defined, we must have

$$\left.\begin{aligned} J + J' - N &= N, \\ \text{or,} \qquad J + J' &= 2N. \end{aligned}\right\} \quad \ldots\ldots \quad (1)$$

The Q points play an important part in the geometry of our quintic.

8.—Any conic drawn through the Q points and O meets the curve in five points whose corresponding points lie on a line.

This theorem is readily proved as follows: we have

$$\Sigma\, I(\theta) + J + J' = N,$$

where Σ refers to the five values of the parameters of the points in in which the conic meets the quintic. Now we proved, in the last Article, that

$$J + J' = 2N.$$

Consequently,

$$\Sigma\, I(\theta) = -N,$$

or,

$$-\Sigma\, I(\theta) = N,$$

which proves the theorem, as $-I(\theta)$ is the value of $I(\theta)$ for the points corresponding to those in which the conic meets the curve.

9.—Given the curve, to determine the Q points. By aid of the theorem of the last Article, we can find the Q points by drawing any line meeting the curve in five points. By means of the ruler alone we can determine their five corresponding points, and through these latter points and O it will be found possible to draw a conic which will meet the curve in the required points.

Since we know the Q points, we can draw the tangents at the triple point.

All we have to do is to draw a line through the Q points meeting the curve in three other points, the lines joining these to O will touch the curve at O.

10.—If any line be drawn through one of the Q points, Q, meeting the curve in four other points, their corresponding points lie on a line which passes through Q'.

We have

$$\Sigma\, I(\theta) + J = N,$$

Σ referring to the four θs of the points in which the line through Q meet the curve. Now

$$J + J' = 2N;$$

therefore,

$$N - J = J' - N;$$

consequently,

$$-\Sigma\, I(\theta) + J' = N,$$

which proves the theorem.

On account of the importance of this theorem, we give another proof.

Let the factors of Q be q and q', so that

$$Q \equiv q q',$$

and let us seek the equation which determines the points in which a line $z = \lambda q$, drawn through one of the Q points meets the curve.

Substituting the value of z in the equation

$$A z^2 - 2Bz + AQ = 0,$$

we find

$$A\lambda^2 q^2 - 2B\lambda q + Aqq' = 0,$$

or, dividing by λq,

$$A(\lambda q + \lambda^{-1} q') - 2B = 0. \quad . \quad . \quad . \quad . \quad (1)$$

Now this is exactly the equation we should find to determine the points in which a line $z = \lambda^{-1}q'$ meets the curve; hence it follows that the lines

$$z - \lambda q = 0, \qquad z - \lambda^{-1}q' = 0$$

meet the curve in points which correspond.

Now, these two lines are obviously connected by a 1, 1 relation and the locus of their intersections is the conic $Q = z^2$ which we call the Q conic.

11.—The eight R points lie on the Q conic. For, if a line be drawn through O meeting the curve in two corresponding points P and P', the lines QP, $Q'P'$ intersect on the Q conic; consequently the Q conic must meet the curve in points which coincide with their corresponding points, or in other words the Q conic passes through the R points.

We shall show how to construct, geometrically, the Q conic, and consequently to determine, geometrically, the R points.

We have already shown how to determine the Q points; consequently, if we draw any three lines through one of the Q points, and through the other Q point the lines which correspond to them, we determine by their intersection three points, which, with the Q points, enables us to determine completely the Q conic.

The R points are then found by describing the Q conic as above indicated.

12.—To draw a tangent to the curve at a given point P. Join P to Q and Q' by lines PQ and PQ', meeting the curve in two sets of three points, one on each line whose arguments are, say, u and v.

Then we have, if θ refer to the point P,

$$\left.\begin{aligned} I(\theta) + u + J &= N, \\ I(\theta) + v + J' &= N, \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

from which we obtain by addition,

$$2I(\theta) + u + v + J + J' = 2N, \quad . \quad . \quad . \quad (2)$$

or, sum $\qquad J + J' = 2N,$

$$2I(\theta) + u + v = 0,$$

we may write this in the form

$$-u - a + \{N - 2I(\theta)\} = N, \quad . \quad . \quad . \quad . \quad (3)$$

the signification of which is that the O cubic through the triplets corresponding to u and v passes through the residual of the pair of consecutive points at P. We can, however, draw the tangent at P by means of two conics as follows—

Let $\quad u = a_1 + a_2 + a_3, \qquad v = b_1 + b_2 + b_3,$

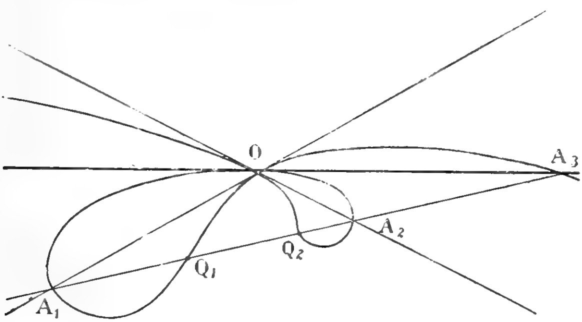
then through the points corresponding to the points a_1, a_2, b_1, b_2 describe an O conic meeting the quintic again in three points c_1, c_2, c_3.

Since $\quad 2I(\theta) + u + v = 0,$

we have $\quad 2I(\theta) + c_1 + c_2 + c_3 + a_3 + b_3 = N,$

which proves that the five points c_1, c_2, c_3, a_3, and b_3 lie on O conic which touches the quintic at P. Hence the tangent required is determined by drawing the tangent to this conic at P.

13.—If a line be drawn through one of the Q points to touch the curve in P, then the tangent at P', its corresponding point, will pass through Q', and the correspondence between the lines QP and $Q'P'$ will be of the kind noted in Article 10.



A_1, A_2, A_3 are the A points lying on a line, and Q and Q' the Q points.

Now twelve tangents can be drawn from each Q point to the curve, and to each tangent from Q, such as QP, corresponds a tangent $Q'P'$, so that the anharmonic ratio of any four tangents from Q is equal to that of the four corresponding tangents from Q'.

The twelve points of intersection, then, of the tangents from Q with the *corresponding* tangents from Q' lie on a conic through Q and Q'.

As the treatment of this quintic is so similar to that of the uninodal quartic, previously dealt with, it is only necessary to indicate how this curve may be submitted to the same manner of investigation with many similar results. We give a figure of the curve on page 45.

V.

THE MULTI-LINEAR QUATERNION FUNCTION.

By CHARLES JASPER JOLY, M.A., D.Sc., F.T.C.D., Royal Astronomer of Ireland, and Andrews' Professor of Astronomy in the University of Dublin.

[Read November 10, 1902.]

1. A bilinear quaternion function is symbolically defined by the equation

$$f(a+b,\ c+d) = f(a,\ c) + f(a,\ d) + f(b,\ c) + f(b,\ d), \qquad (1)$$

a, b, c, and d being any four quaternions. In other words, the function $f(p,\ q)$ is distributive with respect to its first quaternion p, and also with respect to its second quaternion q.

The quaternions e being arbitrarily assumed constants, the function may be expressed in the form

$$f(pq) = e_1 \mathrm{S}pf_1q + e_2 \mathrm{S}pf_2q + e_3 \mathrm{S}pf_3q + e_4 \mathrm{S}pf_4q\,; \qquad (2)$$

and is thus seen to involve sixty-four constants, sixteen in each linear function f_1, f_2, f_3, f_4.

2. Transposing the quaternions alters the function into its *permutate*, which may be distinguished by a sub-accent; thus

$$f(pq) = f_{\prime}(qp), \quad f(qp) = f_{\prime}(pq). \qquad (3)$$

If the linear functions in (2) are self-conjugate, the function is *permutable*, and conversely.

3. Introducing two new functions P and C defined by the equations

$$f(pq) = \mathrm{P}(pq) + \mathrm{C}(pq), \quad f_{\prime}(pq) = \mathrm{P}(pq) - \mathrm{C}(pq), \qquad (4)$$

it is evident that P is a permutable function, and that C changes sign with permutation; in fact (by (3) and (4)),

$$2\mathrm{P}(pq) = f(pq) + f(qp), \quad 2\mathrm{C}(pq) = f(pq) - f(qp). \qquad (5)$$

The function C may be called a *combinatorial* function, for

$$C(p + xq, q) = C(pq), \quad C(pp) = 0. \tag{6}$$

Thus an arbitrary bilinear function is reducible in one way to the sum of a permutable and a combinatorial function.

4. For all quaternions p, q, r, we agree to write

$$Spf(qr) = Sqf'(pr) = Srf''(qp); \tag{7}$$

and we call the new functions $f'(pq)$, $f''(pq)$, the *first* and *second conjugates*, respectively, of the given function. The phraseology is justified by the consideration that the first conjugate is *the* conjugate if the bilinear function is regarded as a *linear* function of its first quaternion.

5. Permuting the quaternions in (7) according to the rule (3), and taking the conjugates, we obtain the series of equal scalars

$$\begin{aligned} Spf(qr) &= Sqf'(pr) = Sr(f')''(pq) = Sq(f')_{,}(rp) \\ &= Srf''(qp) = Sr(f'')_{,}(pq) = Sq(f'')'(rp) \\ &= Spf_{,}(rq) = Sr(f_{,})'(pq) = Sq(f_{,})''(rp); \end{aligned} \tag{8}$$

and from these we obtain the relations

$$\begin{aligned} (f')''(pq) &= (f'')_{,}(pq) = (f_{,})'(pq) = f''(qp), \\ (f')_{,}(pq) &= (f'')'(pq) = (f_{,})''(pq) = f'(qp); \end{aligned} \tag{9}$$

where the brackets are employed to obviate any confusion as to the order in which the operations indicated by the accents have been performed.

These relations, taken in conjunction with the obvious relations

$$f(pq) = (f_{,})_{,}(pq) = (f')'(pq) = (f'')''(pq), \tag{10}$$

enable us to reduce any multiply-accented function to one or other of the six fundamental functions,—the function and its two conjugates, the permutate and its two conjugates.

6. Having now explained the fundamental principles underlying the manipulation of bilinear functions, we shall indicate some of the uses to which they may be applied.

A quaternion being interpreted as representing a point, the equation

$$r = f(pq) \tag{11}$$

establishes a relation between three points p, q, and r.

Let p be supposed given and constant. In this case we have the general homographic transformation in space for a set of points (q) to another set (r). The nature of this transformation is changed for every change in the constant p; and the equation may be taken to represent what Sir Robert Ball might have called a *four-system* of homographic transformations. The four-system of transformations is more clearly exhibited by writing

$$p = t_1 a_1 + t_2 a_2 + t_3 a_3 + t_4 a_4, \tag{12}$$

where the symbols a denote given and constant quaternions, while the symbols t denote scalar parameters. Thus the linear transformation is

$$r = t_1 f(a_1 q) + t_2 f(a_2 q) + t_3 f(a_3 q) + t_4 f(a_4 q); \tag{13}$$

and it is compounded from the four given linear transformations

$$f(a_1 q), \quad f(a_2 q), \quad f(a_3 q), \quad \text{and} \quad f(a_4 q).$$

7. In the second place, consider r to be a constant quaternion, while p and q are variable, subject to the condition (11).

The equation then represents the general *space homography* connecting two points p and q, so that if one is given, the other is generally uniquely determinate.

Again, as in (12), we may replace r by

$$r = s_1 b_2 + s_2 b_2 + s_3 b_3 + s_4 b_4; \tag{14}$$

and, according to the various values assignable to the scalars s, we obtain a four-system of space homographies.

8. In the third place, let $p = q$; then we have (Art. 3),

$$r = f(qq) = \mathrm{P}(qq); \tag{15}$$

and this represents the general quadratic transformation in space, so that to one point q corresponds one point r, and to one point r correspond eight points q determined by the intersections of three quadric surfaces

$$Sr_1 r = Sr_1 \mathrm{P}(qq) = 0, \quad Sr_2 r = Sr_2 \mathrm{P}(qq) = 0, \quad Sr_3 r = Sr_3 \mathrm{P}(qq) = 0, \tag{16}$$

where $Sr_1 r = 0$, &c. are any three planes through the point r.

9. In the fourth place, write

$$r = \tfrac{1}{2}f(pq) - \tfrac{1}{2}f(qp) = \mathrm{C}\,(pq)\,; \tag{17}$$

and we find an equation which represents a one-to-one correspondence between *lines pq* and *points r*.

10. Again, consider the mutual relations of three points p, q, and r, which satisfy the equation

$$\mathrm{S}pf(qr) = 0. \tag{18}$$

If $p = q = r$, the equation

$$\mathrm{S}rf(rr) = 0, \quad \text{or} \quad \mathrm{S}r\mathrm{P}\,(rr) = 0, \tag{19}$$

represents the general cubic surface, and with this surface are associated systems of linear complexes,

$$\mathrm{S}p\,(f(qr) - f(qr)) = 0, \quad \text{or} \quad \mathrm{S}p\mathrm{C}\,(qr) = 0, \tag{20}$$

so that to each value of p corresponds a linear complex represented by (19).

This is quite analogous to the quadric surface and the correlated linear complex

$$\mathrm{S}qfq = 0, \quad \mathrm{S}pfq - \mathrm{S}qfp = 0, \tag{21}$$

obtainable from a linear function f.

Further, by suitable permutation of the quaternions in (18), we may obtain an equation of the form

$$(lpqr) = 0, \tag{22}$$

which is combinatorial with respect to p, q, and r, where l is a constant quaternion determined by the nature of the function f. This equation (22) represents a determinate fixed plane which contains the points p, q, and r.

11. Similarly, for the trilinear function, various analogous results may be deduced; but there is one which deserves special mention. The equation

$$p = f(a, b, q), \tag{23}$$

in which a and b are quaternion constants arbitrarily assignable, represents the *complete group of homographic transformations in space*, or the whole *sixteen-system* of such transformations. This appears on expressing a and b in terms of sets of scalar parameters; and then from (23) we obtain sixteen distinct transformations corresponding to the sixteen products of the scalars of one set by those of the other.

12. From the equation for a trilinear function

$$Saf(bcd) = 0, \tag{24}$$

it is easy to derive, by permutation and conjugation, scalar equations of the form

$$F(\{ab\}, \{cd\}) = 0, \tag{25}$$

which is combinatorial with respect to a and b, and also with respect to c and d. Thus given a line ab, (25) represents a linear complex; and in this equation there is a relation between line and complex and complex and line, somewhat analogous to the relations connecting generators of opposite systems of a quadric.

13. It is possible by suitable permutation to derive from $f(abc)$ a combinatorial function of a, b, c; or, in other words, a linear function (compare (27))

$$F[abc] \tag{26}$$

of the symbol of the plane $[abc]$ containing these points. And in like manner from $Saf(bcd)$, we may deduce a scalar combinatorial function of the four points; but this is simply $(abcd)$ multiplied by a scalar determined by the nature of the function.

Following out this line, it appears at once that the various permutates of a function of the fifth order are not independent. In fact, for the trilinear function, we find the combinatorial function (26), or more fully

$$f(abc) + f(bca) + f(cab) - f(cba) - f(bac) - f(acb); \tag{27}$$

and similarly from the permutates of a function of the fifth order, we can obtain a combinatorial function of the five quaternions a, b, c, d, e, and the function $F(abcde)$. But a combinatorial function of five quaternions is zero; and consequently the $\Pi 5$ permutates of the function are connected by one identical relation. In like manner, for functions of higher order, the permutates obtained from any group of five quaternions are linearly connected; and the number of distinct permutates is reduced in this way to

$$\Pi n - \frac{n \,.\, n-1 \,.\, n-2 \,.\, n-3 \,.\, n-4}{\Pi 5}. \qquad (28)$$

Similarly the conjugates and permutates of a function of the fourth order are connected because $Saf(bcde)$ is a particular case of the function of the fifth order.

The number of conjugates and permutates formed on the plan of Art. 5 is, in the first instance, $\Pi(n+1)$. This reduces, for the reasons given, to

$$\Pi(n+1) - \frac{\Pi(n+1)}{\Pi 5\, \Pi(n-5)} - \frac{\Pi n}{\Pi 4\, \Pi(n-4)}. \qquad (29)$$

VI.

ON BICURSAL CURVES.

By REV. WILLIAM RALPH WESTROPP ROBERTS, M.A.,

Fellow Trinity College, Dublin.

[Read JANUARY 26, 1903.]

It is well known that the coordinates of any point on a curve which possesses its maximum number of double points can be expressed as rational algebraic functions of a variable parameter. The converse theorem is also true, namely, that if the coordinates of a curve are expressed as rational functions of a parameter, such a curve possesses the maximum number of double points. Curves of this nature are termed unicursal curves, and to each value of the parameter corresponds one and one point only lying on the curve.

We propose to consider in this paper curves which we shall call *bicursal*, since to each value of the parameter, in terms of which the coordinates of the curve are expressed, correspond two points lying on the curve.

We suppose then, that the coordinates of such a curve are expressed in terms of a parameter in the following manner :—

$$(1) \qquad x = A_1 + B_1 \sqrt{R}.$$

$$y = A_2 + B_2 \sqrt{R}.$$

$$z = A_3 + B_3 \sqrt{R}.$$

Where A_1, A_2, A_3, are binary quantics of the m^{th} degree in two variables λ and μ, the ratio of λ to μ being regarded as the parameter determining the points on the curve, R is a binary quantic of the $2n^{th}$ degree, and B_1, B_2, B_3 binary quantics of $(m - n)^{th}$ degree in λ and μ.

Such equations obviously remain unchanged in form for any linear transformation of the variables λ and μ.

In order to determine the degree of a curve given by the above equations we have only to ascertain the number of points in which an arbitrary line meets it.

Let the equation of such a line be $lx + my + nz$; and we have evidently the following equation to determine the ratio of λ to μ, or the parameter of each point in which the line meets the curve:—

$$(2) \qquad lA_1 + mA_2 + nA_3 + (lB_1 + mB_2 + nB_3)\sqrt{R} = 0,$$

$$\text{or} \quad (lA_1 + mA_2 + nA_3)^2 = (lB_1 + mB_2 + nB_3)^2 R.$$

Now this being an equation of the $2m^{th}$ degree, the degree of the curve is, in general, $2m$.

We now proceed to investigate the number, and determine the position of, the double points on the curve.

In order to make clear the spirit of our method we shall first show how the double points on the unicursal curve given by the equations,

$$(3) \qquad x = A_1, \quad y = A_2, \quad z = A_3.$$

A_1, A_2, A_3, being binary quantics of the m^{th} degree in λ and μ, may be determined.

Let $U = 0$ be the equation of the curve in x, y, z, which results from the elimination of the parameter from the above equations; and let us call L, M, and N, the differential coefficients of U with regard to x, y, and z, respectively.

We have then, for any point on the curve $Lx + My + Nz = 0$, and for the consecutive point $Ldx + Mdy + Ndz = 0$.

Hence we easily see that we must have

(4)

$$L\left(\lambda\frac{dx}{d\lambda} + \mu\frac{dx}{d\mu}\right) + M\left(\lambda\frac{dy}{d\lambda} + \mu\frac{dy}{d\mu}\right) + N\left(\lambda\frac{dz}{d\lambda} + \mu\frac{dz}{d\mu}\right) = 0,$$

$$L\left(\frac{dx}{d\lambda}d\lambda + \frac{dx}{d\mu}d\mu\right) + M\left(\frac{dy}{d\lambda}d\lambda + \frac{dy}{d\mu}d\mu\right) + N\left(\frac{dz}{d\lambda}d\lambda + \frac{dz}{d\mu}d\mu\right) = 0,$$

since x, y, and z are homogeneous functions of the m^{th} degree in λ and μ.

But these equations show us that L, M, and N are proportional to the determinants

$$\begin{vmatrix} \frac{dy}{d\lambda} & \frac{dz}{d\lambda} \\ \frac{dy}{d\mu} & \frac{dz}{d\mu} \end{vmatrix}, \quad \begin{vmatrix} \frac{dz}{d\lambda} & \frac{dx}{d\lambda} \\ \frac{dz}{d\mu} & \frac{dx}{d\mu} \end{vmatrix}, \quad \begin{vmatrix} \frac{dx}{d\lambda} & \frac{dy}{d\lambda} \\ \frac{dx}{d\mu} & \frac{dy}{d\mu} \end{vmatrix}.$$

Now we may write

$$\frac{dy}{d\lambda}\,\frac{dz}{d\mu} - \frac{dy}{d\mu}\,\frac{dz}{d\lambda} = J(A_2, A_3),$$

where J stands for the Jacobian of the quantics A_2 and A_3, and where it is to be remembered that

$$J(A_2, A_3) = -J(A_3, A_2).$$

Consequently we may write

$$(5) \qquad \begin{aligned} L &= \Lambda\, J(A_2, A_3), \\ M &= \Lambda\, J(A_3, A_1), \\ N &= \Lambda\, J(A_1, A_2), \end{aligned}$$

where Λ is some quantity yet to be determined.

Now the equation of the curve being of the m^{th} degree, $\frac{dU}{dx}$ is of the $(m-1)^{th}$ in x, y, and z, and, as these are each of the degree m in the parameter, L, regarded as a function of the parameter, is of the $m(m-1)^{th}$ degree.

The system of equations (5), however, shows us that L, M, and N are proportional to functions of the parameter of the degree

$$2m - 2, \text{ for } J(A_2, A_3),\ J(A_3, A_1),\ J(A_1, A_2)$$

are of the degree $2m - 2$.

Hence, it follows that L, M, N, when expressed in terms of the parameter, contain a common factor Λ whose degree in λ and μ must be equal to the difference between $m(m-1)$ and $2(m-1)$, or $m^2 - 3m + 2$.

L, M, and N can thus simultaneously vanish for the

$$(m-1)(m-2) \text{ roots of } \Lambda = 0.$$

Now, we know that to each double point correspond two values of the parameter, that is to say, one corresponding to each branch of the curve on which the double point lies. The number of double points is consequently equal to half the number

$$(m-1)(m-2) \text{ or } \tfrac{1}{2}(m-1)(m-2).$$

Having found the equation of the curve, we are then to find the greatest common measure of L, M, and N which will give us the function Λ, and consequently the double points on the curve. This is most simply done by dividing L by $J(A_2, A_3)$.

We now turn to the discussion of the curve given by the equations

$$x = A_1 + B_1\sqrt{R}.$$

$$y = A_2 + B_2\sqrt{R}.$$

$$z = A_3 + B_3\sqrt{R}.$$

Proceeding in the same manner as that adopted in the case of the unicursal curve, we find

L is proportional to the determinant,

$$\begin{vmatrix} \dfrac{dA_2}{d\lambda} + \sqrt{R}\,\dfrac{dB_2}{d\lambda} + \dfrac{B_2\dfrac{dR}{d\lambda}}{2\sqrt{R}} & \dfrac{dA_3}{d\lambda} + \sqrt{R}\,\dfrac{dB_3}{d\lambda} + \dfrac{B_3\dfrac{dR}{d\lambda}}{2\sqrt{R}} \\ \dfrac{dA_3}{d\mu} + \sqrt{R}\,\dfrac{dB_3}{d\mu} + \dfrac{B_2\dfrac{dR}{d\mu}}{2\sqrt{R}} & \dfrac{dA_3}{d\mu} + \sqrt{R}\,\dfrac{dB_3}{d\mu} + \dfrac{B_3\dfrac{dR}{d\mu}}{2\sqrt{R}} \end{vmatrix},$$

or,

$$(6)\quad L = \Lambda\{2R[J(A_1, B_2) + J(B_1, A_2)] + B_2J(A_1, R) + B_1J(R_1 A_2),$$

$$+\sqrt{R}[2J(A_1, A_2) + 2RJ(B_1 B_2) + B_2J(B_1, R) + B_1J(R, A_2)]\}.$$

Now the degree of R is $2n$, that of $J(A_1\, B_2)$ is

$$m - 1 + m - n - 1, \quad \text{or} \quad 2m - n - 2,$$

and consequently the function multiplied by Λ is of the degree $2m + n - 2$ in λ and μ.

But the degree of the curve is $2m$ and consequently the degree of L, M, N, considered as functions of the parameter, will be of the $(2m-1)\,m^{th}$ degree involving $\sqrt{R}$ which is of the n^{th} degree.

And we infer, as before, that the degree of Λ is

$$(2m-1)\,m-(2m+n-2),$$

or

$$\tfrac{1}{2}\{(2m-1)\,2m-4m-2n+4\}.$$

Hence the degree of Λ is

$$\tfrac{1}{2}(p-1)\,(p-2)-(n-1),$$

where $p=2m$.

It must be remembered, however, that as Λ involves $\sqrt{R}$, the equation $\Lambda=0$ must be rationalised to solve it; and consequently the number of roots of this equation, when freed from radicals, is of the degree $(p-1)\,(p-2)-2\,(n-1)$, and admits of as many roots. But, since each double point has two values of the parameter corresponding to it according to the branch on which it lies, the number of the double points of the curve in question is

$$\tfrac{1}{2}(p-1)\,(p-2)-(n-1),$$

that is to say that the deficiency of the curve is $(n-1)$.

The degree of the curve may, however, be reduced if A_1, A_2, A_3 contain a common factor which is also common to R. If the degree of the factor be r, the degree of the curve will be reduced by r.

This is easily seen by determining the values of the parameters corresponding to the points of sections of the curve with an arbitrary right line, when it will appear that the common factor will divide the equation when made rational. The degree then of the curve is

$$p=2m-r.$$

Such a curve is represented by the system of equations

$$x=A_1u+B_1\sqrt{uS}.$$

$$y=A_2u+B_2\sqrt{uS}.$$

$$z=A_3u+B_3\sqrt{uS}.$$

where A_1, A_2, and A_3 are of the $(m-r)^{th}$ degree in λ and μ.

u is of the r^{th} degree and B_1, B_2, B_3, of the $(m-n)^{th}$ degree, the function under the square root being of the degree $2n$.

If we refer to the equation for L in equation 6, we see that, in the present case, it contains the factor u, so that L, M, and N are proportional to functions of the degree

$$2m - 2 + n - r,$$

while L, M, and N, considered as functions of λ and μ, are of the degree

$$m(p-1) - r\frac{(p-1)}{2},$$

when we reject the common factors, and consequently the degree of Λ will be

$$\frac{(p-1)(p-2)}{2} - (n-1).$$

Hence, *in general*, a bicursal curve of the degree p has its deficiency equal to $(n-1)$ where $2n$ is the degree of the quantic under the radical.

In our next paper we shall treat of a special class of bicursal curves.

VII.

THE GEOMETRICAL MEANING OF CAYLEY'S FORMULÆ OF ORTHOGONAL TRANSFORMATION.

BY C. H. HINTON, Patent Office, U.S.A.

[COMMUNICATED BY PROFESSOR A. C. HADDON, F.R.S.]

Read NOVEMBER 29, 1902.

CAYLEY has given the geometrical significance of his formulæ of transformation in the case of three axes. In Vol. XII., *American Journal of Mathematics*, Cole has shown the geometrical significance of the formulæ in a special case for four dimensions. In order to discuss the question of the significance of the general case in four dimensions, I will write down all the forms which can come from any combination of axes and angles. It will be seen that Cayley's forms in the general case are incapable of geometrical significance in terms of axes and angles.

A very convenient form of quaternion symbolism can be used of space of 2^n dimensions, which I will adopt in the present discussion.

Let i, j, k, h be unit vectors mutually perpendicular. Assume

$$i^2 = j^2 = k^2 = h^2 = +1.$$

Let a transposition be accompanied by a change of sign. Taking the two possible Hamiltonian circuitings

$$ijkh = +1, \quad ijkh = -1,$$

let us distinguish between the two systems of equations derivable by calling those derived from $ijkh = +1$ the A kind, and those from $ijkh = -1$ the B kind.

To distinguish when the latter equation is used, introduce a symbol ω, which has simply the significance that the vector symbols after it are combined—according to the $ijkh = -1$ laws.

From the A form $\qquad ijkh = +1,$

we get $\qquad ijk = h, \qquad ij = hk, \qquad ji = kh;$

from the B form $\qquad ijkh = -1,$

we get $\qquad ijk = -h, \qquad ij = -hk, \qquad ji = hk.$

Hence, introducing the symbol ω, we get $\omega ji = \omega hk$, &c.

By using the equations $i^2 = 1$, &c., we get the following multiplication tables:—

Multiplier	i	j	k	h		i	j	k	h
$kh = ji$	j	$-i$	$-h$	k	$\omega hk = \omega ji$	j	$-i$	h	$-k$
$ih = kj$	$-h$	k	$-j$	i	$\omega hi = \omega kj$	h	k	$-j$	$-i$
$jh = ik$	$-k$	$-h$	i	j	$\omega hj = \omega ik$	$-k$	h	i	$-j$.

Here the ω simply denotes that expressions like ωji operate according to the B system.

Now, consider the effect of multiplying ji into

$$xi + yj + zk + wh:$$

we get

$$+ xj - yi - zh + wk,$$

or the projections of the vector are turned by right angles in each of the coordinate planes of ij and kh; ωji gives

$$+ xj - yi + zh - wk,$$

which differs from the last result in that, in the plane of kh, the rotation is in the opposite direction. Hence

$$(\cos\theta' + \sin\theta'\omega ji)(\cos\theta + \sin\theta ji)$$

will turn a vector by the angle $\theta + \theta'$ in the plane of ij, and by the angle $\theta - \theta'$ in the perpendicular plane of kh. Hence ji can be represented as a plane pair—that of ji and of kh.

Now i, j, k, h are any unit lines mutually perpendicular in space: hence this symbolism is perfectly general; and, introducing the six coordinates which define any plane, we have enough constants to determine the next more general rotation—a rotation, namely, in the plane of $\lambda_1\lambda_2$, where λ_1 and λ_2 are any perpendicular unit vectors, by a given angle, and in the plane perpendicular to $\lambda_1\lambda_2$ by another given angle.

The plane $\lambda_1\lambda_2$ has direction cosines $\gamma\alpha\beta$, $\gamma'\alpha'\beta'$ subject to the two equations

$$\alpha^2 + \beta^2 + \gamma^2 + \alpha'^2 + \beta'^2 + \gamma'^2 = 1,$$

and

$$\alpha\alpha' + \beta\beta' + \gamma\gamma' = 0,$$

which give also

$$(\alpha + \alpha')^2 + (\beta + \beta')^2 + (\gamma + \gamma')^2 = 1.$$

Writing $\lambda_1\lambda_2$ as

$$\gamma ji + \alpha kj + \beta ik + \gamma' kh + \alpha' ih + \beta' jh,$$

we see that, by the equations derived from $ijkh = +1$, it becomes

$$(\gamma + \gamma')ji + (\alpha + \alpha')kj + (\beta + \beta')ik,$$

and represents a plane pair whose constituents are to a certain extent indeterminate, the plane pair is derived from all those perpendicular planes, the corresponding sums of whose direction cosines are the same. By "perpendicular," I mean perpendicular like ji and kh, not normal, like the planes of ji and kj.

Any of these plane pairs will turn a vector round in the plane of $\lambda_1\lambda_2$, and in the perpendicular plane.

Now, consider the ω form of the plane $\lambda_1\lambda_2$,

$$\omega\,(\gamma ji + \alpha kj + \beta ik + \gamma' kh + \alpha' ih + \beta' jh)\,;$$

we obtain the plane pair

$$(\gamma - \gamma')\,\omega ji + (\alpha - \alpha')\,\omega kj + (\beta - \beta')\,\omega ik.$$

This plane pair rotates a vector in the plane of $\lambda_1\lambda_2$, and in the perpendicular plane by a right angle in the direction k to h.

Hence the product

$$\begin{gathered}[\cos\theta + \sin\theta\,\{(\gamma+\gamma')ji + (\alpha+\alpha')\,kj + (\beta+\beta')\,ik\}] \\ \times\,[\cos\theta + \sin\theta\,\{(\gamma-\gamma')\,\omega ji + (\alpha-\alpha')\,\omega kj + (\beta-\beta')\,\omega ik\}]\end{gathered}$$

will rotate a vector by 2θ in the plane of $\lambda_1\lambda_2$; and its projection on the perpendicular plane will be unaltered.

If, instead of taking both angles equal, we take different angles θ and ϕ, we get the rotation of amplitude $\theta + \phi$ in the plane of $\gamma, \alpha, \beta, \gamma', \alpha', \beta'$, and $\theta - \phi$ in the perpendicular plane. It is most convenient to take n, l, m, n', l', m' as the direction cosines of a plane, instead of γ, α, β, &c., and denote the sums $n + n'$, &c., by γ, α, β, the differences $n - n'$, &c., by γ', α', β'. The most general rotation is given by letting both angles be different, and taking two plane pairs

$$\gamma ji + \alpha kj + \beta ik, \quad \text{and} \quad \gamma'\omega ji + \alpha'\omega kj + \beta'\omega ik,$$

which I will call π_1 and $\omega\pi'_1$, where γ and γ', &c., are unrelated, and γ and γ' stand respectively for $n + n'$ and $N - N'$, and so on, where lmn, $l'm'n'$, LMN, $L'M'N'$ are the direction cosines of two independent planes.

In order to present the multiplication in a conspicuous form, I write out the multiplication table of the quaternions, with the coefficient adjacent. By assigning values to $\theta, \phi, \theta', \phi', \gamma, \gamma', c, c'$, &c., we can find the combined rotation equivalent to any pair of rotations. For $\cos\theta$ I write θ_1, and $\sin\theta$, θ. It will be found that ωji and ji are commutative as well as any other A and B pairs. The multiplier occupies the two columns to the left.

TABLE 1.—SHOWING PRODUCT

Multiplier.		$\theta_1\phi_1$ 1	$\gamma\theta\phi_1$ ji	$\gamma'\theta_1\phi$ ωji	$\alpha\theta\phi_1$ kj	$\alpha'\theta_1\phi$ ωkj	$\beta\theta\phi_1$ ik	$\beta'\theta_1\phi$ ωik
$\theta'_1\phi'_1$	1	1	ji	ωji	kj	ωkj	ik	ωik
$c\theta'\phi'_1$	ji	ji	-1	$\omega ji . ji$	ik	$\omega kj . ji$	$-kj$	$\omega ik . ji$
$c'\theta'_1\phi'$	ωji	ωji	$\omega ji . ji$	-1	$\omega ji . kj$	ωik	$\omega ji . ik$	$-\omega kj$
$a\theta'\phi'_1$	kj	kj	$-ik$	$\omega ji . kj$	-1	$\omega kj . kj$	ji	$\omega ik . kj$
$a'\theta'_1\phi'$	ωkj	ωkj	$\omega kj . ji$	$-\omega ik$	$\omega kj . kj$	-1	$\omega kj . ik$	ωji
$b\theta'\phi'_1$	ik	ik	kj	$\omega ji . ik$	$-ji$	$\omega kj . ik$	-1	$\omega ik . ik$
$b'\theta'_1\phi'$	ωik	ωik	$\omega ik . ji$	ωkj	$\omega ik . kj$	$-\omega ji$	$\omega ik . ik$	-1
$c'c\theta'\phi'$	$\omega ji . ji$	$\omega ji . ji$	$-\omega ji$	$-ji$	$\omega ji . ik$	$\omega ik . ji$	$-\omega ji . kj$	$-\omega kj . ji$
$aa'\theta'\phi'$	$\omega kj . kj$	$\omega kj . kj$	$-\omega kj . ik$	$-\omega ik . kj$	$-\omega kj$	$-kj$	$\omega kj . ji$	$\omega ji . kj$
$bb'\theta'\phi'$	$\omega ik . ik$	$\omega ik . ik$	$\omega ik . kj$	$-\omega kj . ik$	$-\omega ik . ji$	$-\omega ji . ik$	$-\omega ik$	$-ik$
$c'a\theta'\phi'$	$\omega ji . kj$	$\omega ji . kj$	$-\omega ji . ik$	$-kj$	$-\omega ji$	$\omega ik . kj$	$\omega ji . ji$	$-\omega kj . kj$
$ca'\theta'\phi'$	$\omega kj . ji$	$\omega kj . ji$	$-\omega kj$	$-\omega ik . ji$	$\omega kj . ik$	$-ji$	$-\omega kj . kj$	$\omega ji . ji$
$a'b\theta'\phi'$	$\omega kj . ik$	$\omega kj . ik$	$\omega kj . kj$	$-\omega ik . ik$	$-\omega kj . ji$	$-ik$	$-\omega kj$	$\omega ji . ik$
$ab'\theta'\phi'$	$\omega ik . kj$	$\omega ik . kj$	$-\omega ik . ik$	$\omega kj . kj$	$-\omega ik$	$-\omega ji . kj$	$\omega ik . ji$	$-kj$
$b'c\theta'\phi'$	$\omega ik . ji$	$\omega ik . ji$	$-\omega ik$	$\omega kj . ji$	$\omega ik . ik$	$-\omega ji . ji$	$-\omega ik . kj$	$-ji$
$bc'\theta'\phi'$	$\omega ji . ik$	$\omega ji . ik$	$\omega ji . kj$	$-ik$	$-\omega ji . ji$	$\omega ik . ik$	$-\omega ji$	$-\omega kj . ik$

θ_1 is written for $\cos\theta$, and θ for $\sin\theta$.

A ROTATOR BY A ROTATOR.

$\gamma'\theta\phi$ ji . ji	$\alpha\alpha'\theta\phi$ ωkj . kj	$\beta\beta'\theta\phi$ ωik . ik	$\alpha\gamma'\theta\phi$ ωji . kj	$\alpha'\gamma\theta\phi$ ωkj . ji	$\alpha'\beta\theta\phi$ ωkj . ik	$\alpha\beta'\theta\phi$ ωik . kj	$\beta'\gamma\theta\phi$ ωik . ji	$\gamma'\beta\theta\phi$ ωji . ik
ji . ji	ωkj . kj	ωik . ik	ωji . kj	ωkj . ji	ωkj . ik	ωik . kj	ωik . ji	ωji . ik
ωji	ωkj . ik	− ωik . kj	ωji . ik	− ωkj	− ωkj . kj	ωik . ik	− ωik	− ωji . kj
− ji	ωik . kj	− ωkj . ik	− kj	ωik . ji	ωik . ik	− ωkj . kj	− ωkj . ji	− ik
ji . ik	− ωkj	ωik . ji	− ωji	− ωkj . ik	ωkj . ji	− ωik	− ωik . ik	ωji . ji
ik . ji	− kj	ωji . ik	− ωik . kj	− ji	− ik	ωji . kj	ωji . ji	− ωik . ik
i . kj	− ωkj . ji	− ωik	− ωji . ji	ωkj . kj	− ωkj	− ωik . ji	ωik . kj	− ωji
j . ji	− ωji . kj	− ik	ωkj . kj	− ωji . ji	− ωji . ik	− kj	− ji	ωkj . ik
+ 1	ωik . ik	ωkj . kj	− ik	− ωik	− ωik . kj	− ωkj . ik	ωkj	kj
k . ik	+ 1	ωji . ji	ωik	ik	− ji	− ωji	− ωji . ik	− ωik . ji
j . kj	ωji . ji	1	− ωkj . ji	− ωji . kj	ωji	ji	− kj	− ωkj
ik	− ωik	− ωkj . ji	1	− ωik . ik	ωik . ji	ωkj	ωkj . ik	− ji
ik	− ik	− ωji . kj	− ωik . ik	1	kj	ωji . ik	− ωji	ωik . kj
k . kj	ji	− ωji	ωik . ji	− kj	1	− ωji . ji	ωji . kj	ωik
kj . ik	ωji	− ji	− ωkj	ωji . ik	− ωji . ji	1	ik	ωkj . ji
ωkj	− ωji . ik	kj	ωkj . ik	ωji	ωji . kj	− ik	1	− ωkj . kj
kj	− ωik . ji	ωkj	ji	ωik . kj	− ωik	ωkj . ji	− ωkj . kj	1

θ_1 is written for $\cos\theta$, and θ for $\sin\theta$.

From the foregoing Table 1, we can write down the coefficient of the compounded rotator by simply collecting terms, and can, by a simple calculation, find the angle and axis planes of the compound rotation.

TABLE 2.—SHOWING MULTIPLICATION OF ROTATOR INTO A VECTOR.

		x i	y j	z k	w h
$\theta_1\phi_1$	1	i	j	k	h
$\theta\phi_1\gamma$	ji	j	$-i$	$-h$	k
$\theta_1\phi\gamma'$	ωji	j	$-i$	h	$-k$
$\theta\phi_1\alpha$	kj	$-h$	k	$-j$	i
$\theta_1\phi\alpha'$	ωkj	h	k	$-j$	$-i$
$\theta\phi_1\beta$	ik	$-k$	$-h$	i	j
$\theta_1\phi\beta'$	ωik	$-k$	h	i	$-j$
$\theta\phi\gamma\gamma'$	$\omega ji\,.\,ji$	$-i$	$-j$	k	h
$\theta\phi\alpha\alpha'$	$\omega kj\,.\,kj$	i	$-j$	$-k$	h
$\theta\phi\beta\beta'$	$\omega ik\,.\,ik$	$-i$	j	$-k$	h
$\theta\phi\alpha\gamma'$	$\omega ji\,.\,kj$	k	h	i	j
$\theta\phi\alpha'\gamma$	$\omega kj\,.\,ji$	k	$-h$	i	$-j$
$\theta\phi\alpha'\beta$	$\omega kj\,.\,ik$	j	i	h	k
$\theta\phi\alpha\beta'$	$\omega ik\,.\,kj$	j	i	$-h$	$-k$
$\theta\phi\beta'\gamma$	$\omega ik\,.\,ji$	h	k	j	i
$\theta\phi\beta\gamma'$	$\omega ji\,.\,ik$	$-h$	k	j	$-i$

θ_1 is written for $\cos\theta$, and θ for $\sin\theta$.

Table 2 shows the effect of multiplying the quaternion $(\theta_1 + \theta\pi_1)(\phi_1 + \phi\pi'_1)$ into a vector.

The direction cosines of a transformation can be found from Table 2 by collecting the terms: $xi + yj + zk + wh$ becomes

$$
\begin{aligned}
& i\big[x\{\theta_1\phi_1 - \theta\phi(\gamma\gamma' - \alpha\alpha' + \beta\beta')\} + y\{-\theta\phi_1\gamma - \theta_1\phi\gamma' + \theta\phi(\alpha'\beta + \alpha\beta')\} \\
& \quad + z\{\theta\phi_1\beta + \theta_1\phi\beta' + \theta\phi(\alpha\gamma' + \alpha'\gamma)\} + w\{\theta\phi_1\alpha - \theta_1\phi\alpha' + \theta\phi(\beta'\gamma - \beta\gamma')\}\big] \\
& + j\big[x\{\theta\phi_1\gamma + \theta_1\phi\gamma' + \theta\phi(\alpha'\beta + \alpha\beta')\} + y\{\theta_1\phi_1 - \theta\phi(\gamma\gamma' + \alpha\alpha' - \beta\beta')\} \\
& \quad + z\{-\theta\phi_1\alpha - \theta_1\phi\alpha' + \theta\phi(\beta'\gamma + \beta\gamma')\} + w\{\theta\phi_1\beta - \theta_1\phi\beta' + \theta\phi(\alpha\gamma' - \alpha'\gamma)\}\big] \\
& + k\big[x\{-\theta\phi_1\beta - \theta_1\phi\beta' + \theta\phi(\gamma\alpha' + \alpha'\gamma)\} + y\{\theta\phi_1\alpha + \theta_1\phi\alpha' + \theta\phi(\beta\gamma' + \beta'\gamma)\} \\
& \quad + z\{\theta_1\phi_1 - \theta\phi(\alpha\alpha' + \beta\beta' - \gamma\gamma')\} + w\{\theta_1\phi_1\gamma - \theta\phi\gamma' + \theta\phi(\alpha'\beta - \alpha\beta')\}\big] \\
& + h\big[x\{-\theta\phi_1\alpha + \theta_1\phi\alpha' + \theta\phi(\beta'\gamma - \beta\gamma')\} + y\{-\theta\phi_1\beta + \theta_1\phi\beta' + \theta\phi(\alpha\gamma' - \alpha'\gamma)\} \\
& \quad + z\{-\theta\phi_1\gamma + \theta_1\phi\gamma' + \theta\phi(\alpha'\beta - \alpha\beta')\} + w\{\theta_1\phi_1 + \theta\phi(\gamma\gamma' + \alpha\alpha' + \beta\beta')\}\big].
\end{aligned}
$$

These formulæ agree with Cayley's if $\theta = \phi$, and $\gamma = n + n'$, &c., $\gamma' = n - n'$, &c., in which case the rotation is about a plane, by the angle 2θ.

In no case, however, can they be made to assume his general form. The reason appears to be that he starts from the determinants

$$\begin{vmatrix} z & b & c & d \\ -b & z & f & g \\ -c & -d & z & h \\ -d & -g & -h & z \end{vmatrix},$$

and the form with the rows and columns interchanged in defining his quantities a, b, c, f, g, h. Now an inspection of the form above shows that the determinant of a transformation effected by any kind of rotation cannot assume this form. Hence there is no geometrical interpretation of Cayley's constants with angles and axial planes.

VIII.

METHOD OF OBTAINING THE CUBIC CURVE HAVING THREE GIVEN CONICS AS POLAR CONICS.

By J. P. JOHNSTON, Sc.D.

Read June 22, 1903.

The problem to obtain the cubic which will have three given conics as polar conics was solved by Dr. Salmon (*Conics*, § 389 *c*) by finding the equation of the cubic when the equations of each of the conics was written in the form

$$ax^2 + by^2 + cz^2 + dw^2 = 0.$$

The form in which he obtained the cubic in this case enabled him to state at once that in the general case the cubic was the Hessian of the Jacobian of the three conics minus twice the Jacobian multiplied by the invariant T. The following is a different method of investigating the same problem, by which it is seen at once that the solution, where possible, is unique.

Let the equations of the conics be

$$u \equiv (a,\ b,\ c,\ f,\ g,\ h \between xyz)^2 = 0.$$

$$v \equiv (a',\ b',\ c',\ f',\ g',\ h' \between xyz)^2 = 0,$$

$$w \equiv (a'',\ b'',\ c'',\ f'',\ g'',\ h'' \between xyz)^2 = 0.$$

If these transform to

$$U \equiv \frac{1}{3}\frac{d\Phi}{dX}, \quad V \equiv \frac{1}{3}\frac{d\Phi}{dY}, \quad W \equiv \frac{1}{3}\frac{d\Phi}{dZ}$$

by means of substitution

$$x = \lambda X + \mu Y + \nu Z,$$

$$y = \lambda' X + \mu' Y + \nu' Z,$$

$$z = \lambda'' X + \mu'' Y + \nu'' Z,$$

then since

$$\frac{dV}{dZ} \equiv \frac{dW}{dY}; \quad \frac{dW}{dX} \equiv \frac{dU}{dZ}; \quad \frac{dU}{dY} \equiv \frac{dV}{dX},$$

we must have

$$\left(\nu \frac{d}{dx} + \nu' \frac{d}{dy} + \nu'' \frac{d}{dz}\right) v \equiv \left(\mu \frac{d}{dx} + \mu' \frac{d}{dy} + \mu'' \frac{d}{dz}\right) w$$

$$\left(\lambda \frac{d}{dx} + \lambda' \frac{d}{dy} + \lambda'' \frac{d}{dz}\right) w \equiv \left(\nu \frac{d}{dx} + \nu' \frac{d}{dy} + \nu'' \frac{d}{dz}\right) u \qquad (1)$$

$$\left(\mu \frac{d}{dx} + \mu' \frac{d}{dy} + \mu'' \frac{d}{dz}\right) u \equiv \left(\lambda \frac{d}{dx} + \lambda' \frac{d}{dy} + \lambda'' \frac{d}{dz}\right) v.$$

Equating the coefficients of x, y, z in these identities we get nine equations of the form

$$\nu a' + \nu' h' + \nu'' g' = \mu a'' + \mu' h'' + \mu'' g''.$$

The eliminant of these equations with respect to λ, μ, ν, λ', &c., is a skew symmetrical determinant of the ninth order, which consequently vanishes indentically. Therefore the nine equations are not independent, but are connected by a linear relation. It is therefore possible, in general, to transform the conics to the required form, the transformation being given uniquely by any eight of the equations. If the values obtained for λ, μ, &c., are such that

$$\begin{vmatrix} \lambda & \mu & \nu \\ \lambda' & \mu' & \nu' \\ \lambda'' & \mu'' & \nu'' \end{vmatrix} = 0,$$

the transformation fails, and it is not possible to obtain a cubic having the three conics as polar conics, for the vanishing of this determinant would imply that $x = 0$, $y = 0$, $z = 0$, passed through a common point.

Let ϕ be what Φ becomes when we replace X, Y, Z in it by the corresponding values of x, y, z. Then since

$$\Phi = XU + YV + ZW,$$

we have

$$\phi = Xu + Yv + Zw,$$

but

$$x = \lambda X + \mu Y + \nu Z,$$

$$y = \lambda' X + \mu' Y + \nu' Z,$$

$$z = \lambda'' X + \mu'' Y + \nu'' Z.$$

Therefore,

$$\begin{vmatrix} \phi & u & v & w \\ x & \lambda & \mu & \nu \\ y & \lambda' & \mu' & \nu' \\ z & \lambda'' & \mu'' & \nu'' \end{vmatrix} = 0.$$

Therefore the equation of the cubic having u, v, w, as polar conics is

$$\begin{vmatrix} 0 & u & v & w \\ x & \lambda & \mu & \nu \\ y & \lambda' & \mu' & \nu' \\ z & \lambda'' & \mu'' & \nu'' \end{vmatrix} = 0.$$

and u, v, w, are the polar conics of the points whose coordinates are $(\lambda, \lambda', \lambda'')$, (μ, μ', μ''), (ν, ν', ν''), respectively, since $\bar{U}$, $\bar{V}$, $\bar{W}$ are the polar conics of Φ with respect to the points $(1, 0, 0)$, $(0, 1, 0)$, $(0, 0, 1)$.

The equations (1) show that there are three points, say P, Q, R, associated with any three conics u, v, w, such that the polar line of R with respect to v, and Q with respect to w; of P with respect to w, R with respect to u; and Q with respect to u, and P with respect to v, are coincident. If P, Q, and R are not collinear, it is possible to find a cubic having u, v, w as polar conics, and they are the polar conics of the points P, Q, and R.

The algebraical statement of the problem under consideration is to transform three ternary quadrics, so that they may be the first deriveds of a ternary cubic. The corresponding problem for binary quantics is to transform two binary cubics so that they may be the first deriveds of a binary quantic; and I would remark, in conclusion, that the above method of investigation readily gives a solution of this latter problem also.

IX.

SOME NEW RELATIONS IN THE THEORY OF SCREWS.

By PROFESSOR C. J. JOLY, M.A., D.Sc., F.T.C.D.

Read December 14, 1903. Published January 26, 1904.

In a paper, communicated to the Academy two years ago, and since published in the Transactions,[1] I wrote :—

"As another example, if μ, λ represent a wrench, λ being the force, and μ the couple at the origin as base-point; the ratios of the independent terms of the array

$$\begin{Bmatrix} \mu_1, & \mu_2, & . & . & . & \mu_n \\ \lambda_1, & \lambda_2, & . & . & . & \lambda_n \end{Bmatrix}$$

include all the invariants of an n-system of screws."

In other words, the ratios of independent terms are the same for all screws of the system.

Naturally one seeks to reduce invariants to their simplest form, but it is possible to overlook some important relations involved in the crude and unreduced expressions. Consequently I did not notice the following theorem until recently, in framing an example for a textbook. It is one of many, but I have not leisure at present to examine the subject in detail.

By the laws of quaternion arrays, two independent terms in the array for a three-system of screws afford the invariant

$$\frac{S\mu_1\lambda_2\lambda_3 + S\mu_2\lambda_3\lambda_1 + S\mu_3\lambda_1\lambda_2}{S\lambda_1\lambda_2\lambda_3} = a + b + c,$$

where a, b, and c are the pitches of the principal screws of the system. In this replace μ_1 by $p_1\lambda_1 + V\alpha\lambda_1$, &c., where p_1 is the pitch and α the

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[1] Vol. xxxii, Section A, p. 30. See also p. 28.

vector to any point A on the axis of the screw (μ_1, λ_1). The invariant reduces at once to

$$\frac{SV\alpha\lambda_1 V\lambda_2\lambda_3 + SV\beta\lambda_2 V\lambda_3\lambda_1 + SV\gamma\lambda_3 V\lambda_1\lambda_2}{S\lambda_1\lambda_2\lambda_3} + p_1 + p_2 + p_3 = a + b + c;$$

and on expansion of the terms in the numerator it becomes

$$\frac{S(\beta-\gamma)\lambda_1 S\lambda_2\lambda_3 + S(\gamma-\alpha)\lambda_2 S\lambda_3\lambda_1 + S(\alpha-\beta)\lambda_3 S\lambda_1\lambda_2}{S\lambda_1\lambda_2\lambda_3} + p_1 + p_2 + p_3 = a + b + c.$$

Let A, B, C be any points on the axis of three screws (the extremities of the vectors α, β, and γ); let B_1C_1 denote the projection of the line BC on the axis of the screw (μ_1, λ_1); let (23) be the angle between the axes of the screws (μ_2, λ_2) and (μ_3, λ_3); and let sin (123) denote the sine of the solid angle determined by lines parallel to the three axes (rotation from λ_1 to λ_2 to λ_3 being supposed positive); then the invariant is

$$\frac{B_1C_1 \cos(23) + C_2A_2 \cos(31) + A_3B_3 \cos(12)}{\sin(123)} + p_1 + p_2 + p_3 = a + b + c.$$

In particular if three axes intersect, and if the three points are taken to be at the point of intersection,

$$p_1 + p_2 + p_3 = a + b + c;$$

while for any points on the axes,

$$B_1C_1 \cos(23) + C_2A_2 \cos(31) + A_3B_3 \cos(12) = 0;$$

and from this single theorem many other consequences may be deduced.

X.

A METHOD OF REDUCTION OF A QUARTIC SURFACE POSSESSING A NODAL CONIC TO A CANONICAL FORM. WITH AN APPLICATION OF THE SAME METHOD TO THE REDUCTION OF A BINODAL QUARTIC CURVE TO A CANONICAL FORM.

By JOHN FRASER, M.A., F.T.C.D.

Read December 14, 1903. Published January 26, 1904.

The equation of a quartic surface possessing a nodal conic may be written in the form—

$$[\alpha x^2 + \beta y^2 + \gamma z^2]^2 + w^2\,\{[a,\ b,\ c,\ d,\ f,\ g,\ h,\ l,\ m,\ n]\,[xyzw]^2\} = 0.$$

We may write x for $x\sqrt{\alpha}$, &c.; and then the equation becomes

$$[x^2 + y^2 + z^2]^2 + w^2\,\{[abcd\,fgh\,lmn]\,[xyzw]^2\} = 0.$$

If the quadric

$$x^2 + y^2 + z^2 + [\alpha x + \beta y + \gamma z + \delta w]w = 0$$

has double contact with the quartic, then it must have double contact with the quadric

$$[\alpha x + \beta y + \gamma z + \delta w]^2 + [abcd\,fgh\,lmn]\,[xyzw]^2 = 0;$$

and hence

$$[\alpha x + \beta y + \gamma z + \delta w]^2 + [abcd\,fgh\,lmn]\,[xyzw]^2 + 2\lambda[x^2 + y^2 + z^2 + w(\alpha x + \beta y + \gamma z + \delta w)] \equiv LM,$$

where $L = 0$ and $M = 0$ are two planes.

Hence, since every plane meets this quadric in a pair of lines, every first minor of the discriminating determinant of this quadric must vanish.

Let Δ denote this determinant: then

$$\Delta = \begin{vmatrix} a + 2\lambda + \alpha^2 & h + \alpha\beta & g + \alpha\gamma & l + \alpha(\lambda + \delta) \\ h + \beta\alpha & b + 2\lambda + \beta^2 & f + \beta\gamma & m + \beta(\lambda + \delta) \\ g + \gamma\alpha & f + \gamma\beta & c + 2\lambda + \gamma^2 & n + \gamma(\lambda + \delta) \\ l + \alpha(\lambda + \delta) & m + \beta(\lambda + \delta) & n + \gamma(\lambda + \delta) & c + (\lambda + \delta)^2 - \lambda^2 \end{vmatrix}$$

$$\Delta = \begin{vmatrix} 1 & 0 & 0 & 0 & 0 \\ \alpha & a + 2\lambda + \alpha^2 & h + \alpha\beta & g + \alpha\gamma & l + \alpha(\lambda + \delta) \\ \beta & h + \beta\alpha & b + 2\lambda + \beta^2 & f + \beta\gamma & m + \beta(\lambda + \delta) \\ \gamma & g + \gamma\alpha & f + \gamma\beta & c + 2\lambda + \gamma^2 & n + \gamma(\lambda + \delta) \\ \lambda + \delta & l + \alpha(\lambda + \delta) & m + \beta(\lambda + \delta) & n + \gamma(\lambda + \delta) & d + (\lambda + \delta)^2 - \lambda^2 \end{vmatrix}$$

$$= \begin{vmatrix} 1 & -\alpha & -\beta & -\gamma & -(\lambda + \delta) \\ \alpha & a + 2\lambda & h & g & l \\ \beta & h & b + 2\lambda & f & m \\ \gamma & g & f & c + 2\lambda & n \\ \lambda + \delta & l & m & n & d - \lambda^2 \end{vmatrix}.$$

Now since any first minor of the original form of Δ vanishes, then any first minor of the latter form must vanish. Hence,

$$\text{i.} \quad \begin{vmatrix} a + 2\lambda & h & g & l \\ h & b + 2\lambda & f & m \\ g & f & c + 2\lambda & n \\ l & m & n & d - \lambda^2 \end{vmatrix} = 0,$$

which is a quintic for λ.

$$\text{ii.} \quad \alpha L + \beta M + \gamma N + (\lambda + \delta) D = 0,$$

where L, M, N, D are first minors of i.

$$\text{iii.} \quad \begin{vmatrix} -1 & \alpha & \beta & \gamma \\ \alpha & a + 2\lambda & h & g \\ \beta & h & b + 2\lambda & f \\ \gamma & g & f & c + 2\lambda \end{vmatrix} = 0.$$

Since $$\alpha L + \beta M + \gamma N + (\lambda + \delta) D = 0,$$

$$\delta D = -[\alpha L + \beta M + \gamma N + \lambda D],$$

and $$x^2 + y^2 + z^2 + w[\alpha x + \beta y + \gamma z + \delta w] = 0;$$

$$\therefore \quad D(x^2 + y^2 + z^2) + \alpha Dwx + \beta Dwy + \gamma Dwz = -\delta Dw^2$$
$$= w^2[\alpha L + \beta M + \gamma N + \lambda D];$$

$$\therefore \quad \alpha[Dwx - w^2 L] + \beta[Dwy - w^2 M] + \gamma[Dwz - w^2 N]$$
$$+ D[x^2 + y^2 + z^2] - \lambda Dw^2 = 0.$$

This denotes then a system of quadrics possessing a Jacobian surface.

That is, the system of quadrics passing through the nodal conic and touching the quartic surface twice possesses a Jacobian surface, and there are five such systems.

$$J = \begin{vmatrix} Dw & 0 & 0 & Dx - 2wL \\ 0 & Dw & 0 & Dy - 2wM \\ 0 & 0 & Dw & Dz - 2wN \\ Dx & Dy & Dz & -\lambda Dw \end{vmatrix}$$

$$= -D^3w^2[Dx^2 + y^2 + z^2) - 2w[Lx + My + Nz] + \lambda Dw^2].$$

J contains w^2 as a factor; and the remaining surface is the quadric

$$x^2 + y^2 + z^2 - \frac{2w[Lx + My + Nz]}{D} + \lambda w^2 = 0.$$

And there are five, and only five, such quadrics.

Consider the point which has w for its polar plane with respect to

$$\alpha u + \beta v + \gamma w + T = 0,$$

where

$$U = Dwx - w^2L$$
$$V = Dwy - w^2M,$$
$$W = Dwz - w^2N,$$
$$T = D[x^2 + y^2 + z^2 - \lambda w^2],$$

$$D[\alpha w + 2x] = 0, \quad D[\beta w + 2y] = 0, \quad D[\alpha w + 2z] = 0,$$

x, y, z, w being the coordinates of this point; hence if, in iii., we substitute for α, β, γ,

$$-\frac{x}{w}, \quad -\frac{y}{w}, \quad -\frac{z}{w},$$

respectively, we get

$$\begin{vmatrix} w^2 & x & y & z \\ x & a + 2\lambda & h & g \\ y & h & b + 2\lambda & f \\ z & g & f & c + 2\lambda \end{vmatrix} = 0,$$

as the condition which the coordinates must fulfil—that is, the locus of the point is a quadric.

$$J_1 = \left[x^2 + y^2 + z^2 - \frac{2w}{D_1}(L_1x + M_1y + N_1z) + \lambda_1 w^2\right],$$

where $$f(\lambda_1) = 0,$$

and
$$f(\lambda_1) \equiv \begin{vmatrix} a+2\lambda_1 & h & g & l \\ h & b+2\lambda_1 & f & m \\ g & f & c+2\lambda_1 & n \\ l & m & n & d-\lambda_1^2 \end{vmatrix}.$$

Consider

$$\Sigma_1^5 \frac{D_r}{f(\lambda_r)} \left[x^2+y^2+z^2 - \frac{2w}{D_r}(L_rx + M_ry + N_rz) + \lambda_r w^2\right]^2,$$

$$D_r = 8\lambda_r^3 + \&c. \;\ldots\; f(\lambda_r) = -8\lambda_r^5 + \&c.;$$

hence the coefficient of $(x^2+y^2+z^2)^2$ vanishes; and for the same reason the coefficient of $(x^2+y^2+z^2)\,w\,[x, y, z]$ also vanishes.

The coefficient of

$$w^2x^2 = 2\Sigma_1^5 \frac{\lambda_r \,.\, D_r}{f'(\lambda_r)} + 4\,.\,\Sigma_1^5 \frac{L_r^2}{D_r f'(\lambda_r)}.$$

But since $$f(\lambda_r) = 0,$$

$$L_r^2 - A_rD_r = 0.$$

$$\therefore\quad \frac{L_r^2}{D_r} = A_r = -4\lambda_r^4 + \&c.$$

Hence $$\left[2\lambda_rD_r + \frac{4\,.\,L_r^2}{D_r}\right] = (16-16)\,\lambda_r^4 + \&c.;$$

therefore the coefficient of w^2x^2 also vanishes.

The coefficient of

$$w^2xy = \Sigma_1^5 \frac{D_rL_rM_r}{D_r^2 f'(\lambda_r)} = \Sigma \frac{L_rM_r}{D_r f'(\lambda_r)};$$

but $$L_rM_r - H_rD_r = 0.$$

$$\therefore\quad \frac{L_rM_r}{D_r} = H = -2h\lambda_r^3 + \&c. \ldots$$

Hence the coefficients of $w^2[xy, yz, zx]$ all vanish; and hence

$$\Sigma_1^5 \frac{D_r}{f'(\lambda_r)} \left[x^2+y^2+z^2 - \frac{2w[L_rx + M_ry + N_rz]}{D_r} + \lambda_r w^2\right]^2 = 0,$$

that is, that the squares of these five Jacobian Quadrics are connected by a linear relation.

Again, consider

$$\Sigma_1^5 \frac{\lambda_r D_r}{f'(\lambda_r)}\left[x^2+y^2+z^2-2\frac{(L_r x+M_r y+N_r z)}{D_r}w+\lambda_r w^2\right]_g^2 D_r = 8\lambda_r^3 + \&c.,$$

the coefficient of

$$(x^2+y^2+z^2)^2 = \Sigma_1^5 \frac{8\lambda_r^4+\&c.}{f'(\lambda_r)} = -1,$$

the coefficient of

$$wx^3 = \Sigma_1^5 - 4\frac{\lambda_r L_r}{f'(\lambda_r)} = -4\Sigma\frac{\lambda_r[4\lambda_r^2+\&c.]}{f'\lambda_r} = 0;$$

hence the terms

$$w[x^3,\ y^3,\ z^3,\ x^2y,\ x^2z,\ y^2x,\ y^2z,\ z^2x,\ z^2y]$$

do not appear, as their coefficients all vanish for the same reason.

The coefficient of

$$w^2x^2 = \Sigma\frac{\lambda_r D_r}{f'(\lambda_r)}\left[2\lambda_r + 4\frac{L_r^2}{D_r}\right] = \Sigma\left[\frac{2\lambda_r^2 D_r + 4\lambda_r A_r}{f'(\lambda_r)}\right];$$

$$\therefore\quad A_r D_r - L_r^2 = 0$$

$$= \Sigma\left[\frac{2\lambda_r^2\{8\lambda_r^3+4\lambda_r^2(a+b+c)\}+\&c. - 4\lambda_r\{4\lambda_r^4+4\lambda_r^3(b+c)_r\}}{f'(\lambda_r)}\right]$$

$$= \Sigma\frac{a\,.\,8\lambda_r^4+\ldots}{f'(\lambda_r)} = -a;$$

and of course the coefficient of $w^2y^2 = -b$, and of $w^2z^2 = -c$.

The coefficient of

$$w^2xy = \Sigma\frac{8\lambda_r L_r M_r}{f'(\lambda_r)\,.\,D_r} = \Sigma\left[\frac{8\lambda_r\,.\,H_r}{f'(\lambda_r)}\right] = \Sigma\frac{8\lambda_r[-h(c+2\lambda_r)(a-\lambda_r^2)+\&c.]}{f'(\lambda_r)}$$

$$= \Sigma\frac{h\,.\,16\lambda_r^4+\ldots}{f'(\lambda_r)} = -2h.$$

Similarly the coefficient of $w^2y^2z = -2f$, and of $w^2zx = -2g$.

The coefficient of

$$w^3x = -\Sigma_1^5\, 4\frac{L_r\lambda_r^2}{f'(\lambda_r)},\qquad L_r = -4l\lambda_r^5 + \&c.;$$

hence this coefficient $= -2l$, that of $w^3y = -2m$, and of $w^3z = -2n$.

The coefficient of

$$w^4 = \Sigma_1^5\frac{D_r\lambda_r^3}{f'(\lambda_r)},\qquad lL + mM + nN + (d-\lambda^2)D = f(\lambda);$$

L, M, N are only quadratics in λ; hence

$$\lambda_r^3 D_r = -\lambda_r f(\lambda_r) + \lambda_r[lL_r + mM_r + nN_r + dD_r] = d\,.\,8\lambda_r^4 + \&c.;$$

$$\because \quad f(\lambda_r) = 0, \qquad \therefore \quad \Sigma_1^5 \frac{\lambda_r^3 D_r}{f'(\lambda_r)} = -d;$$

$$\therefore -\Sigma_1^5 \frac{\lambda_r D_r}{f'(\lambda_r)} \cdot J_r^2 \equiv (x^2+y^2+z^2)^2 + w^2\left[(a, b, c, d, f, g, h, l, m, n)(x, y, z, w)^2\right].$$

Hence we have the equation of this quartic surface expressed in a canonical form

viz.: $$\Sigma_1^5 \frac{\lambda_r D_r}{f'(\lambda_r)} \cdot J_r^2,$$

where $$\Sigma_1^5 \frac{D_r}{f'(\lambda_r)} \cdot J_r^2 \equiv 0.$$

We might consider particular cases of this quartic surface, according as the conic becomes an ellipse, hyperbola, parabola, or circle.

In particular, the imaginary circle at infinity.

In this case, the plane w becomes the plane at infinity, and the axes x, y, z rectangular; hence we may put, without introducing any other peculiarity, $f = 0 = g = h$, and $\alpha = \beta = \gamma = 1$ in the original equation.

And the Jacobian quadrics become of the form

$$x^2 + y^2 + z^2 - \frac{2(Lx + My + Nz)w}{D} + \lambda w^2,$$

viz., spheres, where

$$0 = f(\lambda) \equiv \begin{vmatrix} a + 2\lambda & 0 & 0 & l \\ 0 & b + 2\lambda & 0 & m \\ 0 & 0 & c + 2\lambda & n \\ l & m & n & d - \lambda^2 \end{vmatrix}.$$

The system of quadrics which have double contact with the surface must also be spheres, since they pass through the circle (imaginary) at infinity, and the locus of the pole of the plane at infinity with respect to them, that is, their centre, is

$$\begin{vmatrix} w^2 & x & y & z \\ x & a + 2 & 0 & 0 \\ y & 0 & b + 2\lambda & 0 \\ z & 0 & 0 & c + 2\lambda \end{vmatrix} = 0,$$

which shows that the five quadrics belong to the same confocal system.

$$R^2 = \frac{L^2 + M^2 + N^2}{D^2} - \lambda = \frac{A + B + C - \lambda . D}{D} = \frac{f'(\lambda)}{D};$$

and hence, in this case, the identical linear relation becomes

$$\Sigma_1^5 \frac{J_r^{\,2}}{R_r^{\,2}} = 0.$$

$$x^2y^2 + z^2\left[(abcfgh)(xyz)^2\right] = 0$$

represents the general equation of a binomial quartic curve having the points $z = 0,\ x = 0$; $z = 0,\ y = 0$ for its two nodes.

$$z(ax + \beta y + \gamma z) + xy = 0$$

denotes a conic passing through the same two points.

If it has double contact with the quartic, then it must also have double contact with the conic

$$(az + \beta y + \gamma z)^2 + (abcfgh)(xyz)^2 = 0;$$

hence

$$(ax + \beta y + \gamma z)^2 + (abcfgh)(xyz)^2 + 2\lambda\left[z(ax + \beta y + \gamma z) + xy\right] \equiv L^2;$$

and therefore every minor of the discriminating determinant must vanish.

Let Δ denote it.

$$\Delta = \begin{vmatrix} a + a^2 & h + \lambda + a\beta & g + a(\lambda+\gamma) \\ h + \lambda + \beta a & b + \beta^2 & f + \beta(\lambda+\gamma) \\ g + (\lambda+\gamma)a & f + \beta(\lambda+\gamma) & c + (\lambda+\gamma)^2 - \lambda^2 \end{vmatrix}$$

$$= \begin{vmatrix} 1 & 0 & 0 & 0 \\ a & a + a^2 & h + \lambda + a\beta & g + a(\lambda+\gamma) \\ \beta & h + \lambda + \beta a & b + \beta^2 & f + \beta(\lambda+\gamma) \\ \lambda + \gamma & g + a(\lambda+\gamma) & f + \beta(\lambda+\gamma) & c + (\lambda+\gamma)^2 - \lambda^2 \end{vmatrix}$$

$$= \begin{vmatrix} 1 & -a & -\beta & -(\lambda+\gamma) \\ a & a & h + \lambda & g \\ \beta & h + \lambda & b & f \\ \gamma & g & f & c - \lambda^2 \end{vmatrix};$$

and every minor of the latter form of Δ must vanish.

i. $$\begin{vmatrix} a & h+\lambda & g \\ h+\lambda & b & f \\ g & f & c-\lambda^2 \end{vmatrix} = 0;$$

ii. $$\alpha G + \beta F + (\lambda + \gamma)\, C = 0;$$

iii. $$\begin{vmatrix} 1 & -\alpha & -\beta \\ \alpha & a & h+\lambda \\ \beta & h+\lambda & b \end{vmatrix} = 0.$$

i. is a quartic for λ, and to each value of λ we have a linear relation connecting α, β, γ, given by ii., and a quadratic relation between α, β, given by iii.

$$xy + z(\alpha x + \beta y + \gamma z) = 0,$$

$$\alpha G + \beta F + (\lambda + \gamma)\, C = 0;$$

$$\therefore \quad \alpha\left[Czx - Gz^2\right] + \beta\left[Czy - Fz^2\right] + Cxy + \lambda Cz^2 = 0$$

is an equation of enveloping conic; and its form shows that it belongs to a system which has a Jacobian cubic curve, viz.:

$$\begin{vmatrix} z & 0 & y \\ 0 & z & x \\ Cx - 2Gz & Cy - 2Fz & -2\lambda Cz \end{vmatrix} = 0,$$

or

$$-2z\left[\lambda Cz^2 + Cxy - Fzx - Gzy\right] = 0.$$

Hence the system which, since it passes through two fixed points, has a common Jacobian conic

$$xy - \frac{z}{C}\cdot\left[Fx + Gy\right] + \lambda z^2 = 0,$$

a conic which also passes through the same two points.

To each value of λ, we have a corresponding conic

$$\alpha\,(Czx - Gz^2) + \beta\,(Czy - Fz^2) + Cxy + \lambda Cz^2 = 0.$$

If this conic becomes a pair of lines, then

$$\begin{vmatrix} 0 & C & \alpha C \\ C & 0 & \beta C \\ \alpha C & \beta C & 2\lambda C - 2\alpha G - 2\beta F \end{vmatrix} = 0,$$

$$= C^2\left[2\alpha\beta C - 2\lambda C + 2\alpha G + 2\beta F\right] = 0;$$

rejecting the factor C^2,

$$2aG + 2\beta F - 2\lambda C + 2a\beta C = 0;$$

but

$$\begin{vmatrix} -1 & \alpha & \beta \\ \alpha & a & h+\lambda \\ \beta & h+\lambda & b \end{vmatrix} = 0.$$

Eliminating β between these two equations, we get a quartic for α, and to each value of α one value, and one only, of β.

Hence, to each value of λ, we have four conics of the system which reduce to a pair of lines, that is, a conic consisting of a tangent from each node of the binodal quartic.

The node of this conic, *i.e.* the point of intersection of these two tangents, must lie on the corresponding Jacobian. Hence, the four Jacobians, as written above, are the equations of four conics, each of which passes through four of the sixteen points of intersection of the tangents to the binodal quartic from its nodes; and hence, we may infer that the anharmonic ratio of the two pencils of tangents is the same, since the conics pass through the nodes.

If the point xyz has the line $z = 0$ for its polar with respect to

$$\alpha\left[Czx - Gz^2\right] + \beta\left[Czy - Fz^2\right] + C\left[xy - \lambda z^2\right] = 0,$$

then

$$\alpha Cz + Cy = 0, \quad \alpha Cz + Cx = 0;$$

hence

$$\begin{vmatrix} z^2 & y & x \\ y & a & h+\lambda \\ x & h+\lambda & b \end{vmatrix} = 0.$$

Hence, the locus of the poles of the line $z = 0$ with respect to the conics of the system lies on a fixed conic; and the above is its equation determined in terms of the coefficients of the quartic.

Corresponding to each value of λ, we have a conic.

The Jacobian conics are

$$J_r = xy - \frac{z\left[G_r x + F_r y\right]}{C_r} + \lambda_r z^2 + \&c.$$

Consider

$$\Sigma_1^4 \frac{C_r}{f'(\lambda)}\left[xy - \frac{z(G_r x + F_r y)}{C_r} + \lambda_r z^2\right]^2.$$

The coefficients of x^2y^2, zx^2y, zxy^2 vanish since G is of the first order in λ; F is also of the first order, and C of the second order in λ, $f(\lambda)$ being of the fourth order.

The coefficient of z^4 is

$$\Sigma_1^4 \frac{\lambda_r^2 C_r}{f'(\lambda)},$$

$$gG_r + fF_r + (c - x_r) C_r = f_r(\lambda_r),$$

$$\therefore \quad \lambda_1^2 C_r = f(\lambda_r) + gG_r + fF_r = gG_r + fF_r, \quad \because \quad f(\lambda_r) = 0,$$

$\therefore$ the coefficient of z^4 is zero.

The coefficient of

$$2z^2xy = \Sigma_1^4 \left(\lambda_r + \frac{G_rF_r}{C_r}\right) \frac{C_r}{f'(\lambda_r)};$$

but

$$F_rG_r - C_rH_r = 0, \quad \because \quad f(\lambda_r) = 0,$$

$$\therefore \quad = \Sigma_1^4 \frac{[\lambda_r C_r - H_r]}{f'(\lambda_r)} = \Sigma_1^4 \frac{h\lambda_r^2 + \&c.}{f'(\lambda_r)} = 0.$$

The coefficient of

$$z^2x^2 = \Sigma_1^4 \frac{G_r^2}{f'(\lambda_r)\, C_r},$$

$$B_rC_r - F_r^2 = 0, \quad \therefore \quad \frac{F_r^2}{C_r^2} = B_r = -\lambda^2 + \&c.;$$

$$\therefore \quad \Sigma_1^4 \frac{G_r^2}{f'(\lambda_r)\, C_r} = 0;$$

and

$$\therefore \quad \Sigma_1^4 \frac{C_r}{f'(\lambda_r)} \left[xy - z\frac{(G_rx + F_ry)}{C_r} + \lambda_r z^2\right]^2 \equiv 0.$$

Again consider

$$\Sigma_1^4 \frac{\lambda_r C_r}{f'(\lambda_r)} \left[xy - \frac{(F_rx + G_ry)z}{C_r} + \lambda_r z^2\right]^2.$$

The coefficient of

$$x^2y^2 = \Sigma_1^4 \frac{\lambda_r C_r}{f'(\lambda_r)} = \Sigma_1^4 \frac{-\lambda_r^3 + \&c.}{f'(\lambda_r)} = -1.$$

The coefficient of

$$zx^2y = \Sigma_1^4 \frac{\lambda_r F_r}{f'(\lambda_r)} = \Sigma_1^4 \frac{\lambda_r^2 + \ldots}{f'(\lambda_r)} = 0.$$

The coefficient of

$$z^2x^2 = \Sigma_1^4 \frac{\lambda_r F_r^2}{f'(\lambda_r)\, C_r} = \Sigma_1^4 \frac{B_r \lambda_r \ldots}{f'(\lambda_r)} = \Sigma_1^4 \left(\frac{-a\lambda_r^3 + \&c.}{f'(\lambda_r)}\right) = -a.$$

The coefficient of

$$z^4 = \Sigma_1^4 \frac{\lambda_r^3\, C_r}{f'(\lambda_r)} = -c\,;$$

$$\because \quad gG_r + fF_r + (c - \lambda_r^2)C_r = f(\lambda_r) = 0,$$

$$\therefore \quad \lambda_r^3 C_r = \lambda_r[cC_r + gG_r + fF_r] = -c\lambda^3 + \ldots$$

The coefficient of

$$z^3x = -2\Sigma_1^4 \frac{\lambda_r^2 F}{f'(\lambda_r)} = -2\Sigma_1^4 \left[\frac{g\lambda_r^3 + \ldots}{f'(\lambda_r)}\right] = -2g$$

The coefficient of

$$z^2xy = -2\Sigma_1^4 \frac{\lambda_r F_r G_r}{C_r} f'(\lambda_r) = -2\Sigma_1^4 \frac{\lambda_r H_r}{f'(\lambda_r)} = -2\Sigma_1^4 \frac{h\lambda_r^3 + \ldots}{f'(\lambda_r)} = -2h.$$

Hence

$$-\Sigma_1^4 \frac{\lambda_r C_r}{f'(\lambda_r)} \left[xy - \frac{(F_r x + G_r y)z}{C_r} + \lambda_r z^2\right]^2$$
$$\equiv x^2y^2 + z^2[(a, b, c, f, g, h)(x, y, z)^2],$$

and
$$\Sigma_1^4 \frac{C_r}{f'(\lambda_r)} \left[xy - \frac{(F_r x + G_r y)z}{C_r} + \lambda_r z^2\right]^2 \equiv 0.$$

The bicircular quartic might be treated in precisely the same manner, $z = 0$ denoting the line at infinity in the plane, and $x + iy$ written for x, $x - iy$ written for y. But it can also be treated directly, thus—

$$(x^2 + y^2)^2 + ax^2 + by^2 + c + 2gx + 2fy = 0$$

denotes its equation.

If the circle $x^2+y^2+2\alpha x+2\beta y+\gamma=0$ has double contact with it, then

$$(2\alpha x+2\beta\gamma+\gamma)^2+ax^2+by^2+c+2gx+2fy+c+\lambda[x^2+y^2+2\alpha x+2\beta y+\gamma] \equiv L^2;$$

hence, as before, every minor of

$$\Delta = \begin{vmatrix} a+\lambda+4\alpha^2 & 4\alpha\beta & 2\alpha\gamma+g+\alpha\lambda \\ 4\beta\alpha & b+\lambda+4\beta^2 & 2\beta\gamma+f+\beta\lambda \\ 2\alpha\gamma+g+\lambda\alpha & 2\beta\gamma+f+\lambda\beta & c+\lambda\gamma+\gamma^2 \end{vmatrix}$$

$$= \begin{vmatrix} 1 & -4\alpha & -4\beta & -(\lambda+2\gamma) \\ \alpha & a+\lambda & 0 & g \\ \beta & 0 & b+\lambda & f \\ \frac{\lambda}{4}+\frac{\lambda}{2} & g & f & c-\frac{\lambda^2}{4} \end{vmatrix} = 0.$$

i. $\begin{vmatrix} a+\lambda & 0 & g \\ 0 & b+\lambda & f \\ g & f & c-\frac{\lambda^2}{4} \end{vmatrix} = 0,$ or $\dfrac{g^2}{a+\lambda}+\dfrac{f^2}{b+\lambda}-c+\dfrac{\lambda^2}{4}=0;$

ii. $\begin{vmatrix} 1 & -4\alpha & -4\beta \\ \alpha & a+\lambda & 0 \\ \beta & 0 & b+\lambda \end{vmatrix} = 0,$ or $\dfrac{4\alpha^2}{a+\lambda}+\dfrac{4\beta^2}{b+\lambda}+1=0;$

iii. $\begin{vmatrix} \alpha & a+\lambda & 0 \\ \beta & 0 & b+\lambda \\ \frac{\lambda}{4}+\frac{\lambda}{2} & g & f \end{vmatrix} = 0,$ or $\dfrac{2\alpha g}{a+\lambda}+\dfrac{2\beta f}{b+\lambda}=\gamma+\dfrac{\lambda}{2}.$

i. Shows that λ is determined by a quartic.

ii. Shows that the centre of the enveloping circle moves on a fixed conic, and also to each value of λ we have a determinate conic, and the conics are confocal.

iii. Shows that the circle cuts the fixed circle

$$x^2 + y^2 + \frac{2g}{a+\lambda}x + \frac{2f}{b+\lambda}y + \frac{\lambda}{2} = 0$$

orthogonally; but, since

$$\frac{g^2}{a+\lambda_1} + \frac{f^2}{b+\lambda_1} - c + \frac{\lambda^2}{4} = 0,$$

$$\frac{g^2}{a+\lambda_2} + \qquad\qquad = 0,$$

$$\frac{2g^{12}}{(a+\lambda_1)(a+\lambda_2)} + \frac{2f^2}{(b+\lambda_1)(b+\lambda_2)} = \frac{\lambda_1+\lambda_2}{2};$$

hence the fixed circles are orthogonal, and as in the case of the binodal quartic the 16 points of intersection of the tangents from the circular points to the quartic lie by fours on these circles,

$$\Sigma_1^4 \frac{C_r}{f'(\lambda_r)}\left[(x^2+y^2) + \frac{2g}{a+\lambda_r}x + \frac{2fy}{b+\lambda_r} + \frac{\lambda_r}{2}\right]^2 = 0,$$

where

$$C_r = (a+\lambda_r)(b+\lambda_r);$$

and

$$-\Sigma_1^4 \lambda_r \frac{(a+\lambda_r)(b+\lambda_r)}{f'(\lambda_r)} \cdot \left[(x^2+y^2) + \frac{2gx}{a+\lambda_r} + \frac{2fy}{b+\lambda_r} + \frac{\lambda_r}{2}\right]^2,$$

$$\equiv (x^2+y^2)^2 + ax^2 + by^2 + 2gx + 2fy + c,$$

where $f(\lambda_r) = \begin{vmatrix} a+\lambda_r & 0 & g \\ a & b+\lambda_r & f \\ g & f & c - \frac{\lambda_r^2}{4} \end{vmatrix} = 0.$

The reduction is just the same

$$C = (a+\lambda)(b+\lambda),$$

$$-F = g(b+\lambda),$$

$$-G = f(a+\lambda),$$

&c. . . .

It is interesting to show, from this point of view, that

$$\frac{f'(\lambda)}{(a+\lambda)(b+\lambda)} = R^2,$$

$$R^2 = \frac{g^2}{(a+\lambda)} + \frac{f^2}{(b+\lambda)^2} - \frac{\lambda}{2},$$

$$\frac{g^2}{a+\lambda} + \frac{f^2}{b+\lambda} - c + \frac{\lambda^2}{4} = \frac{-f(\lambda)}{(a+\lambda)(b+\lambda)};$$

also

$$\frac{g^2}{(a+\lambda)^2} + \frac{f^2}{(b+\lambda)^2} - \frac{\lambda}{2} = \frac{\delta}{\delta\lambda} \cdot \frac{f(\lambda)}{(a+\lambda)(b+\lambda)} = \frac{f'(\lambda)}{(a+\lambda)(b+\lambda)},$$

since

$$f(\lambda) = 0;$$

hence

$$\Sigma_1^4 \frac{J_r^2}{R_r^2} = 0,$$

$$-\Sigma_1^4 \frac{\lambda_r . J_r^2}{R_r^2} \equiv (x^2 + y^2)^2 + ax^2 + by^2 + 2gx + 2fy + c.$$

PROCEEDINGS

OF THE

ROYAL IRISH ACADEMY

VOLUME XXIV

SECTION B.—BIOLOGICAL, GEOLOGICAL, AND CHEMICAL SCIENCE

DUBLIN

PUBLISHED AT THE ACADEMY HOUSE, 19, DAWSON STREET

SOLD ALSO BY

HODGES, FIGGIS, & CO., LIMITED, 104, GRAFTON STREET

AND BY WILLIAMS & NORGATE, LONDON, EDINBURGH, AND OXFORD

1902–1904

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SECTION B.—BIOLOGICAL, GEOLOGICAL, & CHEMICAL SCIENCE

DATES OF PUBLICATION

PART	1.	Pages	1	to	94.	July, 1902.
,,	2.	,,	95	,,	230.	September, 1902.
,,	3.	,,	231	,,	302.	April, 1903.
,,	4.	,,	303	,,	386.	September, 1903.
,,	5.	,,	387	,,	502.	January, 1904.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

PAPERS READ BEFORE THE ACADEMY.

I.

ON TYPES OF DISTRIBUTION IN THE IRISH FLORA.

By R. LLOYD PRAEGER, B.A., B.E.

[Read March 15, 1902.]

For the purpose of expressing the horizontal range of flowering plants in Great Britain, H. C. Watson[1] has employed eight "Types of Distribution," which he has named and defined as follows:—

1. British type—species widely spread through S.M.N. Britain.
2. English type—species chiefly seen in S. or S.M. Britain.
3. Scottish type—species chiefly seen in N. or N.M. Britain.
   Intermediate type—species chiefly seen in Mid Britain.
4. Highland type—species chiefly seen about the mountains.
5. Germanic type—species chiefly seen in East England.
6. Atlantic type—species chiefly seen in West England.
   Local species, restricted to single or few provinces.

Watson is careful to state that in the use of the names for these types he does not make any suggestion regarding the centre of dispersal or route of migration of the plant-groups which they represent; he uses them simply to express facts of present distribution.

Since range in latitude corresponds phytologically to range in altitude, it will be seen that the first five of these divisions are, to-

[1] *Cybele Britannica*, I. 43 (1847), IV. 409 (1859), and *Compendium of the Cybele Britannica*, 23 (1868–70).

a considerable extent, a grouping according to one and the same standard—the latitudinal, or vertical, range of the species, whichever term we prefer to employ. The vertical limit of plants is usually more defined than their latitudinal limit. A small range in altitude corresponds to a comparatively large range in latitude, and the limit of latitudinal range is often obscured by local conditions. Thus, while the vertical limit of a plant may often be represented by a straight line, the latitudinal limit frequently resembles rather an indented coast-line, with promontories, bays, and outlying islands. The fifth and sixth "Types of Distribution" are of a different character, and represent eastern and western range in England. The focus of the "Germanic" plants is in the south-eastern counties, of the "Atlantic" group in the south-western.

In books and papers dealing with the vegetation of Ireland, whether of the whole country or of selected districts, it has been usual to analyse the flora according to these types of distribution, which were chosen with reference to Great Britain only, and without reference to Ireland.[1] The distribution of plants in Ireland was not, indeed, in Watson's time sufficiently worked out to allow of its being ranged alongside Great Britain. Now that the distribution of species in this country is at least as well known as in Great Britain, it is possible to institute comparisons and analyses. I propose, in the first place, to review the distribution in Ireland of Watson's Types, and from that to pass on to the consideration of natural Types of Distribution in Ireland as revealed by a study of the flora of this country.

The most convenient way of expressing the facts to be dealt with is by means of a series of statistical maps, constructed according to a uniform plan. As regards the basis of these maps, the lists of the Watsonian plant-groups are compiled from the "Compendium of the Cybele Britannica," which, though now over thirty years old, is the latest pronouncement on the subject. In his works, each species is referred by Watson either to a definite type, such as "English," or to a qualified type, as "English-Germanic," which signifies that the species belongs to the former type, with tendencies towards the latter. It should be noted in passing that these qualified types approximate nearly to each other, so that, as Watson admits, the reference of a species to one such type or its counterpart may become arbitrary.

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[1] This fact was recognized in the first edition of *Cybele Hibernica* by the consistent use of the term "type in Great Britain," instead of merely "type"; an important distinction which has not been retained in the second edition.

Between "English-Atlantic" and "Atlantic-English" no wide difference exists, and it can be readily imagined that the distribution of a species may place it between the two. Especially in such cases, the finding of a plant in a couple of new counties might turn the scale. Many such discoveries have been made since Watson defined the "type of distribution" of each British plant in 1870, yet the "types" have not been revised. Therefore, for our purposes, it will be better to use pure types only, where possible.

The maps are constructed, according to a uniform plan, in five depths of shading. The units of area employed are the forty county-divisions of "Irish Topographical Botany" and the standard used as a list of the Irish flora, and its distribution, is taken from the same work, posted up to date. For the construction of the maps, the distribution in the forty divisions of the component species of each group has been tabulated. In order to balance the statistics, and maintain their scientific integrity, sub-species (*i.e.* those printed in italics in "Irish Topographical Botany") are not reckoned, nor records of doubtful value (*i.e.* those of which the accuracy is doubted, or to which the marks signifying "probably introduced" or "certainly introduced" are applied). From the totals thus obtained for the county-divisions, giving the number of plants of the type present in each, the lowest and highest figures are taken, and the intervening space divided into five equal portions. The forty totals are grouped according to these five portions, and the map shaded accordingly in the order:—

(1) white, (2) ≡, (3) =|=|=|=, (4) ÷|÷|÷|÷, (5) black.

An example will make the process clear. Say we find that of the plant-group in question the maximum number of species occurring in any one of the county-divisions is 30, and the minimum 11. Dividing this difference into five equal portions, we get as our series:—

11 to 14,	15 to 18,	19 to 22,	23 to 26,	27 to 30
white	≡	=|=|=	÷|÷|÷	black.

It is to be distinctly understood that the shading of each division represents the *number* of plants of the group which occur in it, not their *distribution* in the division. For instance, in the Highland type map, the actual distribution of the species in many divisions would show as little more than a few dots on the map; instead of which an even shading is spread over the whole of each division according to the number of Highland plants growing within it.

1. British Type: "Species widely spread through S.M.N. Britain." —To this type belongs the mass of our common plants. From the definition of the type we should expect to find plants of this group largely represented and widely spread in Ireland. According to our standard list, the number of Irish plants of purely British type is 377; the list for Great Britain adds but a very few to this number—namely, one species, *Avena pratensis*, unknown in Ireland, and two or three others whose claims to native rank in Ireland are doubtful or inadmissible. If we include in the list all plants of qualified British type, the number of Irish absentees is increased to eight, which will be found listed in "Cybele Hibernica," p. xlii; most of these are of British-English type, or have, in other words, a southern tendency in Great Britain.

As examples of typical "British" plants, Watson selects the following:—

Alnus glutinosa.
Betula alba.
Corylus Avellana.
Lonicera Periclymenum.
Hedera Helix.
Calluna vulgaris.
Ranunculus acris.
Cerastium triviale.
Trifolium repens.
Stellaria media.
Lotus corniculatus.
Bellis perennis.
Cnicus palustris.
Plantago lanceolata.
Polygonum aviculare.
Urtica dioica.
Juncus effusus.
Carex panicea.
Poa annua.
Festuca ovina.
Anthoxanthum odoratum.
Pteris Aquilina.
Polypodium vulgare.

All of these occur in every Irish county-division.

Of the distribution of the 377 typical British type plants in Ireland, I have made a somewhat minute analysis, to discover if the varying conditions of soil and climate produce any increase or diminution in their numbers in north or south, east or west. There is no indication of the kind. It appears that the number of species present in the forty divisions ranges from 85 to 99 per cent. of the Irish total—a very small amount of variation. On mapping their distribution, the result is found to correspond so remarkably with map IV. of "Irish Topographical Botany," which shows the extent to which the flora of each division is at present known, that there can be no doubt that, in the majority of cases, the absences are only apparent, and that, as a group, these 377 species will eventually prove to be as evenly spread in Ireland as in Great Britain. The only portions of the country to which a comparison within such narrow limits can be safely applied are those which have been practically thoroughly explored; namely, Kerry and Cork, Dublin and Wicklow, Donegal, and the North-east. As these areas are widely scattered, the figures may be worth comparing, especially since the divisions in question are all maritime, which renders them more comparable:

Antrim, ...	375	North Kerry, ...	361
Down, ...	372	West Cork, ...	359
Derry, ...	369	Wicklow, ...	359
East Donegal, ...	363	South Kerry, ...	356
West Donegal, ...	362	Dublin, ...	356
East Cork, ...	362	Mid Cork, ...	351

The smallest number on record is 297, in Monaghan—the least worked of all the Irish divisions.

It should be noted, however, that the whole of these British type plants are not widely spread in Ireland. There are a few notable exceptions. One, as already mentioned, is absent from this country. A few others are very rare therein, as exemplified below, where the first number shows in how many of the British 112 vice-counties each species occurs, the second number in how many of the Irish 40:

	Great Britain.	Ireland.
Adoxa Moschatellina, ..	91, or 81 per cent.	1, or 2½ per cent.
Ulmus montana, ..	98 ,, 88 ,,	5 ,, 12 ,,
Mercurialis perennis, ..	107 ,, 96 ,,	11 ,, 27 ,,
Juniperus communis, ..	77 ,, 69 ,,	12 ,, 30 ,,
Poa nemoralis, ..	90 ,, 80 ,,	16 ,, 40 ,,
Pilularia globulifera, ..	59 ,, 53 ,,	5 ,, 12 ,,

2. ENGLISH TYPE: "Species chiefly seen in S. or S.M. Britain."—These are the southern plants of Great Britain, having their head-quarters in the south of England. They are largely lowland species favouring light soils.

As typical "English" plants, Watson selects the following:—

Rhamnus catharticus.
Ulex nanus.
Tamus communis.
Bryonia dioica.
Hottonia palustris.
Chlora perfoliata.
Sison Amomum.
Linaria Elatine.
Ranunculus parviflorus.
Lamium Galeobdolon.
Hordeum pratense.
Alopecurus agrestis.
Ceterach officinarum.

Of these, six are unknown in Ireland in the native state; of the rest, *Chlora* and *Ceterach* are the only ones which are not rare and local.

Here again the number of the group in Ireland is so large—close on 400 altogether—that we may restrict our analysis to those plants which are of *purely* English type. Of such plants, 135 are included, according to our standard list, in the Irish flora. But of these, no less than 44, or 33 per cent., are reckoned in Ireland as possibly, probably, or certainly introduced. Here, in fact, we come upon the home of the large section of our vegetation which owes its presence in the country to the operations of man—the weeds of cultivation, and light-soil plants. And while 44 represents the number of doubtfully native plants of this type which have *established* themselves in Ireland, the number which occur in this country more or less sporadically would largely increase this figure. For our present purpose, however, we are concerned only with the balance of 91 species which are reckoned indigenous in Ireland. The maximum in any county-division is 63, or 69 per cent. of the Irish list, in Dublin; the minimum 18, or 20 per cent., in Monaghan. A map constructed according to the principle laid down gives the following result:—

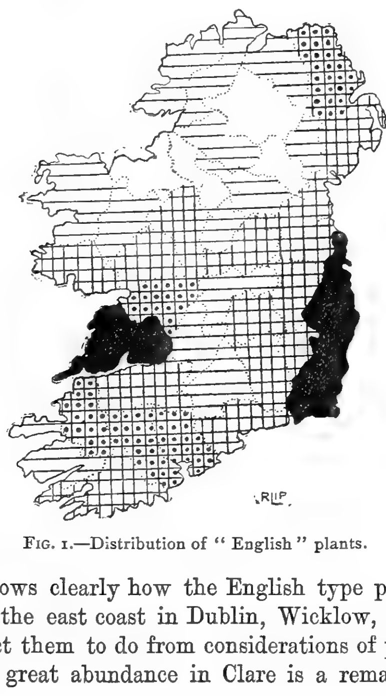

FIG. 1.—Distribution of "English" plants.

This map shows clearly how the English type plants reach their maximum along the east coast in Dublin, Wicklow, and Wexford, as we should expect them to do from considerations of position, soil and climate. Their great abundance in Clare is a remarkable point, to which we shall presently return. For the rest, excepting their frequency in Antrim, they decrease from S.E. to N.W., reaching their minimum in Sligo, Leitrim, Monaghan, and Tyrone. It may be pointed out that the group embraces a number of maritime plants, and therefore the maritime divisions are necessarily slightly richer in species than divisions situated inland.

3. SCOTTISH TYPE: "Species chiefly seen in N. or N. M. Britain."—This type is the opposite of the last. With headquarters well up in Scotland, the species range southward in diminishing numbers. They are the northern plants of Britain.

As characteristic examples of the Scottish type Watson cites—

Empetrum nigrum.
Rubus saxatilis.
Trollius europæus.
Geranium sylvaticum.
Trientalis europæa.
Ligusticum scoticum.
Mertensia maritima.

Of these, *Trientalis* is absent from Ireland; of the remaining six, three are confined to the north. This and the succeeding groups being much smaller than the British and English types, we will call in the full strength of the group, whether the species be of pure or qualified type, in order to strengthen the features indicated by their distribution. The Scottish type in Ireland is represented by 50 species, or less than half of the British total—

Scottish.

Trollius europæus.
Viola lutea.
Geranium sylvaticum.
Prunus Padus.
Callitriche autumnalis.
Drosera anglica.
Ligusticum scoticum.
Pyrola media.
secunda.
Melampyrum sylvaticum.
Ajuga pyramidalis.
Lamium intermedium.
Mertensia maritima.
Salix pentandra.
Habenaria albida.
Potamogeton filiformis.
nitens.
Scirpus rufus.
Carex limosa.
Festuca sylvatica.
Polypodium Dryopteris.
Equisetum umbrosum.
variegatum.

Scottish-British.

Thalictrum minus.
Sagina subulata.
Vicia sylvatica.
Parnassia palustris.
Antennaria dioica.
Pyrola minor.
Pinguicula vulgaris.
Galeopsis versicolor.
Carex dioica.
filiformis.
Elymus europæus.
Polypodium Phegopteris.
Equisetum hyemale.

Scottish-Highland.

Rubus saxatilis.	Lobelia Dortmanna.
Saxifraga hypnoides.	Empetrum nigrum.
Circæa alpina.	Salix phylicifolia.
Crepis paludosa.	Listera cordata.

Scottish-Intermediate.

Arenaria verna.	Saxifraga Hirculus.
Vicia Orobus.	Potamogeton prælongus.

Scottish-Atlantic.

Orobanche rubra.	Eriocaulon septangulare.

This is a purely native group; not one of them is under any suspicion of introduction. Most of them are plants of thoroughly wild ground—hills, heaths, glens, lakes, and bogs.

The maximum in any division is 43 (or 86 per cent.) in Antrim, the minimum 5 (or 10 per cent.) in East Cork. Constructing our map we get the following:—

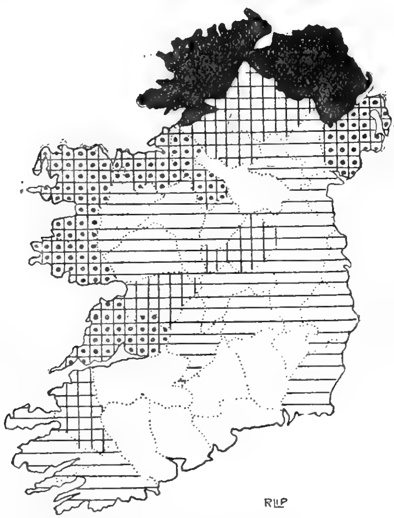

FIG. 2.—Distribution of "Scottish" plants.

The result is striking. The Scottish type plants are concentrated in the north, as we should expect. Thence they range down the coast on either side: but while on the east they greatly diminish south of

Co. Down, on the west coast they maintain their sway as far south as Clare, or even North Kerry. Inland everywhere they are few in number, Westmeath alone falling barely within the third grade. The latter fact cannot be accounted for by the absence of saline conditions in central Ireland, as out of the 50 species only four—*Ligusticum*, *Mertensia*, *Scirpus rufus*, and *Elymus*—are maritime plants. Nor is it due to an avoiding of the Central Plain on account of its limestone expanses, for the limestones of Sligo, Leitrim, and Clare yield them in abundance, and they attain their minimum in the south-east and south, where limestone is only very locally developed. Neither does the distribution of hilly ground satisfactorily account for their range, which is apparently due to climatic conditions as yet imperfectly understood.

4. Highland Type: "Species chiefly seen about the mountains."—As H. C. Watson points out, the more characteristic members of this group might be better called Arctic Type, as they consist of high northern species, brought into our latitudes by the elevation of the land into mountains. This group occupies the northern end of the series of four latitudinal types—English, Intermediate (a small and indefinite group), Scottish, Highland. Its headquarters are on the high Scotch mountains and in the extreme north of that country. The list of Highland type plants in Ireland is as follows:—

Thalictrum alpinum.
Subularia aquatica.
Draba incana.
Arabis petræa.
Silene acaulis.
Dryas octopetala.
Rubus Chamæmorus.
Alchemilla alpina.
Epilobium alsinefolium.
Sedum Rhodiola.
Saxifraga stellaris.
  nivalis.
  aizoides.
  oppositifolia.
Galium boreale.
Saussurea alpina.
Hieracium senescens.
  anglicum.
  iricum.
  prenanthoides.
  crocatum.
Hieracium strictum.
  gothicum.
  corymbosum.
Arctostaphylos Uva-ursi.
Vaccinium Vitis-Idæa.
Polygonum viviparum.
Oxyria digyna.
Salix herbacea.
Juniperus nana.
Carex pauciflora.
  rigida.
  aquatilis.
Aira alpina.
Sesleria cærulea.
Poa alpina.
Cryptogramme crispa.
Aspidium Lonchitis.
Asplenium viride.
Lycopodium alpinum.
Selaginella selaginoides.
Isoetes lacustris.

All of these are classed by Watson as of purely Highland type except *Subularia* and *Vaccinium Vitis-Idæa,* which he ranks as Highland-Scottish, and *Sesleria,* which goes as Highland-Intermediate. Plants of this group are thinly spread in Ireland, as is to be expected from the conformation of the country; but taking into account the character and altitude of the mountain-groups, the total does not fall much below what might be expected. With the vertical distribution of the species, the present paper is not concerned; but some interesting points become apparent from the mapping of their horizontal range. Here the maximum is 29 (or 69 per cent.) in West Donegal, the minimum 0 in Mid and East Cork. (Fig. 3.)

Being essentially a mountain group, it is desirable to contrast their distribution with that of high land in Ireland—say of over 1000 feet elevation. The actual distribution of land of over 1000 feet in Ireland is shown in fig. 4.

But for purposes of comparison, it may be well to construct a graduated map on the same principle as the floral maps (fig. 5). A difficulty is encountered here, for the amount of high land in two of the divisions—Wicklow and South Kerry—so far surpasses that which is found elsewhere, that were an evenly graduated scale employed, the varying elevation of the rest of the country would not be brought out. We therefore employ the following scale:—

0 – 25	square miles	over 1000 feet	elevation,	white
26 – 50	,,	,,	,,	=
51 – 75	,,	,,	,,	=|=|=
76 – 100	,,	,,	,,	÷|÷|÷
200 – 225	,,	,,	,,	black

For comparison, I add the distribution of ground over 2000 feet elevation (fig. 6), according to the scale—

0	square mile	over 2000 feet,	white
up to 1	,,	,,	=
1 to 3	,,	,,	=|=|=
3 to 8	,,	,,	÷|÷|÷
20 to 25	,,	,,	black

If we contrast these two maps with map 3, we have the materials for comparing the distribution of "Highland" plants in Ireland with that of high ground. In area of high ground, whether the 1000 foot

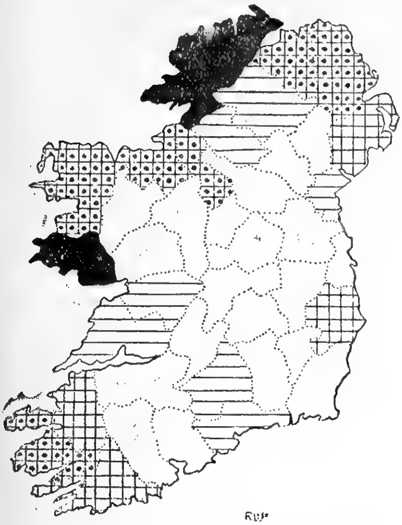

FIG. 3.—Distribution of "Highland" plants.

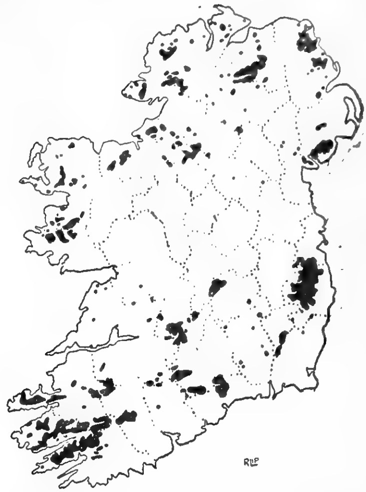

FIG. 4.—Actual distribution of land over 1000 ft.

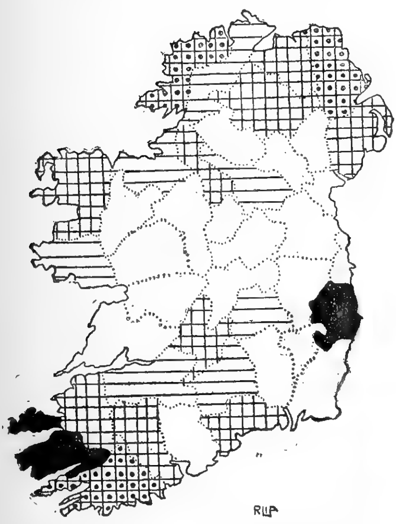

FIG. 5.—Distribution of land over 1000 feet.

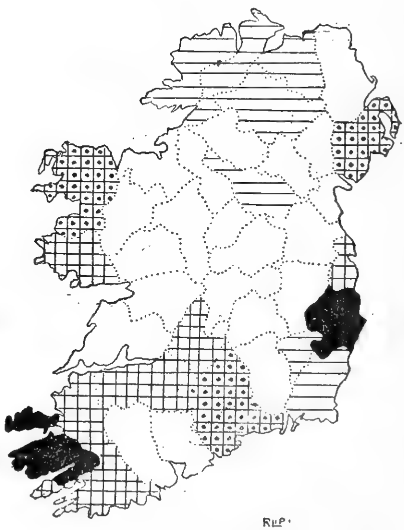

FIG. 6.—Distribution of land over 2000 feet.

or 2000 foot contour line be taken, Wicklow and South Kerry far outstrip any other portion of the country: yet both fall below the maximum of alpine plants, which is carried off by West Galway, and the two divisions of Donegal. The distribution of highland ground is in fact no criterion of the distribution of the highland flora. The amount of high ground in western Ireland (Kerry to Donegal inclusive) is about the same as that in eastern Ireland: but the collective Highland flora of the western half is double that of the eastern. If we want to get an analogue of the distribution of the alpine flora we will turn to the Scottish type map (fig. 2), and will at once see many points of resemblance. The distribution of these two allied groups is distinctly similar, the bulk of the species which compose them inhabiting chiefly the hilly grounds of the north and west, and being but sparsely spread over the east and south-east, and also of course over the centre.

Those "Highland" plants which occur in the east, as on the Mourne and Wicklow mountain ranges, are usually truly alpine in habitat; in the west a change of conditions is clearly shown by the frequent descent of alpines to sea-level, and by the ascent of maritime plants to high elevations (such as *Cochlearia officinalis, Silene maritima, Armeria maritima, Plantago maritima*) which are absent on the eastern mountains.

Leaving for the present the distribution in Ireland of Watson's latitudinal types, we must briefly consider those which are by their definition longitudinal—namely, the Germanic and Atlantic types.

5. GERMANIC TYPE: "Plants chiefly seen in East England."—This is a special group of English type plants, segregated and separately classed on account of their marked aggregation towards the south-east. As Watson points out, the Cretaceous deposits lie almost exclusively in the eastern and south-eastern provinces of England, so that the "chalk plants" fall within this type.

As examples of the Germanic type Watson names

Frankenia lævis.	Pulicaria vulgaris.
Anemone Pulsatilla.	Lactuca Scariola.
Reseda lutea.	Atriplex pedunculata.
Silene conica.	Aceras anthropophora.
noctiflora.	Spartina stricta.
Pimpinella magna.	

Of these, only one, *Pimpinella magna*, is certainly native in Ireland; of the rest, two alone, *Reseda lutea* and *Silene noctiflora*, are included in the Irish flora, marked as doubtfully indigenous.

Being the furthest removed from Ireland as regards not only actual distance, but soil and climate, it is to be expected that this should be the type least numerously represented in this country, and such is the case. Out of 102 "Germanic" plants in England, only thirteen are enumerated in the Irish flora, and four of these cannot be reckoned in the certainly indigenous list. The list is as follows; the extent of range of the members of the group in Ireland is so variable, that after each species the number of divisions in which it is known to occur is added, in order to illustrate this feature.

Germanic.

*Crepis biennis, 13.
† taraxacifolia, 18.
Polygonum mite, 4.
Scirpus triqueter, 2.
Glyceria Borreri, 2.

Germanic-British.

Astragalus Hypoglottis, 1.
*Senecio viscosus, 1.

Germanic-English.

‡Galium erectum, 8.
Hypopithys multiflora, 6.
Limosella aquatica, 2.
Teucrium Scordium, 7.
Orchis pyramidalis, 38.
Bromus erectus, 9.

This is, in Ireland, distinctly a calcicole group of plants. All but two—*Crepis biennis* and *Polygonum mite*—are confined to limestone districts or to limy sea-sands. Leaving out of account the two "certainly introduced" species, *Crepis biennis* and *Senecio viscosus*, as their range is devoid of phyto-geographical significance, and giving the remaining two dubious natives the benefit of the doubt, the distribution of the group works out as shown in fig. 7, next page.

Here the maximum is 8 species in Clare, the minimum 0 in Tyrone. Our scale is 0–1, 2–3, 4–5, 6–7, 8–9 species. The group is seen to attain its maximum in Clare, S.E. Galway, and Dublin; while the only divisions in which more than one species occur are certain counties in which limestone largely predominates. This result is significant, even though, when dealing with the distribution of so small a number of plants, it is unwise to lay too great emphasis on present results. The fact is that, as a group, the Germanic plants have no place in the Irish flora; such stragglers as have found their way here have a distinctly *limestone* range.

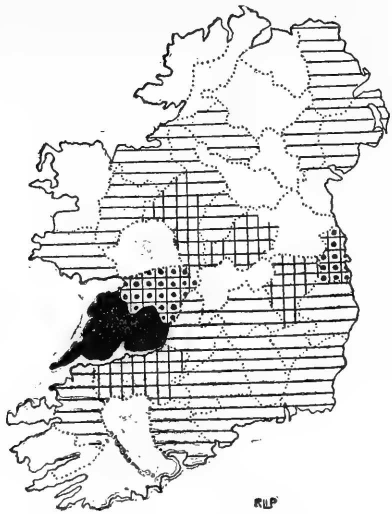

Fig. 7.—Distribution of "Germanic" plants.

6. Atlantic Type: "Species chiefly seen in West England."—This group has its headquarters in the south-west of England, and is in this way related to the "Hibernian" and "Lusitanian" groups of Ireland, since among them are the remnants of the old southern flora that flourished on the lost south-western shore-line of the British Isles. Watson's Atlantic type has other components besides these ancient species, but it is still the smallest of his British plant-groups, numbering altogether but 62 species.

As typical examples of "Atlantic" plants, Watson cites—

Sinapis monensis.
Matthiola sinuata.
Raphanus maritimus.
Sedum anglicum.
Cotyledon Umbilicus.
Bartsia viscosa.
Pinguicula lusitanica.
Euphorbia portlandica.
Scirpus Savii.
Sibthorpia europæa.
Erica ciliaris.
Polycarpon tetraphyllum.
Adiantum Capillus-Veneris.
Cynodon Dactylon.

Of these, four are unknown in Ireland; three are confined to the south and west; most of the others have a wide range in this country.

Of the 62 "Atlantic" plants occurring in Britain, Ireland possesses 33, as follows:—

Atlantic.

Matthiola sinuata.
Raphanus maritimus.
Viola Curtisii.
Lavatera arborea.
Erodium moschatum.
Carum verticillatum.
Crithmum maritimum.
Rubia peregrina.
Wahlenbergia hederacea.
Bartsia viscosa.
Sibthorpia europæa.
Euphorbia Peplis.
portlandica.
Asparagus officinalis.
Rhynchospora fusca.
Scirpus Savii.
Asplenium lanceolatum.
Adiantum Capillus-Veneris.
Hymenophyllum tunbridgense.

Atlantic-British.

Hypericum Androsæmum. Cotyledon Umbilicus. Lastrea æmula.

Atlantic-English.

Linum angustifolium.
Hypericum elodes.
Erodium maritimum.
Sedum anglicum.
Inula crithmoides.
Statice occidentalis.
Euphorbia Paralias.

Atlantic-Scottish.

Pinguicula lusitanica.
Scilla verna.

Atlantic-Highland.

Hymenophyllum unilaterale.

Atlantic-Intermediate.

Meconopsis cambrica.

Two other members of the group, *Senebiera didyma* and *Bromus madritensis*, are omitted as probable introductions into Ireland. It will at once be remarked that a large number of these—a full dozen—are maritime plants. The rest are largely plants of rocks and bogs the group is characteristic of thoroughly wild ground.

The maximum in any Irish county-division is 24 (or 72 per cent. of the Irish list) in South Kerry, West Cork, and Waterford, the minimum 2 (or 6 per cent.) in Kildare. Our map works out very prettily:—

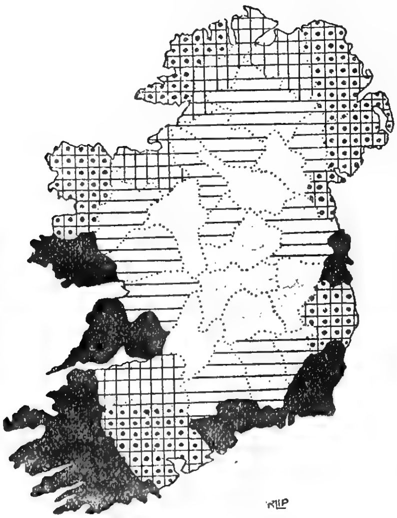

Fig. 8.—Distribution of "Atlantic" plants.

The group is seen to be essentially coastal—partly on account of the plentiful sprinkling of maritime species, partly because the remainder are largely plants of the rough country which often accompanies the older rocks; such country as is found in the home of the group in Devon, Cornwall, and Wales, and in Ireland round a great portion of the seaboard. The group also shows an increase southward, and attains its full luxuriance round the shores of the southern half of Ireland.

Before proceeding to briefly sum up the features brought out by the foregoing series of maps, it will be well to consider one important factor in plant-distribution. Apart from climate, the most potent influence affecting the flora is undoubtedly soil, and it is the presence or absence of lime in soils that most affects the vegetation which they support. Ireland consists, roughly speaking, of a great plain of Carboniferous limestone occupying the centre, with more elevated and broken ground formed of non-calcareous rocks around the margin. The actual distribution of limestone is shown in black on the following map (fig. 9). Let us compare this with the distribution of lime-loving and lime-avoiding plants.

FIG. 9.—Actual distribution of Carboniferous limestone.

The data are at hand. Mr. Colgan has paid much attention to these soil-relations in Ireland, and has compared his results with those obtained in France; in the second edition of "Cybele Hibernica" he indicates the calcicole and calcifuge species, using three grades (A, B, C) for each, according to their degree of preference for a limy soil or soil free from lime, "A" indicating the most marked preference in either case.

The calcicole plants of "Cybele" range as follows:—

Calcicole A.

Geranium lucidum.
Potentilla fruticosa
Galium sylvestre.
Carlina vulgaris.
Gentiana verna.
Calamintha officinalis.
Galeopsis Ladanum.
Orchis pyramidalis.
Ophrys apifera.
Sesleria cærulea.

Calcicole B.

Aquilegia vulgaris.
Reseda Luteola.
Hypericum perforatum.
Anthyllis Vulneraria.
Poterium Sanguisorba.
Pimpinella Saxifraga.
magna.
Rubia peregrina.
Galium boreale.
Asperula cynanchica.
Erigeron acre.
Tussilago Farfara.
Carduus nutans.
Centaurea Scabiosa.
Crepis taraxacifolia.
Leontodon hirtus.
Leontodon hispidus.
Chlora perfoliata.
Gentiana Amarella.
Lithospermum officinale.
Verbascum Thapsus.
Salvia Verbenaca.
Origanum vulgare.
Ophrys muscifera.
Spiranthes autumnalis.
Juncus glaucus.
Carex divulsa.
glauca.
Trisetum flavescens.
Avena pubescens.
Adiantum Capillus-Veneris.
Ceterach officinarum.

Calcicole C.

Arabis hirsuta.
Sisymbrium Alliaria.
Viola hirta.
Cerastium arvense.
Euonymus europæus.
Antennaria dioica.
Pulicaria dysenterica.
Convolvulus arvensis.
Habenaria conopsea.
Carex muricata.
Festuca rigida.

Total 53. Our maximum is 50 in Clare, minimum 20 in Tyrone. The map works out as shown in fig. 10, opposite page.

The result is somewhat unexpected. The calcicole group has its headquarters, not in the Limestone Plain, but in the west, reaching its maximum in Clare, S.E. Galway, and Limerick. Thence it follows the edge of the limestone northwards, so that although West Galway has nothing more than a strip of limestone along its eastern edge, this division is high in the scale, along with N.E. Galway and E. Mayo. A prevalence of calcicole plants appears also in E. Cork, Kilkenny, Kildare, and Dublin, none of which occupy the first rank as regards area of limestone. Elsewhere the distribution of the group is what we should expect: the minimum is reached in Ulster, where, on the Silurian area and elsewhere, but few calcicole plants maintain an existence. The reason for the great development of the calcicole group in the west is not far to seek; it lies in the occurrence of bare limestone pavements in the Burren area, in Limerick, and around the great lakes of Corrib and Mask. It is the presence of live limestone rock over large areas that produces the calcicole flora in its full development. The tough limestone drift which covers the rock over the greater portion of the Central Plain and eastern counties, may, as a matter of fact, have all the lime washed out of its surface layers, and yield a non-calcareous soil.

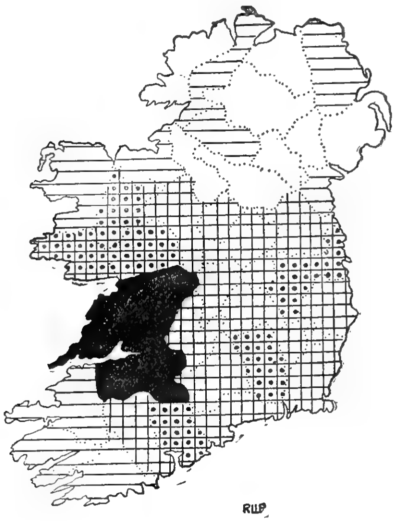

FIG. 10.—Distribution of calcicole plants.

To turn to the calcifuge group. The plants which show a preference for a non-calcareous soil are more numerous than those which prefer lime; so that the species classed as *calcifuge A* in "Cybele" almost equal in number the whole calcicole group and will alone suffice for our purpose. They are as follows:—

Calcifuge A.

Corydalis claviculata.
Viola palustris.
Polygala serpyllacea.
Montia fontana.
Elatine hexandra.
Hypericum elodes.
Radiola linoides.
Cytisus scoparius.
Ulex Gallii.
Lathyrus macrorrhizus.
Saxifraga stellaris.
umbrosa.
Drosera rotundifolia.
anglica.
intermedia.
Peplis Portula.
Galium saxatile.
Gnaphalium uliginosum.
Senecio sylvaticus.
Lobelia Dortmanna.
Jasione montana.
Wahlenbergia hederacea.
Vaccinium Vitis-Idæa.
Myrtillus.

Calcifuge A—continued.

Calluna vulgaris.
Erica Tetralix.
    cinerea.
Microcala filiformis.
Digitalis purpurea.
Scutellaria minor.
Polygonum Hydropiper.
Rumex Acetosella.
Narthecium ossifragum.
Juncus squarrosus.
    supinus.
Potamogeton polygonifolius.
Scirpus cæspitosus.
    fluitans.
Carex pilulifera.
    binervis.
Deschampsia flexuosa.
Nardus stricta.
Blechnum Spicant.
Athyrium Filix-fœmina.
Lastrea dilatata.
Osmunda regalis.

Total 46. The group reaches its maximum in Kerry and West Cork with 44 species, minimum in Westmeath with 26 species.

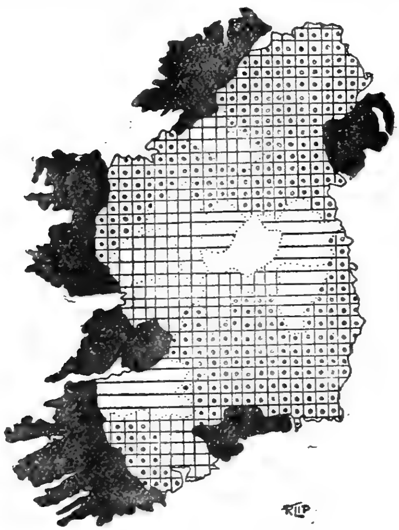

FIG. 11.—Distribution of calcifuge plan

It will be noted that calcifuge plants are more widely spread than calcicole. Not only is the scale somewhat higher than that of the calcicole group, being 56 to 95 per cent. of the group, as against 38 to 95 per cent., but the number of high percentages is much greater, even though we are dealing with only the most strongly calcifuge species. The reason is clearly to be seen in the fact that non-calcareous soils are to be found in limestone areas, both on account of the washing-out process referred to, and by reason of accumulation of vegetable matter, in woods, and much more in bogs, which are largely developed in the Irish limestone districts. On the other hand, no natural process is at work in this country producing a calcareous soil in districts devoid of limestone, except on coastal sands, where shelly accumulations may have a distinct effect on the flora.

Glancing at the map, it will be seen by comparison with map 8 that, as contrasted with the distribution of limestone, the range of the calcifuge flora is quite normal. It reaches its maximum on the old non-calcareous rocks that stand grouped around the coast; its minimum in the Limestone Plain. The absolute minimum is reached in Westmeath, the only division in Ireland which can be said to be altogether under the sway of the limestone. It will be noted that in Clare, where the calcicole flora attains its greatest development, the calcifuge flora is also at high-water mark; but in the rich and remarkable flora of that varied county, almost every group, whether English or Scottish, Atlantic or Germanic, calcicole or calcifuge, attains or approaches its maximum!

Considering generally the series of maps showing the range in Ireland of the "types" of Great Britain, it will be seen that we have really three topographical groups to deal with:—

(1) ENGLISH and GERMANIC, the latter a peculiar and intensified section of the former. A southern group, often light-soil and often calcicole in their proclivities. The Germanic plants represent the xerophile and thermophile element in the flora of England, and are congregated where a comparatively continental climate produces hot and dry summers. In Ireland these groups are concentrated along the east and south-east coasts, where position, soil, and climate apparently account for their predominance; and in the Clare district, where the warm dry limestone pavements probably form the attraction.

In referring the paucity of "Germanic" plants in Ireland to the breaking down of the Irish-English land-connection prior to that of the English-Continental, the editors of "Cybele Hibernica," ed. II., remark (p. xliii):—"The advance guard of aggressive species, the British type and a large section of the English type, had time to push westward into Ireland before its eastward land-connections were broken down; but the rear-guard of more slowly spreading species found their westward progress checked by the land subsidence which created the Irish Sea. The mass of this rear-guard was probably formed of the Germanic type plants, a group so little aggressive in character that it seems to have been quite unable to push its way, as a whole, across England, in the face of the more hardy settlers who had gone before and occupied the ground." I do not altogether follow this explanation. Rather than compare the stream of plant-migration to the march of an army, of which the main body does the fighting, and the rearguard has merely to follow across ground cleared for its progress, ought we not to choose as a simile the spread of an empire, which enlarges its boundaries without in any way relaxing its hold over the ground already won. The plant-army had to conquer a presumably weaker flora which was in possession of the ground; but the rear-guard had to oust the conquerors! It is a fair assumption that each successive wave of migration was composed of species more hardy and aggressive—better fitted for the struggle for existence—than those which preceded it; otherwise it would not advance. Then, is the "Germanic" group composed of species "more slowly spreading" and "so little aggressive in character"? An examination of the list of "Germanic" plants is not favourable to this view. Mr. Clement Reid[1] has conveniently summarised the seed-characters possessed by British plants which assist them in migration, and has pointed out that capacity for migration consists largely of the power of a species to cross "deserts"—a desert being an area unsuitable to the plant: it may be water, low ground or high ground, dry soil or wet soil, limy soil or soil free from lime. We fail to find, among "Germanic" plants, any characters which render them inferior to the other groups in power of dispersal. Five of our Irish "Germanic" plants are under more or less suspicion of being recent human introductions: namely, ‡*Galium erectum*, **Crepis biennis*, †*C. taraxacifolia*, **Senecio viscosus*, †*Bromus erectus*. All but the fourth have spread widely by natural means, moving freely about the crowded country, and showing no lack either of aggressiveness or of rapidity of migration. The "Germanic" plants may have been the rear-guard of the Post-Glacial migration which provided our islands with the bulk of their present flora. But if so they fought their way right across Europe (where many of them have a wide distribution) against the "British" and "English" plants that had gone before; while the mobile remnant that reached Ireland before the breaking-down of the land-connection marched right across the country, or round its former margin, and still holds its ground on the very edge of the Atlantic. The range of Watson's Germanic type in the British Isles appears

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[1] Origin of the British Flora, chap. iii.

to be due largely to suitability of soil, partly to conditions of climate.

(2) SCOTTISH and HIGHLAND. These are the northern plants, the latter an intensified group of the former. In Ireland they are concentrated in the north, spreading somewhat abundantly down the western coast, much more sparsely along the eastern. It should be noted that the distribution in England and Wales of these plants offers many points of resemblance to their Irish range, though the species extend somewhat further southward in the larger island. As in Ireland, the group spreads far down the west coast of England, much less so down the eastern, so that, on a rough examination, South Wales appears to contain as many "Scottish" plants as the Trent province. Physical conditions will suggest themselves in explanation of this in a manner not applicable to Ireland, where the problem is more difficult of solution. A line drawn north-eastward from the Bristol channel to the Wash will cut off, on the northward, most of these plants; and this line would appear to correspond well with one in Ireland drawn from the Shannon mouth to Dundalk Bay.

To account for the greater abundance of alpine plants in the west than in the east of Ireland, the suggestion has been made, in "Cybele Hibernica," ed. II., and elsewhere, that during the Glacial Period the mantle of ice drove these species downward to the seaboard in the milder west, whence, on the retreat of the ice-sheet, they colonized the western mountains. This appears as likely a hypothesis as can be put forward. But the similarity of the range of "Highland" and of "Scottish" species suggests that at least some of the "Highland" plants, which in Ireland are not alpine in range, may have come into Ireland with the "Scottish" plants, many of which probably colonized this country from the north-east. Another point to be remembered is that—presumably on account of greater moisture—the west of Ireland is undoubtedly more suited, even at low elevations, to the growth of alpine plants than the eastern, and the "lowest limit" line, which for many species almost touches sea-level along the west coast, may, in the east, pass above the tops of the mountains.

(3) ATLANTIC. In England south-western, and including a considerable number of maritime plants. This is the hygrophile element of the English flora, composed of plants which prefer the equable temperature and abundant moisture that pertain to an insular climate. In Ireland the group is rather southern, distributed in fair proportion round the southern half of the littoral, but many of the species occur round the greater part of the Irish coast.

Glancing at the maps showing the distribution of calcicole and calcifuge species, it will be seen that, while the range of the "Scottish," "Highland" and "Atlantic" plants corresponds broadly with that of the calcifuge flora, the distribution of "English" and "Germanic" species offers many points of resemblance to that of the calcicole group; which facts we should expect to be apparent when we consider the petrological conditions prevailing in the homes of Watson's various "types."

So far as I can gather without an elaborate study of the distribution of the flora of Great Britain as known at present (which would be outside the scope of the present paper), there is a greater overlap in northern and southern forms in England than is the case with Ireland. If we construct isophytic lines to represent the limit of the main body of the "Scottish" and "English" floras respectively in Great Britain and in Ireland, they will run somewhat like this :—

FIG. 12.—Isophytic lines in the British flora.
AA. Northern limit of the "English" flora. BB. Southern limit of the "Scottish" flora.

But this statement is only put forward tentatively and as a side-issue of the subject in hand. The material for a proper study of the question is now in existence, though much scattered, and will, I trust, be some day brought together and analysed. It is an interesting point.

To come now to the second portion of my paper—the question of natural geographic plant-groups in the Irish flora. Following on Watson's lines, an essay has been made to group the native species according to their present horizontal range, and without reference (in the first instance) to the environmental or other cause of such distribution. For this purpose, a set of maps was employed, representing the whole Irish flora, each map showing, by means of a uniform wash of colour, the range of one species, the data used being those given in "Irish Topographical Botany" brought up to date. On these maps,

FIG. 13.
Continuous range of a native plant (*Cicuta virosa*).

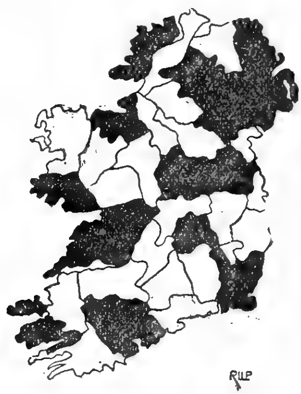


FIG. 14.
Discontinuous range of an introduced plant (*Sedum Telephium*).

divisions in which any plant was considered as probably or certainly introduced were left uncoloured. The set of over eleven hundred maps was then sorted by eye according to the distribution of the colour on each. In this way, by making the process as mechanical as possible, I hoped to determine the natural grouping of the plants, and to eliminate theoretical considerations. The groups thus obtained were then critically examined, and the claim of each member to belong to it considered. This involved questions of relative frequency throughout the range, and considerations relating to possible introduction in certain divisions. All species ranked as probably or certainly introduced in Ireland were kept apart. as their range could throw but little light on natural plant groups. It may be remarked that the maps brought out very clearly the discontinuity of range which marks the alien flora. Speaking generally, the native lowland plants are characterized by a continuous range between their limits, while the alien plants frequently exhibit a broken and discontinuous range (figs. 13, 14). Remarkable exceptions to both rules exist, and will be mentioned later on.

In arranging the maps under types of distribution, one difficulty was quick to make itself felt. This was, that in the natural flora every gradation exists between any two types of distribution which we may select. The difficulty was met by using Watson's plan—the only possible one—of modified or intermediate types as already referred to; but considering the unsatisfactory nature of such fine distinctions in a flora not yet fully worked out, the creation (by publication) of such intermediate types is for the present withheld, and lists will be given chiefly of those plants whose range is sufficiently characteristic to allow of their being referred without qualification to one definite type of distribution.

The grouping of the maps established in the first place two classes: (A) plants which show no aggregation in any portion of the country; and (B) plants which show an aggregation or diminution in some portion of the country.

Class A consists of (1) universal species, *i.e.* species on record for all the forty botanical divisions, and showing no marked increase or decrease in frequency in any direction; (2) species of probably universal distribution, the occasional gaps on the maps being with little doubt the result of incomplete knowledge. To sections (1) and (2) some 360 species may be referred, or about one-third of the Irish flora. (3) Following these we have a range of species of diminishing frequency but wide distribution, the list extending from the border of the "probably universal" species down to plants which have only a few widely scattered stations in Ireland, and which might be separately classed as of local type. Following the nomenclature of Watson, who gave the name of British type to all species evenly spread throughout Great Britain (though not necessarily *continuously* distributed), we may define the three groups of the above Class A as of "Irish" type so far as the Irish flora is concerned; but the use of this term, except with the qualification appended, might mislead; and I prefer to employ, in the present paper, the term "General type of distribution," for all species whose distribution shows no marked aggregation in any part of the country. It does not appear necessary to list those common plants, over 260 in number, which are at present known to be universal in Ireland—inhabitants of every botanical division. As might be expected, the plants of universal distribution in this country are almost all of Watson's British type likewise; it will be worth while to note the exceptions. In the following list the "probably universal" species which are not of British type are added to the "universal" plants, and distinguished by an asterisk.

PLANTS OF GENERAL DISTRIBUTION IN IRELAND WHICH ARE NOT OF BRITISH TYPE.

British-English, 41 species.

Ranunculus bulbosus.
Barbarea vulgaris.
*Reseda Luteola.
*Arenaria trinervia.
Malva sylvestris.
Hypericum tetrapterum.
Trifolium dubium.
*Lotus uliginosus.
Geum urbanum.
Agrimonia Eupatoria.
Epilobium parviflorum.
Circæa lutetiana.
*Æthusa Cynapium.
Caucalis Anthriscus.
Sambucus nigra.
Viburnum Opulus.
Eupatorium cannabinum.
Petasites officinalis.
Anagallis arvensis.
Myosotis palustris.
*Veronica polita.
*Veronica montana.
*Mentha sativa.
*Lycopus europæus.
*Polygonum lapathifolium.
Rumex nemorosus.
Euphorbia Peplus.
*Salix alba.
*Allium ursinum.
Typha latifolia.
*Sparganium simplex.
*Potamogeton crispus.
Carex remota.
* sylvatica.
hirta.
Briza media.
*Bromus giganteus.
* asper.
Nardus stricta.
Scolopendrium vulgare.
Aspidium angulare.

British-Scottish, 5 species.

Potentilla palustris.
Habenaria viridis.
Scirpus cæspitosus.
Eriophorum vaginatum
Botrychium Lunaria.

British-Highland, 3 species.

Chrysosplenium oppositifolium.
Vaccinium Myrtillus.
Lycopodium Selago.

English-British, 11 species.

*Nuphar luteum.
Potentilla reptans.
Epilobium hirsutum.
*Bidens cernua.
Lysimachia vulgaris.
*Samolus Valerandi.
Calystegia sepium.
*Convolvulus arvensis.
*Juncus glaucus.
Carex disticha.
*Equisetum maximum.

Scottish-British, 1 species.

*Antennaria dioica.

Atlantic-British, 1 species.

Hypericum Androsæmum.

Atlantic-English, 1 species.

*Cotyledon Umbilicus.

English, 7 species.

Sagina apetala.
Euonymus europæus.
Pyrus Malus.
Apium nodiflorum.
Pulicaria dysenterica.
Arum maculatum.
Ceterach officinarum.

Scottish-Highland, 1 species.

*Crepis paludosa.

From this analysis, we find that the "Universal" plants of Ireland which are not equally widespread in Great Britain are generally in the latter island of rather southern range (British-English and English-British); and a few are distinctly southern (English); this result we might expect from a comparison of the range of latitude of the two islands. The most noteworthy feature of the few other species in the lists is the abundance in Ireland of the distinctly northern (Scottish-Highland) *Crepis paludosa.*

Cnicus pratensis has an anomalous range. Though recorded from every Irish division, it is rare in the east and increases westward, becoming abundant in the west and north; while in Great Britain it is of characteristic English type, being unknown north of Yorkshire. Its range in Ireland is the reverse of that of most English type plants—see fig. I. above.

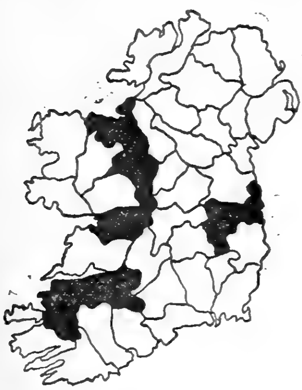
In the case of a few other "Universal" plants, their distribution over the country is not even, but it is yet not sufficiently accentuated to render their separation necessary. These are mostly calcicole or calcifuge species, which increase in abundance in the centre or round the margin according to their proclivities.

As regards the plants of General type which are not universal. In some cases the gaps in range are with little doubt only apparent; this applies particularly to critical species, such as the two whose distribution is illustrated below (figs. 15, 16).

FIG. 15.—*Viola Reichenbachiana.*

FIG. 16—*Ranunculus heterophyllus.*

But many other cases are instances of genuine discontinuous distribution; four good examples are illustrated below, all being well-known and easily recognized species (figs. 17–20).



17.—*Hypopithys multiflora.*

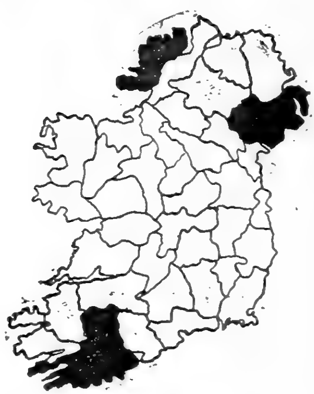


Fig. 18.—*Linaria repens.*

Fig. 19.—*Stachys Betonica.*

Fig. 20.—*Cephalanthera ensifolia.*

The following is a list of the species of General type of distribution other than the universal species, plants of intermediate or doubtful type being omitted; for comparison, the Watsonian type in Great Britain is appended (in initial) to each species[1]:—

Name.	Irish Census.	Watsonian type.
Anemone nemorosa,	39	B
Ranunculus trichophyllus,	30	E ?
Drouetii,	12	—
heterophyllus,	20	—
Auricomus,	24	BE
Nuphar luteum,	39	EB
Fumaria pallidiflora,	24	B
confusa,	29	—
Boræi,	14	—
muralis,	14	—
officinalis,	28	B
Nasturtium sylvestre,	10	E
Cardamine flexuosa,	39	—
Lepidium campestre,	8	BE
Reseda Luteola,	39	BE
Viola palustris,	38	B
canina,	36	B
Reichenbachiana,	12	—
arvensis,	37	B
Polygala vulgaris,	37	B
serpyllacea,	38	—
Silene Cucubalus,	39	B
Stellaria Holostea,	39	B
Arenaria trinervia,	37	BE
serpyllifolia,	39	B
Sagina nodosa,	39	B
Montia fontana,	38	B
Ilex Aquifolium,	39	B
Trifolium medium,	29	B
procumbens,	39	B
Anthyllis Vulneraria,	37	B
Lathyrus macrorrhizus,	36	B
Potentilla procumbens,	32	B
Rosa spinosissima,	36	B
involuta,	8	B ?
mollis,	17	B
Cotyledon Umbilicus,	39	AE
Myriophyllum spicatum,	35	B
Callitriche stagnalis,	32	—
obtusangula,	12	—
Apium inundatum,	38	B
Æthusa Cynapium,	37	BE

[1] In this and following lists, since statistics are no involved, segregates ar included if their distribution is characteristic.

Name.	Irish Census.	Watsonian type,	Name.	Irish Census.	Watsonian type.
Scandix Pecten-Veneris,	32	BE	Polygonum maculatum,	4	—
Asperula odorata,	39	B	Salix alba,	38	BE
Valeriana Mikanii,	13	—	Empetrum nigrum,	31	SH
Scabiosa arvensis,	29	B	Ceratophyllum demersum,	10	EB
Solidago Virgaurea,	38	B	Neottia Nidus-avis,	23	BE
Bidens cernua,	39	EB	Cephalanthera ensifolia,	12	E
Achillæa Ptarmica,	37	B	Epipactis latifolia,	30	BE
Senecio sylvaticus,	38	B	Orchis latifolia,	10	?
Arctium minus,	29	B	Allium ursinum,	37	BE
Crepis paludosa,	37	SH	Juncus glaucus,	39	EB
Hieracium murorum,	11	B	Sparganium simplex,	36	BE
umbellatum,	17	E	affinis,	20	BS
Erica cinerea,	39	B	Butomus umbellatus,	16	E
Hypopithys multiflora,	7	GE	Potamogeton heterophyllus,	30	BE
Lysimachia nemorum,	39	B	nitens,	19	S
Samolus Valerandi,	39	EB	lucens,	28	EB
Myosotis versicolor,	39	B	perfoliatus,	37	BE
Lithospermum officinale,	30	BE	obtusifolius,	20	EB
Convolvulus arvensis,	36	EB	Eleocharis acicularis,	23	EB
Veronica hederæfolia,	36	B	Scirpus sylvaticus,	16	BE
agrestis,	39	B	Eriophorum vaginatum,	39	BS
polita,	36	BE	latifolium,	10	BE
montana,	36	BE	Carex sylvatica,	39	BE
Anagallis,	39	B	vesicaria,	37	BE
scutellata,	39	B	Phleum pratense,	33	BE
Melampyrum pratense,	39	B	Glyceria plicata,	21	EB
Utricularia vulgaris,	37	B	Bromus giganteus,	39	BE
minor,	39	B	asper,	39	BE
Mentha sativa,	35	BE	Lolium temulentum,	30	BE
Lycopus europæus,	37	BE	Nardus stricta,	39	BE
Scutellaria galericulata,	33	B	Polypodium Dryopteris,	5	S
Stachys Betonica,	11	EB	Botrychium Lunaria,	36	BS
Lamium hybridum,	21	B	Equisetum maximum,	37	EB
Teucrium Scorodonia,	39	B	hyemale,	16	SB
Polygonum lapathifolium,	33	BE			

If we analyse this list, making in the case of composite type plants a certain allowance in each of the types concerned, we find that the plants are 70 per cent. British type, 24 per cent. English, 5 per cent. Scottish, and less than 1 per cent. each Atlantic, Germanic and Highland. This result calls for no remark.

Under the general type also we can best place our common maritime plants (see p. 39)—species which are of general occurrence where saline conditions prevail, such as *Cochlearia officinalis*, *Arenaria peploides*, *Eryngium maritimum*, *Salicornia herbacea*, *Triglochin maritimum*, *Glyceria maritima*, *Asplenium marinum*. These are about forty in number: they are almost exclusively of British type in Great Britain; their distribution calls for no remark, and we need not delay over them.

Before leaving the plants of general distribution in Ireland, it is to be noted that a group of species drops in here which belongs neither to Class A treated of above nor to Class B which follows. These are widely distributed species the feature of whose range is their *absence* from some one defined area. The distribution of these is not sufficiently even to allow of their being placed in Class A, nor is it sufficiently restricted to permit of their inclusion in any portion of Class B. The thinning out or absence of a plant as shown in these instances is of high interest, and of as great phyto-geographical importance as the restriction of another to the same area. It will presently appear that the two phenomena sometimes go hand-in-hand, and I shall further refer to ranges such as the above-mentioned after the converse case of plants characteristic of the same areas has been discussed. It may be pointed out that even if such gaps in range are eventually filled up by the discovery of a few stations in the blank counties, the result will be to obscure rather than to do away with an interesting feature of their distribution, for they are in any case much rarer in these areas than in the rest of Ireland.

We now pass to the second and more important of the two large classes into which the set of maps naturally divides itself—plants which show an aggregation in some portion of the country.

It is to be remembered that, as compared with Great Britain, Ireland is small, with a more restricted range both in latitude and in longitude, and in altitude as well. It is also of more even shape, being roughly elliptical in outline, and possesses less variety of surface and climate. It is not surprising, therefore, that the flora of its various portions displays a reduced diversity; in other words, that the number of species of strongly marked local range is not large. Nevertheless, some definite features of distribution came out clearly as the maps were studied. The first strong character displayed is a tendency towards a central or marginal distribution, a peculiarity not found to any marked degree in the flora of Great Britain, and resulting from the physical features of the country. The non-calcareous rocks and the mountain-groups lie around the edge of the island, and here is concentrated the flora pertaining to such conditions; while the low-lying limestone plain with its numerous bogs, marshes, and lakes, is the head-quarters of a different set of species. By referring a plant to the Central type of distribution, then, we signify that it is found chiefly in the Central Plain. While plants of this type often extend to the margin of the island in the east and west, they show a marked restriction of range towards the north and south.

The area of the Central type of distribution may be defined as being limited by a line joining the Shannon mouth with Waterford on the south, and a line joining Sligo Bay with Dundalk Bay on the north, while in its most characteristic form it does not touch either the eastern or western margin of the island. The circle on fig. 21 approximately defines its ideal boundary.

The Marginal type, which is generally speaking the converse of this, hardly requires definition, as its name is sufficiently descriptive. The plants which belong to it are characterized by a tolerably even though frequently discontinuous range through those divisions which lie around the margin of the island, and by an avoiding of the Limestone Plain. The negative character of avoidance of the Central Plain is the most striking feature of this type of distribution; and the ring which marks the range of the constituent species frequently thickens considerably in the north and south, where the coast-line lies far from the edge of the plain. The area of the Marginal type of distribution may be described as lying outside the circle on fig. 21.

A number of the rarer and more interesting plants of Ireland are more or less marginal in distribution (being rare in the Central Plain), but are restricted to limited areas; while many others show a general increase towards the north, south, east, or west of the island. As regards these, the strongest phytological boundary which developed itself is one which corresponds with the curves evolved from a consideration of the range in Ireland of the northern and southern plants of Great Britain (see fig. 12); and this boundary can be best localized by drawing a line from Galway Bay on the west to Dundalk Bay on the east. The need of a dividing line between eastern and western plants also became clear; and the most natural boundary appeared to be a line passing through the cities of Londonderry and Cork—a division which corresponds with the partition into eastern and western already employed in "Irish Topographical Botany."

The central circle and these two intersecting lines, then, define six types of distribution which I believe are founded on the actual range of plants in the country. The names most conveniently employed for the "types" will be

2. Central.	5. Mumonian.
3. Marginal.	6. Lagenian.
4. Ultonian.	7. Connacian.

the last four being named after the four provinces of Ireland, in which each type respectively reaches its maximum, namely: Ultonian type in Antrim, Mumonian type in East Cork, Lagenian type in Dublin, Connacian type in West Galway.

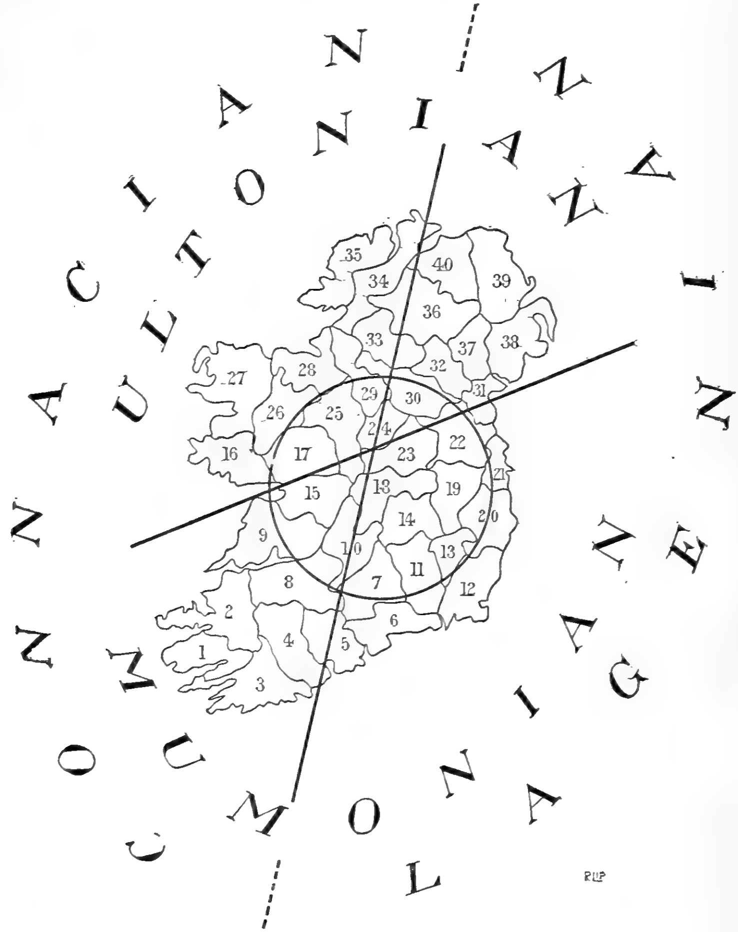


FIG. 21.—Boundaries of the areas of the Irish Types of Distribution.

We have now to consider in detail the six types of distribution above defined. In the lists of species which follow, only the more characteristic plants of each type are mentioned. No attempt is made, considering the still incomplete state of our knowledge, to refer *every* Irish plant to some type or combination of types. It is quite possible that some of the plants which appear in the lists below may, in the course of time, receive an extension of range that will place them outside of the type to which they are at present referred. On the other hand, future confirmation of the present limits of range may allow other species to be definitely referred to one or other of the "types" which are at present unclassed. After the name of each species, its Irish census is given, and its type in Great Britain is added for comparative purposes.

2. CENTRAL TYPE.—Thirty-eight species, with an average range of 15 divisions per species, fall into this group. The distribution of four characteristic plants of this type is shown in figs. 22 to 25.

FIG. 22.—*Stellaria palustris.*

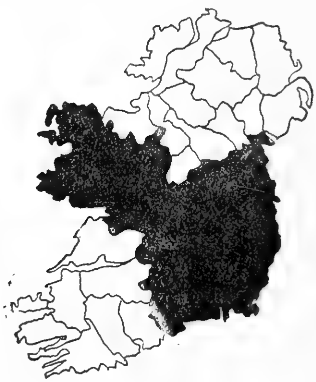


FIG. 23.—*Orchis Morio.*

FIG. 24.—*Sium latifolium.*

FIG. 25.—*Andromeda Polifolia.*

Thalictrum flavum,	23	E	Gentiana Amarella,	29	BE
Ranunculus circinatus,	13	EG	Teucrium Scordium,	7	GE
Caltha radicans,	2	—	Betula verrucosa,	17	—
Stellaria palustris,	19	EB	Orchis Morio,	20	E
Rhamnus catharticus,	19	E	Ophrys apifera,	26	EG
Lathyrus palustris,	11	E	muscifera,	8	EG
Poterium Sanguisorba,	21	E	Juncus obtusiflorus,	26	E
Myriophyllum verticillatum,	25	E	Lemna polyrhiza,	8	E
Sium latifolium,	14	EG	Sagittaria sagittifolia,	21	E
Cornus sanguinea,	13	E	Potamogeton plantagineus,	23	EB
Galium uliginosum,	13	BE	Carex paradoxa,	1	LI
Erigeron acre,	17	E	Pseudo-cyperus,	22	E
Inula salicina,	2	absent	Equisetum variegatum,	15	S
Carlina vulgaris,	28	EB	Chara desmacantha,	21	—
Centaurea Scabiosa,	21	BE	polyacantha,	22	—
Crepis taraxacifolia,	18	G	denudata,	1	—
Tragopogon pratensis,	22	BE	tomentosa,	5	—
Andromeda Polifolia,	24	IS	Tolypella glomerata,	11	—
Pyrola rotundifolia,	1	SG	Nitella tenuissima,	2	—

An examination of this list shows a characteristic composition. Eleven of the thirty-eight are aquatic; species nine more are marsh plants. Ten belong to pastures and dry ground; two are bog plants. Eight are calcicole, and none calcifuge, according to the standard of "Cybele Hibernica." All are lowland; none are characteristic of the uplands or highlands. None are woodland species. If we construct a statistical map according to the plan already used, the distribution of the group comes out clearly (fig. 26).[1] Here the minimum is 1 in South Kerry and West Donegal, the maximum 35 (or 92 per cent. of the group)

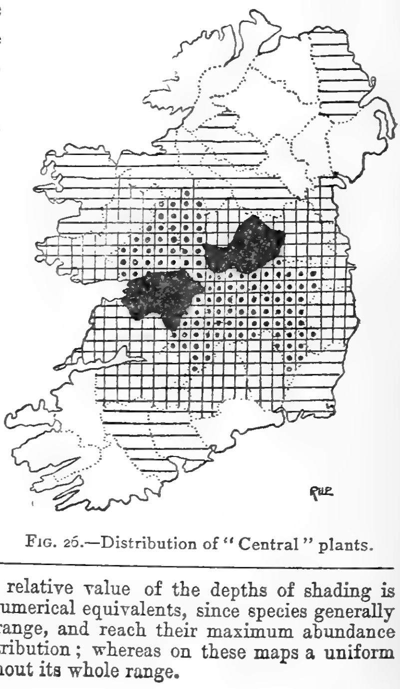


Fig. 25.—Distribution of "Central" plants.

[1] It may be pointed out that the relative value of the depths of shading is really higher than expressed by the numerical equivalents, since species generally thin out towards the limits of their range, and reach their maximum abundance about the centre of their areas of distribution; whereas on these maps a uniform value is awarded to each plant throughout its whole range.

in Westmeath, followed by 31 in S.E. Galway. It will be noted that Antrim furnishes a sufficient number of species to raise it above the minimum grade; this is the effect of the Lough Neagh flora, which includes a number of stragglers from the waters and marshes of the Central Plain, such as *Thalictrum flavum*, *Rhamnus catharticus*, *R. Frangula*, *Lathyrus palustris*, *Sagittaria sagittifolia*. The prolongation of certain species into Mid and East Cork appears to be due to the extension of the limestone into those divisions. Analysed according to their British distribution, this "Central" plant-group is strikingly southern. Of 29 whose types are given by Watson, 18, or nearly two-thirds, are of English or Germanic type; seven more have "English" tendencies, while the only northern plants are one "Scottish" species, *Equisetum variegatum*, and two bog plants of Scottish tendencies, *Andromeda Polifolia* and *Pyrola rotundifolia*.

3. Marginal Type.—Exclusive of maritime plants (of which more anon), the Marginal type is somewhat more numerous in species than the Central. Forty-six plants are listed below; they have an average range of 16 divisions per species.

Subularia aquatica,	10	HS
Senebiera Coronopus,	28	E
Cerastium tetrandrum,	30	B
semidecandrum,	17	BE
arvense,	10	BE
Sagina ciliata,	9	EB
subulata,	8	SB
Elatine hexandra,	10	E
Hypericum elodes,	23	AE
Radiola linoides,	20	B
Erodium moschatum,	17	A
Trifolium striatum,	9	E
arvense,	14	BE
fragiferum,	11	E
Vicia sylvatica,	22	SB
Agrimonia odorata,	20	E
Saxifraga stellaris,	17	H
Sedum Rhodiola,	16	H
Callitriche hamulata,	21	B
Carum verticillatum,	6	A
Filago minima,	18	B
Gnaphalium sylvaticum,	31	B
Anthemis nobilis,	20	E
Saussurea alpina,	9	H
Hieracium anglicum,	19	H
Schmidtii,	8	S
gothicum,	6	H?
cæsium,	7	—
Lobelia Dortmanna,	18	SH
Jasione montana,	29	BE
Centunculus minimus,	15	EB
Myosotis collina,	12	B
Pinguicula lusitanica,	31	AS
Stachys arvensis,	25	B
Galeopsis versicolor,	17	EG
Scleranthus annuus,	16	B
Salix herbacea,	17	H
Zannichellia palustris (aggr.),	20	B
Carex dioica,	20	SB
rigida,	15	H
Milium effusum,	21	BE
Lycopodium alpinum,	12	H
Isoetes lacustris,	17	H
Pilularia globulifera,	5	B
Chara canescens,	3	—
Nitella translucens,	11	—

The distribution of four characteristic examples of this type is given in figs. 27 to 30.

Fig. 27.—*Hypericum elodes.*

Fig. 28.—*Lobelia Dortmanna.*

Fig. 29.—*Pinguicula lusitanica.*

Fig. 30.—*Nitella translucens.*

It will at once be noticed that this group, of homogeneous distribution, is composed of heterogeneous elements, the result of the varied conditions which the marginal area provides. The leading sections are alpine plants, brought in by the numerous mountain groups; calcifuge plants, rejoicing in the absence of limestone; and xerophytes, for which the sands of the coast are an attraction. No less than 23, or one half of the group, are characteristically highland or upland species (though only five of these do not occasionally descend to near sea-level). Thirteen more favour light or sandy soils. Nine are water plants, but marsh and bog plants are few. Seven are typical calcifuge species, one only (*Cerastium arvense*) is slightly calcicole. Comparing their distribution in Great Britain, a corresponding diversity is apparent. Eight are of pure Highland type, one of Scottish, seven more have Highland or Scottish tendencies. Six are of English type, two of Atlantic; the remainder are British or composite.

For our map we have a maximum of 39 species (or 88 per cent. of the group) in Antrim, a minimum of 0 in Longford. The avoidance by the group of the low-lying Central Plain and limestone areas comes out clearly.

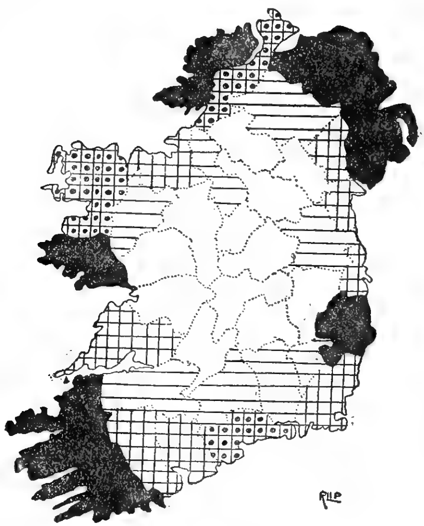


FIG. 31.—Distribution of "Marginal" plants.

Maritime plants of general distribution round the coast are not classed as of Marginal type, as their proper place seems to be rather in the General type. In cases of restricted range, they are placed under the type to which are referred other species of similar distribution.

4. ULTONIAN TYPE.—Into this group comes much of the northern element of the Irish flora. The list given below numbers forty-five species, which might be swelled by the addition of numerous Hawk-

weed segregates. The restricted range of plants of this and the following groups (arising from the more restricted area by which the types are defined) as compared with that of the "Central" and "Marginal" plants, is evident from the fact that the average number of divisions per species drops to 6, as compared with 15 and 16 in the two preceding types.

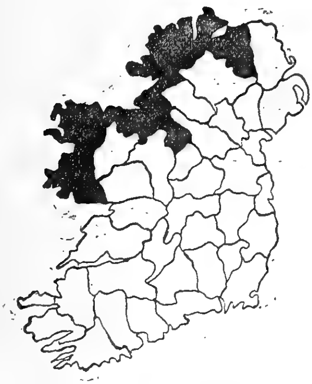


FIG. 32.—*Saxifraga oppositifolia.*

FIG. 33.—*Circæa alpina.*

FIG. 34.—*Cicuta virosa.*

FIG. 35.—*Potamogeton filiformis.*

The distribution of four selected examples of this type is shown in figs. 32 to 35. All of these are comparatively wide-ranging species, but many plants of the type have a quite limited range, mostly with

Antrim as focus. The peculiar and defined range of *Cicuta* is noteworthy, and without a parallel.

Ranunculus fluitans,	1	E	Hieracium strictum,	5	H
Trollius europæus,	3	S	corymbosum,	8	H
Cardamine amara,	6	BG	auratum,	4	—
Barbarea intermedia,	5	—	crocatum,[1]	6	H
Teesdalia nudicaulis,	1	BE	Hypochæris glabra,	1	GB
Silene acaulis,	4	H	Vaccinium Vitis-Idæa,	19	HS
Geranium sylvaticum,	1	S	Pyrola media,	8	S
pratense,	1	BE	minor,	6	SB
Prunus Padus,	20	S	secunda,	3	S
Rubus Chamæmorus,	2	H	Melampyrum sylvaticum,	2	S
Rosa hibernica,	3	I	Polygonum minus,	22	E
Saxifraga oppositifolia,	7	H	mite,	4	G
aizoides,	5	H	Salix pentandra,	27	S
Callitriche autumnalis,	13	S	phylicifolia,	6	SH
Epilobium angustifolium,	7	BS	nigricans,	3	SH
Circæa alpina,	11	SH	Potamogeton filiformis,	10	S
Cicuta virosa,	15	E ?	Carex pauciflora,	1	H
Ligusticum scoticum,	5	S	elongata,	2	E
Galium Cruciata,	2	BE	Buxbaumii,	1	—
Adoxa Moschatellina,	1	B	irrigua,	1	—
Arctium nemorosum,	7	—	Calamagrostis stricta,	4	LI
Hieracium lasiophyllum,	7	—	Cryptogramme crispa,	6	H
argenteum,	4	—	Equisetum pratense,	3	S

The character of this group is shown by the fact that some 30 out of the 45 are hill or mountain species, though very few of these are *confined* to high elevations. Four are water plants; five frequent marshes, and four peat bogs. One is a maritime species. Only six affect dry or cultivated soils. The group is characterized by an absence of either calcicole or calcifuge plants. Analyzed according to the British types, the Highland and Scottish species largely predominate; out of 38 classed by Watson, nine are of Highland type, ten of Scottish; six more have Scottish tendencies. Only five are English. Only one, *Adoxa*, is of British type.

For the construction of our statistical map, we have a maximum of 37 species (or 82 per cent. of the group) in Antrim, a minimum of 0 in various southern divisions. The northern grouping of the species comes out clearly.

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[1] And a number of other Hawkweeds of more restricted range.

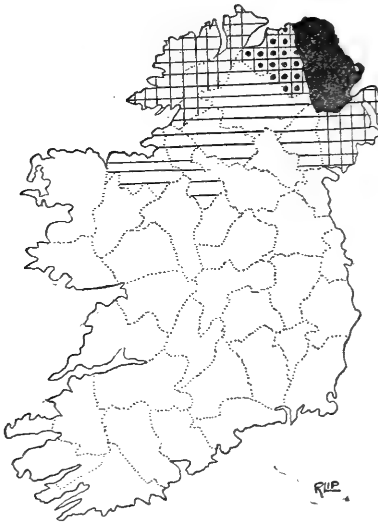

FIG. 36.—Distribution of "Ultonian" plants.

5. MUMONIAN TYPE.—This is the largest of the six groups, being approached in numbers by the Lagenian type alone. Sixty-six species are listed below; these have an average range of 8 divisions per species.

The range of four selected examples of Mumonian plants is shown in figs. 37 to 40, and these are characteristic of well-marked sub-types.

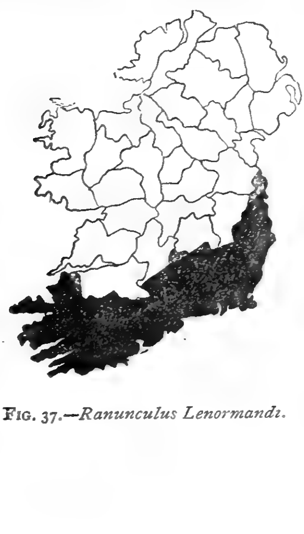

FIG. 37.—*Ranunculus Lenormandi.*

FIG. 38.—*Pinguicula grandiflora.*

FIG 39.—*Campanula Trachelium.*

FIG. 40.—*Chlora perfoliata.*

Fig. 37 (*Ranunculus Lenormandi*) exemplifies the manner in which various southern plants range up the east coast. As further examples of this peculiarity of distribution may be mentioned

Linum angustifolium.	Orobanche major.
Eythræa pulchella.	Salvia Verbenaca.
Wahlenbergia hederacea.	Juncus acutus.

Fig. 38 (*Pinguicula grandiflora*) shows the well-known Kerry-Cork type, of which several of the famous Lusitanian group are note-worthy examples. Other plants of this group are

Rosa micrantha.	Allium Scorodoprasum.
Saxifraga Geum.	Carex punctata.
Arbutus Unedo.	Asplenium lanceolatum.
Microcala filiformis.	Nitella Nordstedtiana.
Sibthorpia europæa.	

Fig. 39 (*Campanula Trachelium*) illustrates the peculiar Barrow valley range which is shared by this species and *Colchicum autumnale*—a well-marked and very rare type of distribution.

Fig. 40 (*Chlora perfoliata*) exemplifies the more wide-ranging Mumonian plants. *Chlora* might, indeed, be called a Central Plain species extending southward, rather than a southern plant extending northward; it is strongly calcicole. *Leontodon hispidus* is a parallel case, and has precisely the same northern boundary. The line joining Dublin and Killala marks, indeed, the northern limit of several of the more widespread of the Mumonian plants.

Ranunculus tripartitus,	1	EL	Microcala filiformis,	3	EA
Lenormandi,	12	E	Erythræa pulchella,	6	E
parviflorus,	6	E	Cynoglossum officinale,	14	EB
Glaucium flavum,	16	EB	Antirrhinum Orontium,	3	E
Matthiola sinuata,	2	A	Sibthorpia europæa,	2	A
Brassica nigra,	10	E	Orobanche major,	6	E
Lepidium latifolium,	5	E	Pinguicula grandiflora,	5	absent
Viola hirta,	5	EG	Calamintha officinalis,	25	E
lutea,	5	S	Thymus Chamædrys,	2	—
Linum angustifolium,	14	AE	Salvia Verbenaca,	10	GL
Geranium pusillum,	6	EB	Scutellaria minor,	16	EA
rotundifolium,	5	E	Chenopodium rubrum,	12	EG
columbinum,	20	EB	Atriplex portulacoides,	11	E
Ornithopus perpusillus,	3	BE	Rumex maritimus,	4	E
Erodium maritimum,	11	AE	pulcher,	3	E
Trifolium filiforme,	12	E	Euphorbia Peplis,	1	A
Lathyrus maritimus,	1	L	Mercurialis annua,	8	E
Alchemilla alpina,	2	H	Spiranthes autumnalis,	16	E
Rosa micrantha,	4	E	Allium Scorodoprasum,	5	IS
Saxifraga Geum,	3	absent	Colchicum autumnale,	2	E
decipiens,	2	L	Juncus acutus,	4	EA
Fœniculum officinale,	8	E	Potamogeton densus,	12	E
Œnanthe pimpinelloides,	1	E	flabellatus,	20	—
Rubia peregrina,	16	A	Scirpus parvulus,	2	—
Dipsacus sylvestris,	16	E	Carex muricata,	16	BE
Diotis candidissima,	2	A	divulsa,	19	EG
Hieracium hypochæroides,	2	—	axillaris,	4	E
Leontodon hispidus,	24	EB	punctata,	5	—
Campanula Trachelium,	4	E	Festuca Myuros,	22	E
Wahlenbergia hederacea,	7	A	Bromus erectus,	7	GE
Arbutus Unedo,	3	absent	Brachypodium pinnatum,	1	GE
Ligustrum vulgare,	3	E	Agropyron pungens,	6	—
Chlora perfoliata,	25	E	Asplenium lanceolatum,	3	A

The chief character of this large group as regards habitat lies in the fact that more than half of them are plants of pastures, light soils, and dry places. Four are water plants, and five marsh plants; none are characteristic of peat bogs. Eleven are maritime species. Only eight are plants of the uplands or mountains. Analyzed according to their distribution in Great Britain, they are a markedly southern and western assemblage. Of 57 classed by Watson, 27 are of English type, 7 Atlantic, and 10 more combinations of English with Atlantic or Germanic. *Viola lutea* is the only Scottish species, and one other, *Allium Scorodoprasum*, has Scottish tendencies. The Highland type is entirely absent except for *Alchemilla alpina*, and the pure British type is unrepresented.

In forming the statistical map, the maximum is 39, or 60 per cent. of the group, in East Cork, closely followed by 38 in West Cork: the minimum is 0 in various northern counties. The manner in which the southern plants run up the east coast, and avoid the Central Plain, comes out very clearly.

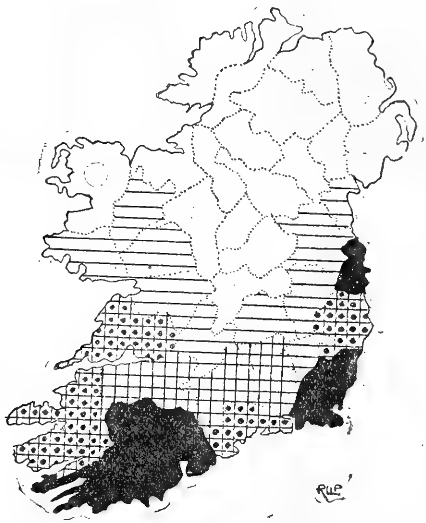

FIG. 41.—Distribution of "Mumonian" plants.

6. LAGENIAN TYPE.—Under this head forty-nine species are placed, with an average range of eight divisions per species.

The distribution of four chosen examples is shown in figs. 42 to 45. Fig. 42 (*Lepidium hirtum*) shows the eastern range at its maximum, fig. 43 (*Trifolium glomeratum*) at its minimum. Fig. 44 (*Cynoglossum officinale*) illustrates a very characteristic Lagenian range, while in fig. 45 (*Scilla verna*) a more northerly trend is illustrated. The most characteristic of the Lagenian plants is the group of light soil or sand plants which are spread along the coast between Wexford and Louth, such as

Sisymbrium Irio.
Medicago sylvestris.
Trifolium subterraneum.
  glomeratum.
  scabrum.
Trigonella ornithopodioides.
Senecio erucifolius.
Festuca uniglumis.
Equisetum Moorei.

FIG. 42.—*Lepidium hirtum.*

FIG. 43.—*Trifolium glomeratum.*

FIG. 44.—*Cynoglossum officinale.*

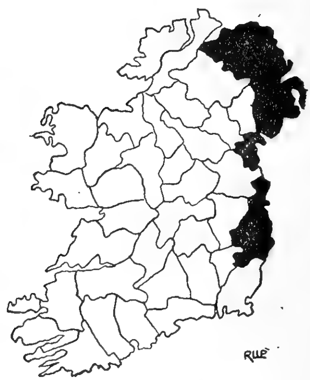

FIG. 45.—*Scilla verna.*

The list of Lagenian plants is as follows :—

Thalictrum dunense,	6	—
Sisymbrium Irio,	1	EL
Lepidium hirtum,	26	BE
Thlaspi arvense,	15	B
Elatine Hydropiper,	2	EL
Hypericum hirsutum,	4	BE
Malva moschata,	27	EB
Medicago sylvestris,	1	—
Trigonella ornithopodioides,	5	E
Trifolium scabrum,	4	E
glomeratum,	2	E
subterraneum,	1	E
Vicia lathyroides,	6	BE
Saxifraga granulata,	3	BI
Epilobium roseum,	4	E
Chærophyllum temulum,	17	BE

Anthriscus vulgaris,	24	B	Scilla verna,	6	AS
Senecio erucifolius,	5	E	Lemna gibba,	13	EG
Carduus crispus,	19	BE	Zannichellia polycarpa,	1	—
Picris echioides,	7	E	Carex dioica,	2	E
Hieracium boreale,	12	BE	paludosa,	26	B
Lycopsis arvensis,	11	B	Poa palustris,	1	—
Cynoglossum officinale,	14	EB	Glyceria aquatica,	17	EB
Lithospermum arvense,	16	B	Borreri,	2	G
Echium vulgare,	16	BE	Festuca uniglumis,	5	EA
Scrophularia umbrosa,	2	EI	Hordeum secalinum,	11	E
Calamintha Acinos,	7	BE	murinum,	9	EB
Galeopsis Ladanum,	7	EB	Equisetum Moorei,	2	absent
Lamium album,	22	BE	Chara connivens,	1	—
Galeobdolon,	3	E	Tolypella prolifera,	1	—
Atriplex farinosa,	6	BL	intricata,	1	—
Salix triandra,	11	EB	Nitella gracilis,	1	—
Asparagus officinalis,	2	A			

This Eastern group is, relative to the other types, xerophytic. Seventeen of the 49 species are inhabitants of sea-sands or sandy soil, 12 more of dry banks or light cultivated ground. Seven are water plants, 5 frequent marshes, 3 more are usually found by river sides. One, *Lepidium hirtum*, is distinctly calcifuge, but on the other hand *Galeopsis Ladanum* is strongly calcicole, and several others also prefer a limy soil. None are mountain plants, or even hill plants, excepting perhaps *Hieracium boreale.*

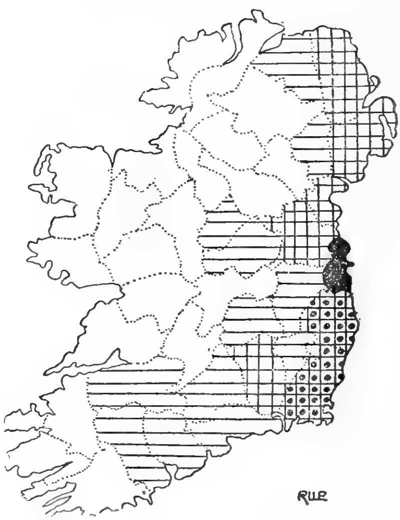

FIG. 46.—Distribution of "Lagenian" plants.

The distribution in Great Britain of the group is chiefly "English," 12 out of 40 species classed by Watson being of that type. *Scilla verna* (Atlantic-Scottish) is the only species in which the northern element makes its appearance. One is of Atlantic type, one of Germanic: the rest mostly intermediate between English and British: in other words, slightly southern in range. As compared with most of the groups, there is an increase of British type, no less than 5 being purely British.

For our map, the maximum is 38 species, or 80 per cent., in Dublin; the minimum 0 in West Mayo (fig. 46).

7. Connacian Type.—This and the Mumonian group are the most numerous in species of the six Irish "types." Sixty-three species are listed below; these have an average range of six divisions per species.

Here belong plants exhibiting a general western trend in their range; such as *Taxus baccata* (fig. 47) and the more restricted *Adiantum Capillus-Veneris* (fig. 48). In this section of the group may be placed nearly one-half of the plants listed below.

Fig. 47.—*Taxus baccata.*

Fig. 48.—*Adiantum Capillus-Veneris.*

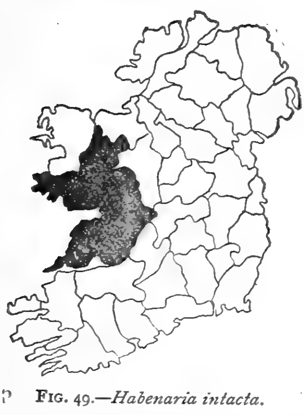

Fig. 49.—*Habenaria intacta.*

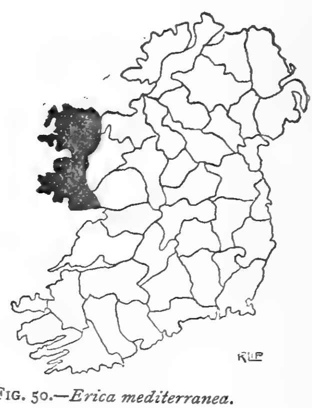

Fig. 50.—*Erica mediterranea.*

The remainder include two very distinct sub-types, which may be called respectively the Burren type and the Connemara type. The former is represented in fig. 49 (*Habenaria intacta*), the latter in fig. 50 (*Erica mediterranea*). The leading members of the Burren group are

Helianthemum vineale.	Limosella aquatica.
Astragalus Hypoglottis.	Ajuga pyramidalis.
Spiræa Filipendula.	Epipactis atro-rubens.
Potentilla fruticosa.	Habenaria intacta.
Gentiana verna.	Potamogeton lanceolatus.

The group reaches its maximum on the bare limestone hills of Burren, whence it spreads in diminishing numbers over the pavements or "crags" of Galway and Mayo. It is essentially a calcicole group.

In marked contrast to this stands the adjoining calcifuge Connemara group. In its restricted sense, it numbers but three species—the remarkable "Lusitanian" heaths, *Erica mediterranea*, *E. Mackaii*, and *Dabeocia polifolia*; but a few more widely-ranging species, such as the equally interesting *Naias flexilis*, may fairly be classed with these.

The list of the Connacian type is as follows:—

Thalictrum alpinum,	5	H
collinum,	20	—
Arabis ciliata,	5	—
Draba incana,	8	H
Helianthemum vineale,	2	IA
guttatum,	2	LA
Viola stagnina,	4	EG
Arenaria ciliata,	1	absent
Geranium sanguineum,	11	B?
Astragalus Hypoglottis,	1	GB
Spiræa Filipendula,	2	EG
Potentilla fruticosa,	4	IS
Saxifraga nivalis,	1	H
umbrosa,	11	absent
Sternbergii,	4	absent
grænlandica,	2	—
Drosera intermedia,	19	E
Galium boreale,	22	H
sylvestre,	6	IH
Asperula cynanchica,	8	E
Hieracium iricum,	15	H
Erica Mackaii,	1	absent
mediterranea,	2	absent
Dabeocia polifolia,	3	absent
Arctostaphylos Uva-ursi,	7	H
Gentiana verna,	5	I
Limosella aquatica,	2	GE
Euphrasia Salisburgensis,	6	absent
Bartsia viscosa,	7	A
Ajuga pyramidalis,	1	S
Polygonum viviparum,	3	H
Oxyria digyna,	8	H
Euphorbia hiberna,	11	LA
amygdaloides,	3	E
Juniperus communis,	12	B
nana	14	H
Taxus baccata,	17	E
Epipactis atro-rubens,	4	I?
Habenaria intacta,	5	absent
Sisyrinchium angustifolium,	6	absent
Simethis bicolor,	1	LA
Allium Schænoprasum,	1	LI
Juncus tenuis,	4	—
Potamogeton Kirkii,	1	absent
lanceolatus,	2	L
Naias flexilis,	3	—
Eriocaulon septangulare,	7	SA
Scirpus triqueter,	2	G
Rhynchospora fusca,	19	A
Carex Bœnninghausiana,	2	G?
trinervis,	1	—
Deschampsia alpina,	3	H
discolor,	1	—
Sesleria cærulea,	13	HI
Poa alpina,	2	H
Trichomanes radicans,	13	A
Adiantum Capillus-Veneris,	6	A
Asplenium viride,	12	H
Aspidium Lonchitis,	6	H
Equisetum trachyodon,	8	—
Lycopodium inundatum,	3	BE
Isoetes echinospora,	4	—
Nitella Nordstedtiana,	2	—

Of this assemblage, the largest constituent groups are mountain plants, which number 16, and plants of dry places—in most cases limestone pavements—which are 19 in number. Of the mountain plants, only half are confined to the higher grounds; the others often occur in great quantities at low levels. Bog plants are well represented by six species; marsh plants number four, water plants seven. Only one, *Scirpus triqueter*, is maritime in habitat. The group has distinct proclivities for limestone, seven of the species being recognized calcicole plants, while two are calcifuge. No less than ten of the species are absent from Great Britain. The remainder are quite heterogeneous as regards their distribution in the sister island: four are English, two Intermediate, one Scottish, four Atlantic, two Germanic, one local; far the largest group is formed by the Highland type (here continually lowland), which numbers thirteen species. Of British type there is one definite and one doubtful example (namely, *Juniperus communis* and *Geranium sanguineum* respectively).

For our map the maximum is 37 species, or 60 per cent. of the list, in West Galway; the minimum 0 in half a dozen eastern counties.

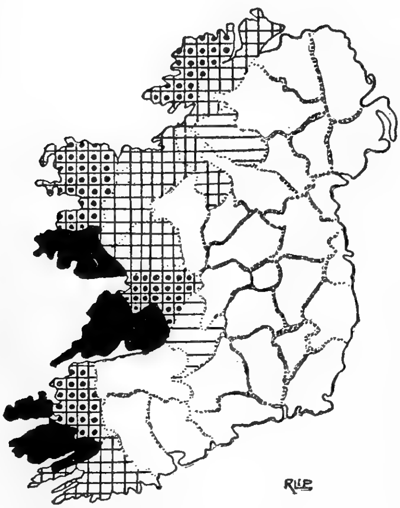

FIG. 51.—Distribution of "Connacian" plants.

It may be useful to set forth in tabular form the characteristics of the six plant-groups which have been described.

Table showing approximately the characters of the Plants forming the Irish Types of Distribution, in percentages of each Group.

Type.	Usual Habitat in the District.											Range in Great Britain.							
	Water.	Marsh.	Peat Bog.	Tillage, pasture, and woods.	Sand, gravel, and dry rocks.	Calcicole.	Calcifuge.	Sea coast.	Lowland (under 500 ft.).	Upland.	Highland (over 1000 ft.).	British.	English.	Intermediate.	Scottish.	Highland.	Atlantic.	Germanic.	Local.
Central.	30	25	5	10	15	35	10	0	94	6	0	14	57	4	7	0	0	11	4
Marginal.	20	0	7	11	33	7	35	0	41	41	18	37	23	0	9	22	7	1	0
Ultonian.	9	13	9	29	18	12	12	2	33	43	23	14	14	3	48	28	0	3	1
Mumonian.	6	12	2	36	24	18	10	12	80	15	2	5	66	1	3	1	16	3	5
Lagenian.	14	12	0	24	44	12	4	25	96	4	0	36	51	2	1	0	5	3	2
Connacian.	11	8	11	12	30	27	18	2	48	30	22	7	13	11	5	31	13	10	10

The figures, especially as regards habitat, are of course merely approximate, as exact data in such matters are not possible; nevertheless, the table brings out in a very striking manner the widely divergent characteristics of the various Types of Distribution, and fits in well with the maps previously given, showing the distribution of plants according to soil and elevation, and also according to type in Great Britain.

Notice has already been taken of the fact that certain plants of wide distribution in Ireland are nevertheless characterized by an absence from definite areas. This interesting point must now engage our attention for a few minutes. One of the most marked ranges of this kind is illustrated in fig. 52 (*Drosera anglica*), which shows an absence from those south-eastern counties where the Lagenian flora reaches its maximum. The following species show a similar absence from or rarity in the south-east:—

Nymphæa alba.	Myrica Gale.
Rubus saxatilis.	Scirpus pauciflorus.
Myriophyllum alterniflorum.	Rhynchospora alba.
Pinguicula vulgaris.	

—while in the case of *Parnassia palustris* and *Selaginella selaginoides*, the centre of the "absent" area lies further south; most of these are universal over the rest of Ireland, while in Great Britain they are as a group "British" with a "Scottish" tendency. It will be noticed that in the main they are plants of lowland boggy places, and such ground reaches its minimum in these divisions; nevertheless some further reason appears necessary to explain their absence. They might be classed as Anti-Lagenian rather than as Pan-Connacian, since they do not exhibit any marked increase westward.

FIG. 52.—*Drosera anglica.*

FIG. 53.—*Œnanthe Phellandrium.*

Another type of absence appears in fig. 53 (*Œnanthe Phellandrium*), consisting of a dying out along the mountain-rim of Ireland, especially in the west. Seven species—

Nasturtium palustre.
amphibium.
Sium angustifolium.
Œnanthe Phellandrium.
Rumex Hydrolapathum.
Elodea canadensis.
Lemna trisulca.

—exhibit this feature conspicuously, and others to a less degree; all are practically universal[1] elsewhere. This is quite a homogeneous group, inhabitants of lowland marshes and ditches, with a strong "English" tendency in Great Britain.

A third group is illustrated in fig. 54 (*Vicia angustifolia*), with which may be classed

Sisymbrium Alliaria.
Ulex Gallii.
Valerianella olitoria.

Here the character is a marked absence from the province of Connaught—the middle part of the Connacian district. These plants have little in common, *Sisymbrium* being calcicole, *Ulex* calcifuge, the others neutral; and they show similar diversity in other respects, the only point of agreement being a preference for dry situations.

FIG. 54.—*Vicia angustifolia.*

FIG. 55.—*Leontodon hirtus.*

[1] By "universal" I mean present in all divisions.

A better-marked group is that whose feature is rarity in or absence from Ulster, especially central Ulster (fig. 55). We may cite

Papaver Rhæas.
Brassica alba.
Saxifraga tridactylites
Carduus pycnocephalus.
Leontodon hirtus.
Verbascum Thapsus.
Scrophularia aquatica.
Origanum vulgare.
Parietaria officinalis.
Orchis pyramidalis.
Festuca rigida.

The proclivities of this "Anti-Ultonian" group are lowland, light soil, calcicole, and "English"; characters which reach their minimum in the Ulster flora. The sandy soils by the sea enable most of these species to creep northward round the Ulster coast, but inland they are rare or absent.

Lastly, there is a group of "Anti-Central" species, too widely spread to be cited as characteristic "Marginal" plants. One of the best marked is figured (fig. 56) in *Œnanthe crocata*, and the following resemble it in range:—

Hypericum humifusum.
Filago germanica.
Myosotis repens.
Carex lævigata.

FIG. 56.—*Œnanthe crocata.*

These are all plants of somewhat marginal type, and increase on the hills and non-calcareous rocks.

One small but well-marked type of distribution which, though in a broad sense "Central," does not typically fall into any of the seven types already defined, deserves mention. The plants composing it show a diagonal range across Ireland from the north-east towards the south-west, having a marked absence in the north-western and south-eastern areas. An example (fig. 57, *Hydrocharis Morsus-ranæ*) will illustrate this type; and to show the similarity of range of the group, a statistical map is added (fig. 58) according to the usual plan, showing the aggregate range of the following members:—

Ranunculus circinatus.
Lathyrus palustris.
Hydrocharis Morsus-ranæ.
Sagittaria sagittifolia.
Eleocharis acicularis.
Carex acuta.
Lastrea Thelypteris.

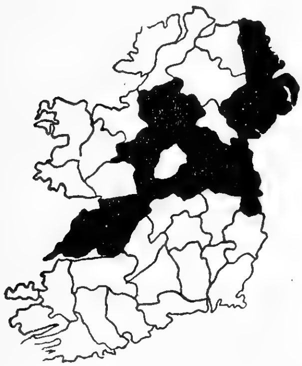

FIG. 57.—*Hydrocharis Morsus-ranæ.*

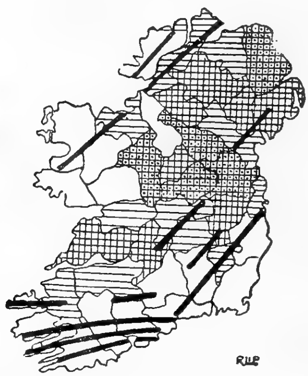

FIG. 58.—Mountain-folding of Ireland.

On the map I have added the main lines of the old "Caledonian" and "Hercynian" folding of Ireland, as demonstrated by Prof. Cole,[1] since this, I believe, is the key to the peculiar range of these species. It will be noticed that they are without exception marsh and water plants, and they follow the great central trough of the island, spreading over the basins of the Shannon, Erne, Boyne, and Bann, which lie in the synclinal area, but avoiding the great anticlines of Leinster, Mayo and Donegal, including the river-system of the south-east; and are absent even from the great western lake-system of which Lough Corrib is the predominant member.

Lastly, as to the distribution of plants which are probably or certainly introduced in Ireland. As before stated, the aliens are generally marked by a discontinuous range. A large number are widely spread;

[1] *Knowledge*, April, 1898.

but others fall in with various Types of Distribution, and as this is no doubt in most cases the effect not of chance, but of soil or climate, it will be worth classifying them. Leaving out of account species which have a restricted range, such as *Senecio squalidus* and *Stratiotes aloides*, the aliens of well-marked range run as follows: —

Central—

Arenaria tenuifolia,	E	Matricaria discoidea	—

Marginal—

Lychnis Githago,	B	Cuscuta Trifolii,	E
Inula Helenium,	E ?	Lycium barbarum,	—
Silybum Marianum,	—	Mimulus guttatus,	—
Centaurea Cyanus,	B	Plantago media,	EB
Cichorium Intybus,	E	Bromus secalinus,	BE
Cuscuta Epithymum,	E		

Ultonian—

Myrrhis odorata,	I ?	Veronica peregrina,	—
Anchusa sempervirens,	E		

Mumonian—

Senebiera didyma,	AE	Verbena officinalis,	E
Valerianella Auricula,	E	Marrubium vulgare	E
Picris hieracioides,	E	Humulus Lupulus,	B
Linaria Elatine,	E	Narcissus biflorus,	—
minor,	E	Leucojum æstivum,	GE

Lagenian—

Draba muralis	—	Campanula rapunculoides,	LI
Sisymbrium Sophia,	BE	Ballota nigra,	E
Medicago maculata,	E	Acorus Calamus,	E
Lactuca muralis,	E		

Connacian—

Allium Babingtonii,	—

It will be seen that the more successful aliens, other than those of general distribution, are grouped round the margin of the island, especially in the south and east. They reach their minimum in the centre, north, and west. Their distribution, in fact, coincides with that of the "English" plants (fig. 1), to which type belong, as will be seen from the analysis appended to the list, 16 out of 26 classed by

Watson. This Mumonian or Lagenian range of the aliens is of interest, for there can be no doubt that it is the result of conditions of climate and soil. In support of this view, one remarkable instance may be cited. Clover seed, imported from England, is sown widely in Ireland; official information supplied to me is to the effect that no more clover is sown in the south and east than in other parts of the country. With the clover come the seeds of the parasite *Orobanche minor*, a plant of English type, not a native of Ireland, and unknown therein until some forty years ago. The plant is now an established and spreading colonist, and its present range coincides in a striking degree with that of the group to which it belongs—the light soil English

FIG. 59.—*Oroban minor.*

type plants. In the central portions of its range—Wexford particularly—it is now abundant and permanent. This further emphasizes the floral peculiarities of the south-eastern portion of Ireland, which have already been demonstrated both from the presence and absence therein of certain groups of species. The great Leinster anticline is an important factor in Irish plant distribution, and a phytological boundary of marked character is formed by the line where its uplands sink into the Central Plain, and by the prolongation of that line northwards and southwards.

Of the seven Types of Distribution proposed in this paper, five have their analogues in the types which Watson instituted for Great Britain. In both series we have a General type, and a Northern, Southern, Eastern, and Western type. The General, Northern, and Southern types of Great Britain and of Ireland in a wide sense correspond in their composition. The Eastern group of Ireland is seen to be essentially southern in Great Britain, while the Eastern group of Great Britain is practically absent from Ireland; nevertheless the two correspond in character, representing in each case the nucleus of the thermophile and xerophile elements of the flora—in England a much more intensified group than in Ireland. The Western plants of the two islands also exhibit a wide diversity in range, those of Great Britain being Southern and Marginal in Ireland, while those of Ireland are not to any extent Western in Great Britain, and include besides a number of species absent from the sister island. But here again the two have affinities, both being hygrophile and frigofuge in character. The two remaining Irish types, the Central and Marginal, have no analogues in Great Britain. The former consists largely of "English" species, the latter chiefly of "British" plants which do not penetrate into the Limestone Plain.

It will be observed that no type corresponding to Watson's Highland type is proposed for Ireland. Plants of this kind form in Ireland a much less distinct group than in Great Britain, being largely reduced in numbers, and not nearly so montane in habitat. Moreover, they have not any so definite head-quarters as, in Great Britain, they find in the Highlands of Scotland. In Ireland, plants of Highland type are distributed almost equally between the Marginal, Ultonian, and Connacian areas. None belong to the Lagenian and only one to the Mumonian, although in those districts occur the largest areas of high elevation, as well as the loftiest summits, in the country. The actual alpine flora of Ireland is extremely limited. Taking the 42 Irish plants belonging to Watson's Highland type, we find that one-third of them descend in Ireland to sea-level. Sixty per cent. may be found at elevations of 500 feet or less. Fully one-half of the group flourish at these low elevations in places where alpine ground—say over 1000 or 1500 feet—does not adjoin, so that their occurrence means not merely the washing down of seeds from their natural high-level habitats. Only 30 per cent. keep above the thousand-foot contour line, only 5 per cent. above the 2000-foot line. In fact, Watson's Highland plants cannot be defined in Ireland as a group "chiefly seen about the mountains." They *are* chiefly seen in certain hill-regions, but the presence of even high mountains does not necessarily involve their appearance. The species seen about the mountains are largely British type plants, with a variable admixture of "Highland" species, and certain local groups—in the north "Scottish" plants, in the south often "Lusitanian." It does not seem desirable to attempt to construct out of these heterogenous materials any group of Irish plants "chiefly seen about the mountains." The peculiar range of the Irish high-level plants—often absent from lofty mountains in the east and present on hills of less elevation or on low grounds in the west—is best brought out by treating them with the other plants of similar distribution.

So much for the facts. The causes which lead or have led to the distribution of the flora as we now find it are difficult to determine. The effect produced by the distribution of lime, and of open light soils, is fairly clear; but climatic effects are not so easily dealt with. As regards temperature, some of the characteristic plants of Connacian type are without doubt frigofuge—in other words, their chief need in our climate is a sufficiently high winter temperature; and in fig. 60, which shows the isotherms of the coldest month of the year in Ireland (January), parallels between isophytic and isothermal lines may easily

FIG. 60.—January isotherms.

FIG. 61.—July isotherms.

be drawn from among the plants of the south and west. Fig. 61 likewise, showing the isotherms of the warmest month (July), suggests that a number of the south-eastern species may be thermophiles—plants for which the most pressing need is a high summer temperature for the ripening of fruit. Questions of rainfall probably effect but little the distribution of plants in Ireland, since (fig. 62) there is everywhere a sufficiency. But the limit of the Connacian type (fig. 51) will be

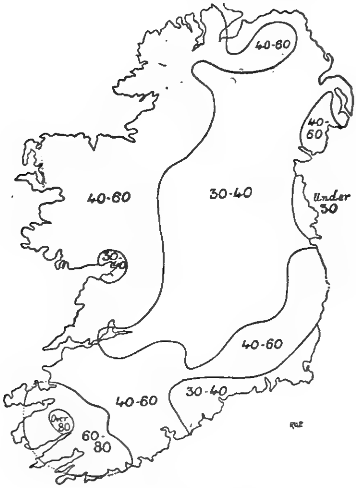

FIG. 62.—Annual rainfall.

seen to correspond with that of the wet west-of-the-Shannon district of Ireland, while the driest area is included in that which marks the range of the Lagenian and most of the English type species. There is even a dry area around Galway Bay which no doubt helps to produce the remarkable aggregation of "English" and "Germanic" species in north Clare. But the facts are not yet brought together, nor the observations made which will enable us to determine how far the present distribution of plants is effected by climatic causes. Nor is this the only direction in which work is required. We can never hope to understand our phyto-geography till its problems have been attacked by the historical method. Yet the history of the Irish flora is still an absolutely unworked field. The records lie buried below our peat bogs and superficial deposits, and their elucidation will furnish evidence of the highest importance. No branch of Irish botany has more pressing claims on the field botanist than this.

II.

GLEANINGS IN IRISH TOPOGRAPHICAL BOTANY.

By ROBERT LLOYD PRAEGER, B.A., B.E.

[Read March 16th, 1902.]

Of the material contributed or collected for "Irish Topographical Botany," a quantity of gleanings remain after the crop has been gathered in. These consist mainly of two sorts—notes of varieties and hybrids, and notes of aliens. Except where the information respecting species could be amplified by including records of their varieties, or where alien species could be admitted as naturalized, neither of these classes of records was included in the book referred to. In now publishing a selection of these notes, I have kept "Cybele Hibernica" before me, and have aimed mainly at giving such records as are supplementary to the information therein contained. Though the bulk of the notes which follow are unpublished previously, I have not hesitated to include records scattered through inaccessible publications; and have sometimes given, in condensed form, all information relating to a plant, whether published or unpublished, usually indicating what matter is original. The notes are arranged under county divisions, and records are quoted according to the rules adopted in "Irish Topographical Botany." References to published papers are given by means of the numbers prefixed to them in the same work; which is followed in other details of arrangement also.

As regards the records for which I am responsible. The heavy field work of 1896–1900 gave little opportunity for the study of critical plants; but in some genera, notably *Alchemilla*, *Euphrasia*, and *Chara*, large collections were made, and the distribution of segregates and varieties in Ireland to a great extent ascertained. My best thanks are due to the several critical botanists who devoted much labour to the naming of the material collected—Mr. Arthur Bennett, the late Prof. A. W. Bennett, Mr. G. C. Druce, Messrs. H. & J. Groves, Rev. E. F. Linton, Rev. E. S. Marshall, Rev. W. Moyle Rogers, and Mr. Frederick Townsend.

Ranunculus peltatus Fr., var. **elongatus** F. Schultz.

38 Down — Canal near Scarva (Lett)—W. B. E. C. '94–5.
Also in 32—see *Irish Top. Bot.*

R. acris, L., var. **Boræanus** (Jord.).

In 12, 16, and 26, '95–6—E. S. Marshall.

var. **Steveni** (Andrz.).

39 Antrim — "Glenarm, &c.," '99—Druce *285*.

Caltha radicans Forst., var. **zetlandica** Beeby.

23 Westmth. — E. S. Marshall refers (*541*) E. F. Linton's plant from Brittas Lake (*Cyb.*, p. 10) to this.

‡**Fumaria Vaillantii** Loisel.

8 Limrck. — Limerick '97 [among casuals] (G. Fogerty)—*Herb.* L.F.C. !

Nasturtium amphibium × **sylvestre** = **N. barbarœdes** Tausch.

6 Waterfd. — Cappoquin '99—P.
29 Leitrim — Carrick-on-Shannon '99—P.

Mr. Bennett is not positive of the determination, but both parents are now known to occur on the Shannon and Blackwater, and there seems little reason to doubt the determination.

N. officinale L., var. **microphyllum** (Reichb.).

In 12 Wexford, and 16 W. Galway—E. S. Marshall.

Barbarea vulgaris R. Br., var. **arcuata** (Reichb.).

1 Kerry S. — *Rossbehy '00—Scully.
39 Antrim — Drum Bridge '94—Stewart.

Arabis hirsuta Scop., var. **glabrata** Syme.

9 Clare — Inishmore '95—P.

***Alyssum calycinum** L.

Divisions 1, 4, 5, 19, 20, 21, 40.

***A. maritimum** L.

5 Cork E. — Queenstown '90—Phillips, and '98—Mrs. Persse !

Sisymbrium officinale Scop., var. **leiocarpum** DC.

3 Cork W. Glandore '96 (J. Groves)—R. A. Phillips.

***Erysimum orientale** R. Br.

Divisions 1, 3, 4, 5, 8, 12, 22, 39.

***Bunias orientalis** L.

Divisions 6, 12, 21—P.

***Camelina sativa** Crantz.

Divisions 4, 12, 16, 20, 21, 23, 27, 31, 32, 38, 39, 40.

***Lepidium Draba** L.

Divisions 5, 8, 11, 12, 21, 37, 38, 39.

Appears to be establishing itself at Limerick—P.

***L. ruderale** L.

Divisions 3, 5, 8, 12, 21.

? **Polygala calcarea** F. Schultz.

Specimens collected near Tuam are doubtfully referred to this form by Prof. A. W. Bennett, while others from Devil's Bit (N. Tipperary) and Athlone (Roscommon), collected by myself, and Kilrea (Derry) by Mrs. Leebody, are marked by the same authority "approaching *calcarea*." *P. calcarea* being as yet unrecorded from Ireland, the occurrence of these intermediate forms is interesting.

***Silene Armeria** L.

Divisions 9, 12, 21, 37, 39, 40.

S. Cucubalus Wibel., var. **puberula** Syme.

13 Carlow Aghade '99—P.

15 Galw. SE. Garryland '00—P.

I believe frequent in Ireland, but I did not note localities.

Cerastium glomeratum Thuill., var. **apetalum** Dum.

3 Cork W. Timoleague '97—Phillips.

C. triviale Link, var. **holosteoides** Fr.

6 Waterfd. By the Blackwater below Cappoquin '99—P.

Arenaria serpyllifolia L., var. **leptoclados** (Guss.).

3, 4, 5	Cork	Frequent—Phillips.
6	Waterfd.	Dungarvan '99, Carrickbeg '00—P.
7	Tipp. S.	Clonmel '00—Phillips. Cahir and Slievenaman '00—P.
8	Limrck.	Limerick '99—Somerville. L. Gur '00—P.
10	Tipp. N.	Nenagh '00—Phillips. Ballingarry '00—P.
11	Kilkny.	Ballyragget '99, Fiddown bridge '00—P.
13	Carlow	By Barrow above Borris '99—P.
14	Queen's	Mountrath '97, Maryborough '96—P.
15	Galw. SE.	Coole '00—P.
18	King's	Birr '00, Banagher '98—P.
19	Kildare	Nurney '97—P.
20	Wicklow	Kilmacannoge '94—P.
21	Dublin	Sutton '94—P.
31	Louth	Soldier's Point '96—P.

Also in 23, 26, 35, 37, 38, 39—see *Cybele* II.

var. **Lloydii** (Jord.).

12 Wexford Carnsore and Gorey districts '97—E. S. Marshall.

Stellaria umbrosa Opiz.

5 Cork E. Near Castletownroche '00—R. A. Phillips.

Rev. E. F. Linton writes of the specimens:—"*S. umbrosa* and *S. media major* seem to run into one another, and this may be regarded as *S. umbrosa* with bluntly tubercular fruit or as var. *major* with glabrous inflorescence; *i. e.*, there are connecting links which seem to abolish *S. umbrosa* as a *species*, and then we have two contiguous vars. at times barely separable—*S. media* var. *umbrosa*, *S. media* var. *major*."

Stellaria umbrosa is unknown in Ireland hitherto.

Spergula arvensis L., var. **vulgaris** (Bœnn.).

Divisions 1, 2, 3, 4, 5, 6, 11, 12, 16, 20, 21, 38.

var. **sativa** (Bœnn.).

Divisions 1, 3, 4, 5, 6, 11, 15, 16, 21, 27, 35, 36.

Apparently the two forms are about equally common.

Montia fontana L., var. **minor** (Gmel.).

Divisions all, *except 8, 22.*

var. **rivularis** (Gmel.).

Divisions 4, 6, 7, 10, 13, 19, 20, 21, 26, 27, 29, 30, 38, 39, 40. Chiefly about the mountains.

Geranium Robertianum L., var. **modestum** (Jord.).

6 Waterfd. Dungarvan '82 (Britten and Nicholson)—B.E.C. '82.

var. **purpureum** Forst.

2 Kerry N. Lower Lake of Killarney '01—G. C. Druce.

Ononis repens L., var. **horrida** Lange.

5 Cork E. Youghal '00: frequent near the sea—Phillips.
6 Waterfd. Bunmahon and Knockmahon '82—Hart *384*.
21 Dublin St. Doulagh's '96—P. Rare.
38 Down Ardglass (Waddell)—S. & P. *874*.

***Medicago falcata** L

5 Cork E. Queenstown Junction 1894–1900, Tivoli '96—Phillips.
8 Limrck. Corbally '98 (Bentley)—*Herb.* L. F. C.! Old quarry at Limerick! '00—R. D. O'Brien.

***Melilotus alba** Desr.

Divisions 1, 4, 5, 8, 9, 12, 21, 22, 34, 38, 39.

Lotus corniculatus L., var. **crassifolius** Persoon.

12 Wexford Near Wexford '96—E. S. Marshall.
38 Down Newcastle '98—G. C. Druce.
And in 39, 40—see *Cybele* II.

Vicia tetrasperma Mœnch.

5 Cork E. Ballyvodock '00—R. A. Phillips.

V. angustifolia Roth., var. **Bobartii** Koch.

4 Cork Mid Coachford '97—R. A. Phillips.

V. cracca L., var. **incana** Thuill.

16 Galw. W. Clonbur '95—M. & S. *545*.
23 Westmth. NW. end of L. Owel '95—Levinge.
26 Mayo E. Clonbur '95—M. & S. *545*.

Lathyrus macrorrhizus Wimm., var. **tenuifolius** Reich. fil.

5 Cork E. Glanmire '00—R. A. Phillips.

***Prunus domestica** L.

10 Tipp. N. Nenagh '00—R. A. Phillips.
16 King's Clonad Wood '96—P.
19 Kildare Carbury '96—P.

Rubus fuscus × incurvatus.

23 Westmth. Crooked Wood '95—H. C. Levinge, and *503*.

R. mucronatus × pyramidalis.

26 Mayo E. L. Corrib near Cong '95—M. & S. *545*.

R. corylifolius × rusticanus.

21 Dublin Malahide '93—P.

R. corylifolius × leucostachys.

14 Queen's Maryborough '93—P.

R. corylifolius × cæsius.

21 Dublin Howth Junction '93—P.
23 Westmth. Knock Ross—Levinge '94 *484*.

Potentilla suberecta Zimm. = **P. procumbens × silvestris.**

10 Tipp. N. Near Cloughjordan '00—P.
14 Queen's Base of Arderin '97—P.
16 Galw. W. About Clonbur '95—M. & S. *545*.
26 Mayo E. Clonbur '95—M. & S. *545*.
29 Leitrim Ballinamore '00, Lurganboy '99—P.
33 Ferman. Newtownbutler '49 (Dr. Mathew)—Marshall *535*.
36 Tyrone Omagh '96—Miss Knowles.
38 Down Newtownbreda '49 (Mateer)—Marshall *535*, and Purchas, *Journ. Bot.* xxxi., 374.
39 Antrim Glenshesk '93—Shoolbred *837*.

Geum intermedium Ehrh. = **G. rivale × urbanum.**

18 King's Clonad Wood '96—P.
20 Wicklow West of Baltinglass '99—P.
26 Mayo E. Ballinrobe '91—Mrs. Persse!
29 Leitrim Annaghearly Lake '99—P.
40 L'derry Limavady '95—B.N.F.C. Garvagh—Miss Knowles.

Also in 14, 15, 19, 21, 24, 33, 37, 39—see *Cybele* II.

Alchemilla vulgaris L.

The paper on the distribution of *Alchemilla* segregates in Ireland, by Rev. E. F. Linton in *Journ. Bot.* and *Irish Nat.*, April, 1900, summarizes our knowledge up to that date. As Mr. Linton has since named for me a large batch of gatherings, and as he has not in many instances given localities in his paper, I give in full all the information I have.

A. pratensis Schmidt.

9	Clare	Co. Clare (*Herb.* R. P. Murray)—Linton '00 *501*.
17	Galw. NE.	Annaghdown '00—P.
18	King's	Tullamore and Clara '99—P.
22	Meath	Ballivor '00, Hill of Down, Oldcastle—P.
23	Westmth.	Knock Eyon '99, Moate, Hare I., Coosan L.—P.
24	Longfd.	Castlerea '00, Ballymahon, Killashee—P.
25	Roscomn.	Lough Key '97—P.
27	Mayo W.	Pontoon and Crossmolina '00—P.
28	Sligo	Ballysadare '00, Lough Key—P.
29	Leitrim	Lough Melvin and Lurganboy '99—P.
30	Cavan	Lough Gowna '00, Lough Sheelin—P.
31	Louth	Ravensdale '00—P.
33	Ferman.	Lower L. Macnean '00, Castle Coole—P.
34	Dongl. E.	Brown Hall '00—P.
36	Tyrone	Lough Muck '97, Cookstown—Miss Knowles.
38	Down	Near Holywood '85—P.
39	Antrim	White Park Bay '97, Dunloy—P. Belfast (Stewart) —Linton *501*.

A. alpestris Schmidt.

3	Cork W.	Gurtavehy '00, Skibbereen '89—R. A. Phillips.
10	Tipp. N.	Youghal Bay '99—P.
16	Galw. W.	Recess '94—P.
18	King's	Above Kinnitty '00—P.
26	Mayo E.	Near Claremorris '00—P.
27	Mayo W.	Castlebar '96—E. S. Marshall.
28	Sligo	Mullaghmore '00, Keishcorran, Lough Gill—P.
29	Leitrim	Glenade and Lough Gill '99—P.
30	Cavan	Ballyconnell '00—A. Somerville.
31	Louth	Carlingford Mountain '00—P.
33	Ferman.	Florencecourt '00, Carragh Creagh, L. Melvin—P.

35	Dongl. W.	Lough Salt (*Herb.* Brit. Mus.)—Linton *501.*
36	Tyrone	Omagh '97—Miss Knowles.
38	Down	Saintfield '96 : common (Waddell)—W.B.E.C.'96–7.
39	Antrim	Dunseverick '97—P. Frequent.

A. filicaulis Buser.

4	Cork Mid	Dripsey '89—R. A. Phillips.
5	Cork E.	Fermoy '50 (T. Chandlee)—*Herb.* S. & A. M.
6	Waterfd.	Cappoquin '99—P.
7	Tipp. S.	Fethard '97, Lough Muskry '00—P.
8	Limrck.	Adare '99—Somerville. Capantimore—*Herb.* L.F.C.
10	Tipp. N.	Ballingarry '00 : common—P.
11	Kilkny.	Kilmacow '00—Miss Horne. Ballyragget—P.
13	Carlow	Goresbridge and Ballintemple '99—P.
14	Queen's	Grantstown '98, Arderin '97—P.
15	Galw. SE.	Chevy Chase '00 : common—P.
16	Galw. W.	Moycullen, Kilbeg Ferry, '99—P. Clonbur.
17	Galw. NE.	Knockmae '99, Dunmore, Barbersfort, &c.—P.
18	King's	Kinnitty '00, Shannon Harbour—P.
19	Kildare	Ballymore '00, near Baltinglass—P.
21	Dublin	Kilternan '94—P.
22	Meath	Ballivor and Slieve Bregh '00—P.
23	Westmth.	Knock Eyon and Lough Iron '99—P.
24	Longford	Longford '98 : common—P.
25	Roscomn.	Rockville '99, Slieve Bane, Mote Park—P.
26	Mayo E.	Ballinrobe—Mrs. Persse !
27	Mayo W.	Mweelrea '82—Hart *380.*
29	Leitrim	Rinn Lough and Carrick-on-Shannon '99—P.
31	Louth	Kearney's Cross '97—P.
32	Monaghn.	Drumreaske '00—A. Somerville.
34	Dongl. E.	Lag '98—H. C. Hart.
36	Tyrone	Omagh '97—Miss Knowles.
37	Armagh	Tynan Abbey '92—P.
38	Down	Scrabo Hill '87—P.
39	Antrim	Cave Hill '98—G. C. Druce. Common.
40	L'derry	Benevenagh—S. A. Stewart. Frequent.

Rosa tomentosa Sm., var. **scabriuscula** (Sm.).

29 Leitrim Lurganboy '99—P.

Also in 20, 33, 39—see *Cybele* II.

R. canina L., var. **lutetiana** Leman.

5	Cork E.	Mitchelstown '97 : frequent—R. A. Phillips.
7	Tipp. S.	Fethard '00—R. A. Phillips.
11	Kilkny.	Kilkenny '00—R. A. Phillips.
12	Wexford	Near Wexford '96—E. S. Marshall.
16	Galw.W.	Clonbur '95—E. S. Marshall.
18	King's	Edenderry '96—P.
26	Mayo E.	Clonbur '95—E. S. Marshall.
34	Dongl. E.	Near Killygordon—*Fl. Donegal.*
38	Down	Saintfield '95—C. H. Waddell.
39	Antrim	Common '93—W. A. Shoolbred.

var. **sphærica** (Gren.).

35	Dongl.W.	Ardara—*Fl. Donegal.*

var. **senticosa** (Ach.).

9	Clare	Ballyvaughan '00—R. A. Phillips.

var. **dumalis** (Bechst.).

3	Cork W.	Skibbereen '96 : frequent—Phillips.
5	Cork E.	Near Mitchelstown '97 : frequent—Phillips.
14	Queen's	Abbeyleix '00—Phillips.
16	Galw. W.	Clonbur '95—E. S. Marshall.
23	Westmth.	Clonave '95—Linton *503*.
26	Mayo E.	Clonbur '96—E. S. Marshall.
35	Dongl.W.	Gweebarra estuary—*Fl. Donegal.*
38	Down	Saintfield '95—C. H. Waddell.
39	Antrim	Glenarm '99—Druce *285*. Common.
40	L'derry.	L. Neagh '99—Druce *285*. Eglinton—Mrs. Leebody.

f. *verticillacantha* (Mérat.)

38	Down	Saintfield '94—C. H. Waddell.

var. **urbica** (Leman).

23	Westmth.	Knock Body '95—Linton *503*.

var. **dumentorum** (Thuill.).

7	Tipp. S.	Fethard '00—R. A. Phillips.
19	Kildare	Co. Kildare—*Cyb.* II.
37	Armagh	Near Lough Gilly '98—Druce *285*.
38	Down	Killowen (Stewart)—*Suppl. Fl. NE.*
39	Antrim	Mazetown (Stewart)—*Suppl. Fl. NE.*
40	L'derry.	Toomebridge '98—Druce *285*.

var. **arvatica** Baker, f. **cæsia** Sm.

35 Dongl. W. Eglish River (F. J. Hanbury)—*Fl. Donegal.*

The above being the first attempt to show the distribution of *R. canina* forms in Ireland, I have given all the reliable records of which I have knowledge.

R. glauca Vill., var. **coriifolia** (Fr.).

39 Antrim Cave Hill '98—Druce *285*.
40 L'derry. Lough Neagh '98—Druce *285*.

Cratægus Oxyacantha L., var. **oxyacanthoides** (Thuill.).

Divisions 34, 35, 38. Not distinguished elsewhere.

var. **monogyna** (Jacq.)

Divisions 12, 21, 23, 34, 35, 38. Probably common.

Pyrus Malus L., var. **acerba** DC.

Divisions all *except 2, 3, 4, 9, 12, 34, 35, 36, 40.*

var. **mitis** Wallr.

Divisions all *except 1, 2, 3, 4, 5, 9, 23, 25, 27, 34, 35, 40.*

***Bryonia dioica** Jacq.

22. Meath Thicket by the Boyne at Oldbridge '01—Miss R. Smith!

Apium nodiflorum Reichb. fil., var. **ocreatum** Bab.

12 Wexford Near Wexford '96—E. S. Marshall.
16 Galw. W. South side of Lough Mask '95—M. & S. *545*.
21 Dublin Ireland's Eye '94—P. *736*.
23 Westmth. L. Owel and L. Derevaragh '95—Linton *503*.
35 Dongl. W. Ramelton and Kincashla—*Fl. Donegal.*

A. inundatum Reichb. fil., var. **Moorei** Syme.

17 Galw. NE. River Clare near Tuam '99—P.
22 Meath Navan '00—P.
34 Dongl. E. North-west of Ballyshannon—*Fl. Donegal.*

Frequent about Downpatrick and in the Bann basin, in 37, 38, 39, 40. A remarkable variety.

Sambucus nigra L., var. **laciniata** L.

15 Galw. SE. Gort '00—R. A. Phillips.

Galium palustre L., var. **Witheringii** (Sm.).

Divisions 5, 8, 11, 12, 16, 21, 23, 25, 26, 28, 29, 30, 34, 37, 38, 39.

Of fifteen Irish gatherings of *G. palustre* submitted to Rev. E. S. Marshall, only one is referred (and that doubtfully) to the type, which appears to be very rare in Ireland.

Valerianella olitoria Poll., var. **lasiocarpa** Reichb.

12 Wexford Common between Greenore and Carnsore '97—E. S. Marshall.

Matricaria inodora L., var. **salina** Bab.

5 Cork E. Ballycotton '96—R. A. Phillips.
12 Wexford Near Wexford '96—E. S. Marshall.
16 Galw. W. Salthill '00—R. A. Phillips. Roundstone—*502*.
20 Wicklow Kilcoole '94—P.
21 Dublin Howth '94—P.
39 Antrim Giant's Causeway '93—W. A. Shoolbred.

Artemisia vulgaris L., var. **coarctata** Forcell.

16 Galw. W. }
26 Mayo E. } About Clonbur '95—E. S. Marshall.

Senecio vulgaris L., var. **radiatus** Koch.

6 Waterfd. Dunmore East '01—Mrs. Persse!
8 Limrck. Kilmallock '00—R. A. Phillips.

S. Jacobæa L., var. **flosculosus** (Jord.).

6 Waterfd. Tramore '99—P.
10 Tipp. N. Dromineer '00—R. A. Phillips.
16 Galw. W. Knocknagoneen '99—P.
22 Meath North of Laytown '96—P.
28 Sligo Strandhill '97—P.
34 Dongl. E. Buncrana (J. Hunter)—Hart *405*.
38 Down Groomsport! '86—Stewart.

Also in 2, 9, 12, 31, 35—see *Cybele* II.
Frequent on coast sandhills: very rare inland.

S. aquaticus L., var. **pennatifidus** Gren. et Godr.

16 Galw. W. Maam and Clonbur '95—M. & S. *545*.
26 Mayo E. Cong '95—M. & S. *545*.

Cnicus palustris × pratensis.

Plants found in several parts of Ireland convinced me that this hybrid is of not infrequent occurrence. In 1900, in a damp pasture north-west of Claremorris, a large colony of plants was found which exhibited every grade from *C. palustris* to *C. pratensis*, both of which were present in abundance. Of specimens midway in the series from this locality Mr. Arthur Bennett writes:—"19. 12. '00. I have to-day compared the *Carduus* specimens at the British Museum. Among the British specimens there is *nothing* so extreme as your specimens. The nearest is an Irish specimen. Watson's *Forsteri* is an *anglicum* [= *pratensis*] with its tenuity of the leaves *retained*—yours has more the harshness of *palustris*. In the general collection at the British Museum there is nothing like it; but when I showed Mr. S. Moore the specimens he said "I think a hybrid." Clearly, your specimens retain to the heads more the characters of *pratensis* than *palustris*. Did *C. tuberosus* occur in Ireland I should have been much inclined to name one of your specimens (*i.e.* 3. 7. '00 N. of Claremorris) *C. palustris × tuberosus*. You will say—well, then, what do you name the specimens after all? I answer, though with some doubt—a hybrid as you make them, probably *C. pratensis × palustris*, but more extreme than any I have seen of English specimens so named." The conditions under which these plants occurred do away in my mind with any doubts which might hang around the few dried specimens submitted; and I group with this gathering other plants obtained in Queen's County and Carlow. As regards certain previous records of this hybrid, no valid reason appears for excluding them. Rev. E. S. Marshall confirms (*541*) Mr. Levinge's Westmeath record (*484*), and also Rev. E. F. Linton (*in litt.*); and if Mr. Levinge, a discriminating observer, is correct about his Westmeath plant, he is probably also correct about his Clare one. I think, therefore, that in recording the undermentioned stations for *C. pratensis × palustris* we are on tolerably safe ground:—

9 Clare Lisdoonvarna '92—H. C. Levinge.
13 Carlow Below St. Mullins '99—P.
14 Queen's Mountrath '97—P.

23 Westmth. Lough Owel—H. C. Levinge *484*.
26 Mayo E. North-west of Claremorris '00—P.
40 L'derry. Garvagh and Jackson Hall (D. Moore)—*Cyb.* I.

C. arvensis Hoffm., var. **mitis** Koch.

3 Cork W. Glengariff '90—Druce *284*.
40 L'derry. Toomebridge '98—G. C. Druce. Aghadowey '95 (Waddell)—W. B. E. C. '95–6.

var. **horridus** (Adam).

1 Kerry S. Kenmare '90—Druce *284*.
11 Kilkny. Ferrybank '95—M. & S. *545*.

var. **setosus** Bess.

27 Mayo W. Gortnaraby '00—P.
34 & 35 Dongl. Frequent—see *Fl. Donegal.*
38 Down Lambeg '00—Davies *272*.
40 L'derry. Between Kilrea and Garvagh '98—Stewart and Miss Knowles.

***Lactuca virosa** L.

8 Limrck. Waste ground at Limerick ! '00—R. D. O'Brien. Holding its own in two stations here.

Taraxacum officinale Web., var. **erythrospermum** (Andrz.).

5 Cork E. Near Youghal '00—R. A. Phillips.
6 Watrfd. Tramore '99—R. A. Phillips.
21 Dublin Portmarnock '01—P.

var. **palustre** (DC.).

8 Limrck. Near Limerick '99—A. Somerville.
9 Clare Near Ballyvaughan '99 (Playfair)—W.B.E.C. '99–'00.
16 Galw. W.
26 Mayo E. } South of Lough Mask '95—M. & S. *545*.
29 Leitrim Drumcoura Lough '00—A. Somerville.
30 Cavan Ballyconnell '00—A. Somerville.
32 Monaghn. Mullyash Hill '00—A. Somerville.
35 Dongl. W. Fanet, &c.: north only—*Fl. Donegal.*
Also in 1, 4, 19, 20, 21, 28, 36, 38, 39—see *Cybele* II.

var. **udum** (Jord.).

12	Wexford	Carnsore '97—E. S. Marshall.
16	Galw. W.	Near Clonbur '96—E. S. Marshall.
23	Westmth.	Knock Drin '95—Levinge. Castletown—Marshall.
26	Mayo E.	Near Cong—Marshall '99 *541*.
27	Mayo W.	Mallaranny '99—E. S. Marshall.

Also in 15—see *Cybele* II.

Sonchus arvensis L., var. **angustifolia** Mey.

26	Mayo E.	S.E. end of Lough Mask '95—M. & S. *545*.

Tragopogon pratense L., var. **minus** (Mill.).

Divisions 7, 8, 15, 18. I believe this is the usual Irish form, but information is lacking.

Jasione montana L., var. **major** Koch.

16	Galw. W.	Mount Gable '95—M. & S. *545*.

Statice auriculæfolia Vahl., var. **intermedia** Syme.

21	Dublin	Howth, Killiney, &c. (Hart)—*Fl. Donegal.*

Erythræa Centaureum Pers., var. **capitata** Koch.

3	Cork W.	Baltimore '96: frequent on coast—Phillips.
9	Clare	Lahinch '01—Miss E. Armitage.
27	Mayo W.	Mallaranny '99—E. S. Marshall.

Symphytum officinale L., var. **patens** (Sibth.).

3	Cork W.	Skibbereen '97: frequent—Phillips.
4	Cork Mid.	Frequent—Phillips '00.
11	Kilkny.	Graiguenamanagh '00—Phillips.
15	Galw. SE.	Portumna '00—Phillips.

***S. tuberosum** L.

Divisions 4, 5, 21, 22, 36, 38.

***Borago officinalis** L.

Divisions 3, 4, 5, 6, 8, 12, 14, 21, 22, 26, 38, 39, 40.

***Antirrhinum majus** L.

Divisions 4, 5, 7, 11, 21, 25, 31, 35, 38, 39.

***Linaria purpurea** L.

Divisions 4, 11, 12, 21.

Scrophularia aquatica L., var. cinerea Dum.

27	Mayo W.	Newport '99—E. S. Marshall.
		And in 16, 23, 26—see *Cybele* II.

Veronica Anagallis L., var. anagalliformis Bor.

12	Wexford	Wexford '96—E. S. Marshall.
16	Galw. W.	Clonbur and Cong frequent '95—M. & S. *545*.
23	Westmth.	Knock Drin and Scraw bog '95—Levinge.
26	Mayo E.	Cong frequent '95—M. & S. *545*.
27	Mayo W.	Mallaranny district frequent '99—Marshall.

Euphrasia officinalis L.

Except for a few gatherings chiefly by English visitors, Irish Eyebrights have as yet, except for my own collecting, been almost unworked. I am under a deep debt of gratitude to Mr. F. Townsend, who has identified all the plants which are recorded in my name below. As no attempt has been made except in Mr. Townsend's *Monograph* (1897) to give the Irish distribution of the Eyebrights, I have included all reliable records of which I have cognisance.

E. stricta Host.

6	Waterfd.	Ballyscanlan Lough '99—P.
8	Limrck.	Mullagh '00—P.
10	Tipp. N.	Cloughjordan '00—P.
15	Galw. SE.	Rinville House '99—P.
17	Galw. NE.	Menlo and Killower Lough '99—P.
18	King's	Clonmacnoise '99—P.
27	Mayo W.	Ballina '00—P.

E. borealis Wettst.

12	Wexford	Between Greenore and Churchtown '97—Marshall *539*.
16	Galw. W.	Oughterard '99—P. Connemara '53 (F. Kirk)—*890*.
19	Kildare	South of Kildare '97—P.
22	Meath	Laytown '96—P.
24	Longfd.	Common by Lough Ree '00—P.
27	Mayo W.	Ballina, Rosserk, Derreen, Crossmolina, '00—P.
33	Ferman.	Lower Lough Macnean '00—P.

E. brevipila Burnat et Gremli.

7	Tipp. S.	Thurles '98—P.
8	Limrck.	Askeaton '00—P.
10	Tipp. N.	L. Ourna '99, Keeper Hill, Devil's Bit, Cloughjordan Portumna—P.
11	Kilkny.	Tory Hill '99, Urlingford '98—P.
13	Carlow	Borris '98, Bagenalstown '97—P.
14	Queen's	Abbeyleix, '98, Mountrath '97—P.
15	Galw. SE.	Garryland and Chevy Chase '00—P.
16	Galw. W.	Oughterard and Gentian Hill '99—P.
17	Galw. NE.	Tuam, Keekill, Oranmore, Menlo '99; Clonbrock—P.
18	King's	Clanmacnoise '99, Edenderry '96—P.
19	Kildare	Rathangan '98, Rathmore, Leixlip, Kilcock, Kilmeage, Carbury—P.
21	Dublin	Near Tallaght '97—P.
22	Meath	Laytown and Enfield '96—P.
24	Longford	Castlerea '00—P.
25	Roscomn.	Slieve Bane '00, Arigna, Corkip Lough, Athlone—P.
26	Mayo E.	NW. of Claremorris '00—P.
27	Mayo W.	Mallaranny district common '99—Marshall. Ballina district common '00—P.
28	Sligo	Carrowkee Hill '97, Lough Gara, Inismurray—P.
29	Leitrim	Ballinamore '00, Garadice L., Glenade, Rinn L., L. Gill—P.
30	Cavan	Mount Nugent '96—P.
31	Louth	Ballymascanlan '00, Ravensdale, Ardee, Togher, Lurgan Green—P.
36	Tyrone	Mullaghcarn and Omagh '96—Miss Knowles.
38	Down	Greypoint '85—P.
39	Antrim	Glenarm and Cave Hill '98—G. C. Druce.
40	L'derry	Toomebridge '98—G. C. Druce.

f. *subglabra.*

10	Tipp. N.	Cloughjordan '00—P.
26	Mayo E.	East of Foxford '00—P.

f. *eglandulosa.*

17	Galw. NE.	Menlo '99—P.

f. *subeglandulosa.*

10	Tipp. N.	Devil's Bit '98—P.
19	Kildare	Above Rathmore '98—P.

E. brevipila × Rostkoviana.

27	Mayo W.	Lough Conn south of Derreen '00—P.

The same hybrid is doubtfully named from 11, 15, 23, 31.

E. nemorosa Mart.

10	Tipp. N.	Cloughjordan '00—P.
15	Galw. SE.	Lough Derg '96 (N. Colgan)—A. Bennett.
23	Westmth.	Lac Lean [Lough Lene ?]—see Townsend *890*.
33	Ferman.	Florencecourt '00—P.

Also recorded from "Mayo" in Wettstein's *Monograph*.

f. *tetraquetra.*

9	Clare	Murrough '95 (N. Colgan)—A. Bennett.
22	Meath	Oldcastle (W. S. Millar)—Townsend *890*.

E. curta Fries, var. **glabrescens** Wettst.

9	Clare	Lahinch '01—Miss E. Armitage.
17	Galw. NE.	Knockmae '00—P.
38	Down	Newcastle '98—G. C. Druce.
39	Antrim	Lough Neagh '98—G. C. Druce.

E. occidentalis Wettst.

5	Cork E.	Poorhead [= Power Head] '95 (Phillips)—Townsend *890*.
6	Waterfd.	Tramore '99—P.
38	Down	Templemore [= Tollymore] Park '98—G. C. Druce.

E. gracilis Fries.

7	Tipp. S.	Fethard and near Cashel '98—P.
10	Tipp. N.	Between Devil's Bit and Ballyhoul '98—P.
11	Kilkny.	Inistioge '98—P.
17	Galw. NE.	Annaghdown '00, Keekill '99—P.
22	Meath	Oldcastle '96—P.
23	Westmth.	Athlone '98—P. L. Derevaragh—Levinge and Groves
28	Sligo	Ballysadare '00—P.

29 Leitrim	Lough Melvin '99—P.
32 Monaghn.	Creeve Lough '00—P.
39 Antrim	Near Ballintoy '93—W. A. Shoolbred.

A few records are withheld, as the determinations were made prior to the recognition of so many forms in these countries.

E. scottica Wettst.

7 Tipp. S.	Thurles '98—P.
13 Carlow	South of Carlow '98—P.
16 Galw. W.	Ross Lake '99—P.
19 Kildare	Hill above Rathmore '98—P.
25 Roscomn.	Athlone '98—P.
26 Mayo E.	East of Foxford '98—P.
27 Mayo W.	Mallaranny '99 (E. S. Marshall).—A. Bennett. Ballina, Rathroeen L., frequent by Lough Conn '00—P.
31 Louth	Carlingford Mountain '00—P.

E. Rostkoviana Hayne.

1 Kerry S.	Dingle '53 (D. Oliver)—Townsend *890*.
6 Waterfd.	Dungarvan and Kilmacthomas '99—P.
8 Limrck.	Doon '00—P.
10 Tipp. N.	Dromineer '99, Devil's Bit '98—P.
11 Kilkny.	Thomastown, Inistioge, Barleeagh Wood, '98—P.
13 Carlow	Killedmond River '99—P.
14 Queen's	Rathdowney '98, Emo '96—P.
15 Galw. SE.	Marble Hill '97, Chevy Chase '00—P.
20 Wicklow	Scalp '72—*Herb.* G. Pim.
22 Meath	Oldcastle '96—P.
23 Westmth.	Moate '99, Athlone—P. Bog of Lynn—Levinge.
25 Roscomn.	Arigna '00—P.
28 Sligo	Ballysadare '00—P.
36 Tyrone	Baronscourt '96—Miss Knowles.

E. Salisburgensis Funk.

Divisions 8, 9, 15, 17, 26, 29—see *Cybele* and *Irish Top. Bot.*

E. Salisburgensis × brevipila.

18 King's	Lough Goura '98—P.

"*E. Salisburgensis × brevipila*, I doubt not."—F. Townsend. Mr. Townsend favours me with a formal description of this new hybrid, which, he remarks, is an exceedingly interesting plant. He is anxious to see further specimens, and I hope any botanist visiting King's County will not lose the opportunity of searching for it. The finding of the parent *E. Salisburgensis* in King's County would alone be a valuable discovery.

Of fourteen "species" of Eyebright—the "species" seem as well founded as those of the *Rubi*—known as British, Ireland possesses ten. Of these, two, *E. brevipila* and *E. Rostkoviana*, appear to constitute the bulk of the Irish Eyebright flora. *E. brevipila* is very widespread in Europe, but in Great Britain appears to increase northward; while *E. Rostkoviana*, a plant of middle Europe, in Great Britain increases southward. For the rest, *E. borealis*, *E. gracilis*, and *E. scottica* are northern in their range, though not so in Ireland. *E. nemorosa* is southern in Great Britain; *E. occidentalis* appears to be a very local plant occurring in N.W. France and Britain, and *E. stricta*, a lowland mid-Europe form, seems to be a rare plant in these countries. The well-known *E. Salisburgensis*, a northern and alpine plant, is as yet unknown in Great Britain, though ranging widely along the west coast of Ireland. Of the four British forms not yet found in Ireland, *E. latifolia* and *E. Foulaensis* are high northern, and *E. Kerneri* a limestone plant of limited distribution. With the exception of *E. Salisburgensis*, none of the Irish Eyebrights show a marked range either horizontally or vertically, though the species differ much in abundance.

Rhinanthus Crista-galli L., var. **fallax** W. & G.

16 Galw. W. Between Clonbur and Mt. Gable '95—M. & S. *545*.
23 Westmth. Lough Owel '95 (W. R. Linton)—B. E. C. '95.
39 Antrim Near Toomebridge '98—Druce *285*.

var. **R. stenophyllus** Schur.

25 Roscomn. Kilteevan '97—T. A. P. Mapother.

Rhiranthus forms are almost unworked in Ireland.

Bartsia Odontites Huds.

Var. *verna* is known from divisions 5, 8, 11, 12, 26: var. *serotina* from 5, 12, 21, 39. Further information is needed as to their distribution in Ireland.

***Mentha alopecuroides** L.

38 Down — Dunny Water Bridge '90—P. This is the *M. rotundifolia* of Hart *381*, and of Stewart & Praeger *873*.

***M. longifolia** Huds.

5 Cork E. — Dodge's Glen (J. Sullivan)—Allin *19*.
11 Kilkny. — Callan '00—R. A. Phillips.
15 Galw. SE. — Gort '00—R. A. Phillips.
Also in 1, 3, 21—see *Cybele* II.

***M. viridis** L.

Divisions 4, 5, 18, 23, 34, 38.

M. hirsuta Huds., var. **subglabra** (Baker).

36 Tyrone — By Lough Neagh '96—Miss Knowles.

M. sativa L., var. **paludosa** (Sole).

15 Galw. SE. — Woodford River '85—Linton *502*.
18 King's — Tullamore and Clara '99—P.
23 Westmth. — L. Derevaragh '95 (W. R. Linton)—B. E. C. '95.
24 Longfd. — Near Ballymahon '00—P.
Also in 2 and 40—see *Cybele* II.

var. **subglabra** Baker.

14 Queen's — Graigue '99—P.

var. **rubra** (Smith).

Divisions 4, 12, 13, 38.

var. **gracilis** (Smith), f. **cardiaca**.

7 Tipp. S. — Fethard '00—R. A. Phillips.

M. verticillata L. = **arvensis** × **aquatica**.

40 L'derry — Toomebridge '98—G. C. Druce.

M. Pulegium L., var. **erecta** Syme.

1 Kerry S. — Gallarus '87 (A. Ley)—*Herb.* Glasnevin

Stachys palustris × **sylvatica**.

4 Cork Mid — Blarney (R. Mills)—Allin *19*.
11 Kilkny. — Ballyragget '98—P.
12 Wexford — Courtown '94—Mrs. Tatlow!

13 Carlow	Borris '98—P.
19 Kildare	Leixlip '96—P.
20 Wicklow	Glen of the Downs '93—P.
22 Meath	Athboy '00, Maynooth, Beauparc, Oldcastle—P.
24 Longfd.	Newtowncashel '00—P.
31 Louth	Togher '96—P.
35 Dongl. W.	Near Gweedore—*Fl. Donegal.*
36 Tyrone	Newtownstewart '96—Miss Knowles.

Also in 5, 21, 37, 38, 39, 40—see *Cybele* II.

Usually nearer *palustris* than *sylvatica*, and cannot then be referred to *S. ambigua* Smith.

Plantago Coronopus L., var. **pygmæa** Lange.

27 Mayo W. Mallaranny '99—E. S. Marshall.

***Chenopodium murale** L.

Divisions 3, 5, 8, 21, 22, 39; recently seen in all except the first two.

Polygonum Convolvulus L., var. **subalatum** V. Hall.

16 Galw. W.	Oughterard '95—M. & S. *545*.
31 Louth	Mouth of the Boyne '96—P.
38 Down	Saintfield '93, Magheralin—Waddell *896*.

P. aviculare L., var. **arenastrum** Syme.

Divisions 6, 21, 27, 38.

var. **littorale** (Link.).

Divisions 21, 22, 31, 38.

P. Persicaria L., var. **glandulosa** V. Bosch.

38 Down Ballynahinch '86—P.

var. **incanum** *auct.*

38 Down Warrenpoint town reservoir '90—P. This is the *P. lapathifolium* of Stewart & Praeger *873*.

Euphorbia Cyparassias L.

19 Kildare Curragh '97—P.

24 Longfd. Saint's Island '99—Miss R. Smith!

In wild ground in these stations.

Betula pubescens Ehrh., var. **denudata** Gren. et Godr.

8 Limrck. Thornfields bog '01—Miss E. Armitage!
20 Wicklow Altadore '93—P.

Salix triandra × fragilis = S. decipiens Hoffm.

32 Monaghn. Lough Avaghon '00—P.

S. pentandra × fragilis = S. cuspidata Schultz.

16 Galw. W. *Maam '99—Marshall *541.*
19 Kildare †Kilcullen '97—P.
26 Mayo E. *Cong '99—Marshall *541.*
A rare hybrid.

S. aurita × cinerea = S. lutescens A. Kern.

3 Cork W. Inchigeela '97—R. A. Phillips.
7 Tipp. S. Between Fethard and Cashel '98—P.
16 Galw. W. Maam '95—M. & S. *545.*

S. nigricans × aurita = S. coriacea Forbes.

23 Westmth. Knock Drin neighbourhood '95—Linton *503.*

S. viminalis × Capreæ = S. Smithiana Willd.

Divisions all, *except 2, 9, 12, 13, 15, 17, 26, 27, 31.*

S. viminalis × cinerea.

7 Tipp. S. Between Cashel and Fethard '98—P.
20 Wicklow Shillelagh '99—P.
22 Meath Kildalkey '00—P.

S. viminalis × aurita = S. fruticosa Doell.

11 Kilkny. By the Nore above Ballyragget '99—P.

S. viminalis × Caprea.

6 Waterfd. Ballyscanlan Lake '99—P.
18 King's Clara '99—P.
23 Westmth. Quarry bog '95—Levinge. Near Athlone '99—P.
25 Roscomn. Rockville '99—P.

***S. purpurea × viminalis = S. rubra** Huds.

I have gathered this in divisions 8, 26, 28, 29.

Populus tremula L., var. **glabra** Syme.

8 Limrck. †Adare '99—A. Somerville.
16 Galw. W. Clonbur '95—E. S. Marshall.

Iris Pseud-acorus L., var. **acoriformis** (Boreau).

27 Mayo W. Mallaranny district abundant '99—Marshall.
Apparently the usual Irish form.

Allium vineale L., var. **compactum** (Thuill.).

8 Limrck. Limerick '99—A. Somerville.

Juncus effusus × **glaucus** = **J. diffusus** Hoppe.

7 Tipp. S. Carrick-on-Suir '00—R. A. Phillips.
Also in Dublin only.

Luzula erecta Desv.

f. *umbellata* in 5, 10, 15, 18, 29, 36, 37, 38, 39.
f. *congesta* in 1, 5, 6, 8, 10, 15, 16, 18, 29, 38, 39, 40.

Both are probably universal.

Arum maculatum L.

The spotted-leaved form, from which the species derives its name, is apparently very rare in Ireland. The only notes I have are :—

15 Galw. SE. Portumna '99—Mrs. Joyce. Dunsandle '99—P.
21 Dublin Glencullen '02—G. H. Pethybridge!

Typha latifolia L., var. **media** Syme.

9 Clare Inishmaan '90—Nowers and Wells *651*.

Sparganium ramosum Huds., var. **microcarpum** Neum.

16 Galw. W. Maam and Clonbur frequent '95—M. & S. *545*.
26 Mayo E. Frequent at Clonbur '95—M. & S. *545*.
38 Down Loughanisland (Waddell)—S. & P. *874*.

Potamogeton crispus × **obtusifolius** = **P. Bennettii** Fryer.

37 Armagh Canal below Caledon '92—P. See *Irish Nat.*, II., 182.

This hybrid was described by Alfred Fryer in 1895 (*Journ. Bot.*, xxxiii., p. 1, tab. 348) from Grangemouth, Stirlingshire, which still remains the only other British station.

P. lucens L., var. **acuminatus** Fr.

23 Westmth. Lough Derevaragh '92—H. C. Levinge.

P. pusillus L., var. **tenuissimus** Koch.

12 Wexford Near Wexford '96—Marshall *537*.
34 Dongl. E. Doagh Island '98—H. C. Hart.
37 Armagh Armagh '76 (S. A. Stewart)—*Herb.* A. Bennett.
38 Down Saintfield '00 (Waddell)—W.B.E.C. 1900–1.

Zostera marina L., var. **angustifolia** Fr.

12 Wexford Wexford Harbour '96—E. S. Marshall.
15 Galw. SE. Kinvarra '00—P.
16 Galw. W. Gentian Hill '00—P.
21 Dublin Malahide inlet '99—P. Baldoyle—*Herb.* S. & A. M.
22 Meath Nanny River '96—P.
27 Mayo W. Near Killala '00—P.
31 Louth Boynemouth '96—P.
34 Dongl. E. Trawbreaga Bay '98—H. C. Hart.
38 Down Strangford Lough, common—P.

Carex teretiuscula Good., var. **Ehrhartiana** (Hoppe).

17 Galw. NE. Near Clonbrock '96—P.
Also in 34 and 35—see *Fl. Donegal.*

C. Goodenovii J. Gay, var. **elatior** (Lange), f. **angustifolia**.

39 Antrim Harbour Island '98—G. C. Druce.

var. **juncella** Fr.

5 Cork E. Youghal '96—R. A. Phillips.
7 Tipp. S. Thurles '00—R. A. Phillips.
15 Galw. SE. Woodford '00—R. A. Phillips.
17 Galw. NE. Donamon '97—P.
32 Monaghn. Bessmount and elsewhere '00—Waddell.
34 Dongl. E. Near Ballyshannon—*Fl. Donegal.*
35 Dongl. W. Milford Lake and Glenties—*Fl. Donegal.*
Also in 1, 4, 12, 16, 23, 26, 39—see *Cybele* II.

C. extensa Good., var. **pumila** Anders.

12 Wexford Wexford Harbour '96—Marshall *537*.
27 Mayo W. Mallaranny '99—E. S. Marshall.

C. flava L., var. **Œderi** Retz.

Mr. Marshall finds this in 12, 16, 26, 27—in all the localities he has worked, so it is probably common in Ireland.

var. **minor** Towns.

17	Galw. NE.	Killower Lough '99—P.
27	Mayo W.	Mallaranny district abundant '99—Marshall.
40	L'derry	Lough Beg '98—G. C. Druce.

C. flava × fulva.

3	Cork W.	Gurtavehy Lake '00—R. A. Phillips.
16	Galw. W.	Ross L. '99—P. NW. side of L. Corrib—M. & S. *545*.
26	Mayo E.	S. side of L. Mask '95—M. & S. *545*.
27	Mayo W.	Newport and west of Castlebar '99—Marshall.
37	Armagh	Derryadd Lough '92—P.

Agrostis alba L., var. **stolonifera** (L.).

Divisions 6, 11, 13, 15, 17, 22, 31—P. No doubt common.

var. **maritima** Mey.

3	Cork W.	Baltimore '96: common on coast—Phillips.
21	Dublin	Portmarnock '90—Druce *284*.
22	Meath	Laytown '95—P.

var. **coarctata** (Hoffm.)

39	Antrim	Islands in Lough Neagh '98—G. C. Druce.
40	L'derry	Common near Lough Beg '98—G. C. Druce.

A. vulgaris With., var. **pumila** (L.).

Divisions 1, 3, 4, 5, 8, 12, 13, 14, 20, 21, 24, 26, 27, 29, 33, 36, 38, 39, 40. Merely a state induced by starvation.

Arrhenatherum avenaceum Beauv., var. **nodosum** Reichb.

8	Limrck.	Thornfields '01—Miss E. Armitage.
23	Westmth.	Knock Drin—Levinge *484*.
36	Tyrone	Omagh '96—Miss Knowles.

Phragmites communis Trin., var. **nigricans** Gren. et Godr.

23	Westmth.	Lough Owel '95—H. C. Levinge.

Koeleria cristata Pers., var. **gracilis** (Bor.).

16	Galw. W.	South of Lough Mask '95—M. & S. *545*.
26	Mayo E.	

Sesleria cærulea Ard., var. **luteoalba** Opiz.

Divisions 9, 15, 17 : apparently frequent where the type occurs.

Poa pratensis L., var. **subcærulea** (Sm.).

12	Wexford	Rosslare '97—E. S. Marshall.
21	Dublin	North Bull '00—R. A. Phillips.
23	Westmth.	Bog of Lynn '95—H. C. Levinge.
27	Mayo W.	Mallaranny '99—E. S. Marshall.

Also 34, 35—see *Fl. Donegal.*

P. trivialis L., var. **Koeleri** (DC.).

12	Wexford	Rosslare '97—E. S. Marshall.
27	Mayo W.	Mallaranny '99—E. S. Marshall.
29	Leitrim	Glenade '99—P.

var. **glabra** Doell.

12	Wexford	South of Greenore '97—Marshall *539*.

Festuca ovina L., var. **capillata** Hackel.

3	Cork W.	Glengariff '90—Druce *284*.
16	Galw. W.	Maam abundant '95—M. & S. *545*.

F. elatior L., var. **pratensis** Huds.

Divisions 8, 11, 16, 18, 19, 20, 21, 24, 25, 28, 29, 33, 34, 35, 36, 38, 39, 40. Probably in all divisions.

F. elatior × **Lolium perenne.**

18	King's	Pallas Lough '00—P.
31	Louth	Boyne mouth '96—P.
34	Dongl. E.	Innishowen Head and Culdaff (Dickie)—*Fl. Donegal.*

Also 13, 17, 23, 39—see *Cybele* II.

Bromus giganteus L., var. **triflorus** Syme.

Divisions 36, 38, 39. Frequent ?.

Agropyron repens Beauv., var. **barbatum** Duval-Jouve.

11 Kilkny. Ballinlaw Ferry '99—P.
21 Dublin Portmarnock '94—P.
31 Louth Queensborough '96—P.
36 Tyrone Omagh '96—Miss Knowles.

*__Lolium perenne__ L., var. **multiflorum** (Lam.).

36 Tyrone Strabane '96—Miss Knowles.

*var. **italicum** (Braun).

Divisions 8, 12, 32.

Ceterach officinarum Willd., var. **crenatum** Milde.

Divisions 4, 5, 6, 7, 9, 10, 11, 13, 16, 17, 18, 20, 22, 24, 25, 26, 27, 29, 38, 39. Generally occurs wherever the plant grows strongly.

Asplenium Adiantum-nigrum L., var. **acutum** (Bory).

5 Cork E. Near Whitegate '00—R. A. Phillips.
11 Kilkny. Snowhill '99—P.
Also in 1, 2, 3, 4, 8, 16, 20, 26, 27, 38—see *Cybele* II.

Lastrea Filix-mas Presl., var. **affinis** Bab.

Divisions 6, 7, 8, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 37, 38, 39, 40.

var. **paleacea** Moore.

Divisions 1, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 37, 38, 39, 40. Both are, no doubt, universal.

var. **abbreviata** Bab.

The only locality whence I have seen undoubted "Lastrea propinqua" is the Mourne Mountains. Mr. Hart has recorded it from Brandon and Mount Leinster (*381*), and states that this is the usual form on the upper part of the Donegal mountains (*Fl. Donegal*).

L. dilatata Presl., var. **collina** Bab.

1 Kerry S. Brandon '87 (A. Ley)—B.E.C. '87.

Polypodium vulgare L., var. **serratum** Willd.

Divisions 4, 5, 8, 9, 11, 23, 28, 39. Not unfrequent in limestone districts when the plant is growing strongly. It develops into var. *semilacerum* and that again into var. *cambricum.*

Equisetum limosum Sm., var. **fluviatile** (L.).

Divisions all *except 3, 4, 5, 9, 11, 20, 32, 34, 35.* The usual form in shade or in running water.

E. palustre L., var. **polystachyum** *auct.*

8 Limrck. Thornfields '01—Miss E. Armitage!
15 Galw. SE. Marble Hill '97—P.

Merely a sport, produced by exuberant growth or more often by injury to the axis.

var. **nudum** Newm.

29 Leitrim Lough Melvin '99—P.

A sport, consisting of an absence of branching, the result of exposed habitat.

CHARACEÆ.

So much material was obtained during my five years' field-work, that I have in most cases supplemented my notes with brief references to additional records, as given in Messrs. Groves' papers, &c., so as to make the following a complete account of the distribution of Characeæ in Ireland so far as present information goes. In *Irish Top. Bot.* the records given under each species include those of its varieties. In the following lists I have separated typical forms from varieties. My warm acknowledgments are due to Messrs. H. and J. Groves for naming or confirming the very large number of the plants listed below, with which my name is associated.

Chara fragilis Desv.

Type—Divisions all, *except 29, 35, 40.*

var. **barbata** Gant.

1 Kerry N. Near Ventry '94—D. McArdle.
9 Clare Killaloe '96—Colgan *219.*

11	Kilkenny	Urlingford '98—P.
14	Queen's	Rathdowney '98—P.
15	Galw. SE.	Loughrea '98 : widespread and frequent—P.
17	Galw. NE.	Clonbrock '96—P.
18	King's	Banagher '98, Shannon Harbour, Geashill—P.
19	Kildare	Rathangan '98, south of Kildare '97—P.
20	Wicklow	Murrough '95 (D. Moore)—Groves *349*.
22	Meath	Near Ardee bog '97—P.
23	Westmth.	Loughanstown—Levinge *484*. Mullingar—Groves *349*.
24	Longfd.	Canal at Killashee '98—P.
25	Roscomn.	Rockville '99—P.
26	Mayo E.	Kilmovee '99—P. About Cong '95—M. & S. *545*.
27	Mayo W.	Lough Conn near Derreen '00—P.
31	Louth	Killencoole '96—P.
38	Down	Holywood hills '91, Clandeboye, Craigauntlet—P.
39	Antrim	Portmore L. ['46] (Thompson), Tardree Hill (Grainger) —S. & P. *874*.

var. **capillacea** Coss. & G.

1	Kerry S.	Cloonee Lough '98—P.
2	Kerry N.	Long Range '87 (Scully)—Groves *349*.
16	Galw. W.	Galway W. '75 (More), Renvyle—Groves *343, 349*.
21	Dublin	Howth '94—P.
29	Leitrim	Glenade Lake '99—P.
31	Louth	Soldier's Point '96—P.
32	Monaghn.	L. Naglack '01—Bullock-Webster. Creeve L. '00—P.
33	Ferman.	Three miles N. of Enniskillen '81–2—Barrington *108*.
38	Down	Glasdrumman '98—Davies. Holywood '85—P.

var. **Hedwigii** Kuetz.

32 Monaghn. Lough Naglack '01—G. R. Bullock-Webster.

Also in divisions 16, 21, 26, 28, 38—see Groves *349*.

var. **delicatula** Braun.

3	Cork W.	Inchigeela '97—R. A. Phillips.
14	Queen's	Rathdowney '98, Maryborough '96—P.
16	Galw. W.	Oughterard, Moycullen, '99—P. Recess (Linton)—*349*.
17	Galw. NE.	Killower Lough '99—P.

21	Dublin	Clondalkin '94—P.
22	Meath	Oldcastle '96—P.
23	Westmth.	Lough Owel '01—G. R. Bullock-Webster.
25	Roscomn.	Lough Ree at Galey '97—P.
26	Mayo E.	Lough Corrib near Cong '95—M. & S. *545*.
27	Mayo W.	Lough Cullin near Pontoon '00—P.
28	Sligo	Lough Gill '99—P.
29	Leitrim	Glenade Lough, Annaghearly L., L. Melvin, '99—P.
31	Louth	Braganstown bog '97—P.
32	Monaghn.	Greaghlone Lough '01—G. R. Bullock-Webster.
33	Ferman.	Blaney Bay on Upper L. Erne '81-2—Barrington *108*.
34	Dongl. E.	Bundrowes River—*Fl. Donegal.*
35	Dongl. W.	Tullyconnell L. '98—Hart *405*. Kinny L. L. Sessiagh.
36	Tyrone	Favour Royal '96 (Mrs. Leebody)—J. Groves.
37	Armagh	Common in Lough Neagh '92—P.
38	Down	Lough Neagh '98—J. H. Davies.
39	Antrim	Lough Beg '94—P. Frequent in Lough Neagh.

C. connivens Braun.

12	Wexford	Lagoon north of Wexford Harbour '97—E. S. Marshall.

C. aspera Willd.

Type—Divisions all, *except 6, 7, 8, 13, 25, 28, 31, 32, 34, 36.*

var. **capillata** Braun.

21	Dublin	Blanchardstown '89 (Scully)—Groves *349*.

var. **curta** Braun.

15	Galw. SE.	Portumna demesne '81—B. King *465*.

var. **subinermis** Kuetz.

3	Cork W.	Near Lough Hyne '96—J. Groves & R. A. Phillips.
12	Wexford	Lagoon north of Wexford Harbour '96—Marshall *537*.
15	Galw. SE.	Kilcolgan '99—P.
28	Sligo	Lough Gill River '84—B. & V. *112*.
29	Leitrim	Glenade Lough '84—B. & V. *112*.
37	Armagh	Lough Neagh '92—P.
39	Antrim	L. Neagh '84 (Lett)—Groves *345*. Rathlin; Ram's I
40	L'derry	R. Bann below Coleraine '94—P.

var. **lacustris** H. & J. Groves.

38 Down Lough Neagh '98—J. H. Davies.

Also in 16, 27, 36, 37, 39—see Groves *349*. So far as at present known, confined to three lakes, Lough Neagh (where it is abundant), Lough Cullin, and a lake at Roundstone.

sub-sp. **desmacantha** H. & J. Groves.

32 Monaghn. Near L. Naglack '01—G. R. Bullock-Webster.

Also in divisions 7, 8, 10, 11, 14, 15, 16, 17, 18, 19, 21, 23, 24, 25, 26, 27, 28, 29, 30, 33, 38—see *Irish Top. Bot.*

C. polyacantha Braun.

32 Monaghn. Carrickmacross and L. Naglack '01—Bullock-Webster.

Also in divisions 5, 7, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 32, 37—see *Irish Top. Bot.*

C. contraria Kuetz.

Type—Divisions 1, 10, 13, 14, 15, 17, 18, 19, 21, 22, 23, 24, 25, 27, 29, 30, 32, 35, 37, 38, 40.

var. **hispidula** Braun.

Divisions 16, 23, 26—see Groves *349*. Common in the Westmeath lakes: elsewhere at Cong only.

C. denudata Braun.

23 Westmth. Brittas Lake '94—Levinge *485*.

C. tomentosa L.

Divisions 10, 15, 23, 24, 25—see *Irish Top. Bot.* Westmeath lakes and Shannon only.

C. hispida L.

Type—Divisions all, *except 3, 6, 12, 26, 29, 30, 33, 34, 36, 39.*

var. **macracantha** Braun.

Divisions 19 [not 21], 20—see Groves *348*.

var. **rudis** Braun.

7	Tipp. S.	Clonmel '97—P.
8	Limrck.	Adare '99—Somerville. L. Gur, Curragh Chase, '00—P.
9	Clare	Inishmore '91 (Stewart)—Groves *349*.
10	Tipp. N.	Ballingarry, Cloughjordan, Youghal Bay, '00—P.
11	Kilkny.	River Nore above Ballyragget '99—P.
14	Queen's	Graigue '99, Erkina marshes, Portarlington, &c.—P.
15	Galw. SE.	Loughrea and Portumna '98—P.
16	Galw. W.	Clonbur '96—E. S. Marshall.
17	Galw. NE.	Barbersfort '99: very frequent—P.
18	King's	Canal at Edenderry '96—P.
19	Kildare	Levitstown '99, Monasterevan, Maynooth, &c.—P.
21	Dublin	Royal Canal at Lucan '94—P.
22	Meath	Lough Crew and Enfield '96—P.
23	Westmth.	Mullingar '99—P. Knock Drin, Brittas L.—Levinge.
24	Longfd.	Ballymahon '00, Killashee, Priest's Island—P.
25	Roscomn.	Corkip L., R. Suck, '99—P. Common in L. Ree.
26	Mayo E.	Claremorris '00—P. L. Mask—M. & S. *545*.
27	Mayo W.	Derreen '00—P. Ballina '91—A. Somerville.
28	Sligo	Ballysadare '00, Rosses Point—P. Frequent in east.
30	Cavan	Lough Sheelin '96—P.
32	Monaghn.	Carrickmacross district f. '01—G. R. Bullock-Webster.
37	Armagh	About Armagh and Loughgall '92—P.
38	Down	Money Lake '91—P. Loughanisland—*Fl. NE.*

C. vulgaris L.

Type—Divisions all, *except 5, 6, 26, 34, 36.*

var. **longibracteata** Kuetz.

2	Kerry N.	Blennerville '88 (Scully)—Groves *349*.
5	Cork E.	Midleton '72 (T. Allin)—Groves *349*.
7	Tipp. S.	Carrick-on-Suir '00—P.
9	Clare	Co. Clare '95 (N. Colgan)—Groves *355*.
11	Kilkny.	Granny '98—P.
14	Queen's	Mountrath '97—P.
15	Galw. SE.	Kinvarra '00, Portumna '98—P.
17	Galw. NE.	Barbersfort and Ballyloughaun '99—P.
19	Kildare	Hills above Rathmore '98, Carbury '96—P.
20	Wicklow	Base of Great Sugarloaf '94—P.

21	Dublin	Ireland's Eye '95—P. Swords (D. Moore)—*349*.
22	Meath	Oldcastle '96—P.
23	Westmth.	Lough Iron '99—P. Frequent.
25	Roscomn.	Rockville '99—P.
26	Mayo E.	Kilmovee '99—P.
28	Sligo	Rosses Point '97—P. Glencar L. '84—B. & V. *112*.
29	Leitrim	Lough Melvin '99—P.
31	Louth	Greenore '00, Castlebellingham—P. Dundalk—*349*.
32	Monaghn.	Carrickmacross and Moynalty L. '01—Bullock-Webster.
33	Ferman.	Belleek '00—P.
38	Down	Kircubbin '90—P. Near Belfast (Stewart)—*349*.
39	Antrim	Springfield '57 (Hind)—Groves *349*.

var. **papillata** Wallr.

1	Kerry S.	Waterville '89 (Scully)—Groves *349*.
8	Limrck.	Limerick '99—A. Somerville.
11	Kilkny.	Thomastown '98—P.
12	Wexford	North side of Wexford Harbour '96—Marshall *537*.
13	Carlow	Bagenalstown '99—P.
14	Queen's	Near Farmhill '90 (Scully)—Groves *349*.
15	Galw. SE.	Near Portumna '97—P.
27	Mayo W.	Ballina '00—P.

C. canescens Loisel.

Divisions 1, 12, 17—see *Irish Top. Bot.*

For the Irish species of the genera *Tolypella* and *Nitella*, I have no information additional to that given in *Irish Top. Bot.* except the following :—

Nitella tenuissima Kuetz.

23 Westmth. Lough Owel '01—G. R. Bullock-Webster.

N. mucronata Kuetz.

32 Monaghn. Carrickmacross, Lough Naglack, and abundant in Moynalty Lough '01—G. R. Bullock-Webster.

An interesting addition to the Irish flora.

N. flexilis Ag., var. **crassa** Braun.

24 Longfd. Lough Gowna '00—P.

var. **nidifica** Wallm.

25 Roscomn. Lough Allen at Arigna '00—P.
30 Cavan Lough Sillan '01—G. R. Bullock-Webster.
32 Monaghn. Annaghmakerig Lough '00—P.

A very rare variety, its only other British record being Marlee Loch, East Perth (Sturrock, 1882).

I have included in these notes records up to the Spring of 1902. The unequal nature of the records shows how much work is still required among Irish critical plants. An excellent example of the interesting results which will still reward careful field work in the country is shown by Rev. G. R. Bullock-Webster's discoveries in the *Characeæ* of Monaghan, of which he has given an account in *Irish Naturalist*, vol. xi., pp. 141–146, 1902.

III.

ON THE WASTE OF THE COAST OF IRELAND AS A FACTOR IN IRISH HISTORY. By J. P. O'REILLY, C.E.

[Read December 9, 1901.]

Having proposed to myself the examination of certain points relative to the forms and structure of some of the ancient monuments of Ireland, I was led on to the study of the past and present physical geography of the country, as being intimately connected with its history, and, therefore, with that of the peoples to whom certain of these monuments have been attributed. Modern historians show their strong appreciation of this connexion, by the care they take to illustrate by maps and drawings the localities or places wherein or whereat have taken place the events which they treat of, as also in pointing out the changes which have occurred in the localities since the period considered by them in their narration. That this is no easy task has been shown by Sir Charles Lyell in his "Principles of Geology," vol. i., p. 252, where he says:—

"To those whose attention has never been called to the former changes in the Earth's surface which geology reveals to us the position of land and sea appear fixed and stable. It might not seem to have undergone any material alteration since the earliest times of History; but when we inquire into the subject more closely we become convinced that there is annually some small variation in the geography of the globe. In every century the land is in some places raised and in others depressed in level, and so likewise is the bed of the sea. By these and other ceaseless changes the configuration of the Earth's surface has been remodelled, again and again, since it was the habitation of organic beings; and the bed of the ocean has been lifted up to the height of some of the loftiest mountains; the result is in general view insignificant, if we consider how slightly the highest mountain chains cause our globe to differ from a perfect sphere. Chimborazo, though it rises to more that 21,000 feet above the sea, would be represented on a globe of about 6 feet diameter, by a grain of sand somewhat less than $\frac{1}{18}$th of an inch in diameter."

Indeed the great difficulty which meets the conscientious writer of History, at every step, is that of placing the reader in a position to realize as fully as possible the conditions under which the events he narrates have taken place, and that for the particular period he may be treating of. Even correct maps can only represent the present state of the country or ground considered, since accurate surveys may be said to date from the nineteenth century only. As to the geographical delineation of countries previously to that time, one has only to examine the maps of the eighteenth and seventeenth centuries to become aware of their insufficiencies and defects however valuable they may have been at the time or may be still historically. As to restorations, the remarks of Sir Charles Lyell in this respect are well worthy of citation. "The difficulty," he says, "or rather the impossibility of restoring the geography of the globe, as it may have existed at any former period, especially a remote one, consists in this, that one can only point out where part of the sea has been turned into land, and we are almost always unable to determine what land may have become sea" (Lyell's "Principles of Geology," vol. i., p. 255).

As regards Great Britain and Ireland the splendid maps of the Ordnance Survey give us the correct representation of these countries as they are at the present period, and furnish therefore a thoroughly complete and reliable standard by which to judge of the changes that time may bring, or by which to work out what may have been the geography of these countries in former times.

It might be supposed that but few changes can have taken place in the outline or general character of these islands during historical time, and that any such changes, if of any magnitude, would be found recorded in some document or historical work. That many records of such changes exist is certain, but that all have been noticed or recorded is very doubtful. The changes attributable to atmospheric erosion during historic times, are probably on the whole not very great, and have been more or less approximatively estimated by geologists. Those, however, which have been due to the action of the ocean on the coast lines are in certain respects more important and more easily observable. Few great storms from the west, north-west or south-west fail to leave their mark on the coasts somewhere or other; and the steady continuous beat of the Atlantic waves on the rocky headlands and coast lines works their disintegration and removal, slowly it may be, but most effectually. As an example of this action on the east coast of Ireland may be pointed out the coast line between Killiney and Bray, as also that between Bray Head and Greystones, along which considerable extents of the coast are formed by the drift, the surface of which slopes down towards the sea, and seems to have met it at some former period. Forming at present a cliff of more or less altitude, it is being steadily eaten into by the tidal action and waves to such an extent and so rapidly, as to have given cause to the withdrawal of the railway line further inland during the last quarter of the past century, more particularly along the part lying between Bray Head and Greystones; and to have rendered necessary frequent if not incessant, and therefore very costly, defence and embankment work by the Railway Company for the safety of the line (quite lately, January 22nd, 1901, the Chairman of the Company estimated this cost at £18,000). It is to be regretted that such inroads of the sea along our coasts are not more carefully noted, measured, and mapped for future record and information as their total amount must in time become very appreciable.

Besides this steady corrosion of the coasts, especially on those most exposed to the Atlantic waves and storms, are to be counted with, the slow alterations of level which have been noticed in Great Britain, if not in Ireland, during historic time. Hence, it may be inferred that unless land be reformed proportionally to the waste along our coasts arising out of the tidal and wave action and erosion, the superficial area of these countries must be slowly decreasing, and presuming that the same causes have been in action during the past, this area must in former times have been greater than it is at present. This decrease of superficial extent of land is thus noticed in a criticism of "The Reclamation of Land from Tidal Waters," by Alex. Beaseley, M.INST.C.E. (1900), which appeared in *Nature*, vol. 62 (19th July, 1900), p. 266:—

"The area of this country is gradually diminishing by the continual waste that is going on all round the coast. On the Yorkshire coast it is estimated that two miles have disappeared since the Roman occupation, and more modern records show that towns and villages have disappeared with their houses and churches, and in some cases the whole parish has been washed away. Along the Norfolk coast the only record of several villages is 'washed away by the sea,' and on the Kentish coast churches and houses have fallen down the cliffs, on which are to be seen the bones formerly deposited in a vanishing churchyard. On the south coast, although the chalk cliffs at the east end of the English Channel are subject to continual falls and slips, more care has been taken to protect them, but along the clay cliffs of Dorsetshire the waste is continuous; here 20 acres slipped down seaward in one night from the cliffs at Axminster.

"On the west coast the nets of the fishermen are said to become occasionally entangled in the ruins of houses and buildings buried in the sea some distance from the coast of Blackpool."

These considerations would apply still more strongly to the islands which border the western coast of Ireland, and which may be presumed to have been in former times larger and more important than they are at present, as also more numerous. Such greater extent, number, and importance of them in former times, would enter as factors into the question of the advent of man in these countries and of the various colonizations which it gave rise to. It is mainly to geology, and in part to tradition and history, that we must have recourse for evidence of these alterations in the coast line of the country, more particularly as regards former extent. With the aid of the Admiralty maps which furnish reliable data as regards soundings, and which, by the aid of the contour lines in depth, which these soundings enable us to draw, can be indicated the probable extent and nature of the changes, which have taken place in the coast lines of the country as the result of immersion or emersion and general action of the sea. From this point of view the subject has been very fully and lucidly treated by Professor Boyd Dawkins in his work "Early Man in Britain and his place in the Tertiary Period," published in 1880, and from which work the following extracts are taken:—

He opens (p. 3) with the remark: "The continuity between Geology, Prehistoric Archæology, and History is so direct that it is impossible to picture early man in this country without using the results of all these sciences."

(p. 5.)—He states: "Before our ancestors were in Europe, and before our country was an island, there were Palæolithic tribes in Britain, ignorant of the use of polished stone and of metals, without domestic animals, living solely by the chase, fishing, and fowling. Of these, the older or 'river drift men' have left evidence that they wandered over the greater part of western and southern Europe, over North Africa, Asia Minor, and over the whole of India, while the newer or 'cave men' have been traced over a large part of Europe."

(p. 9).—He gives his reasons for starting on his inquiry with the commencement of the Tertiary Period as follows: "In the Tertiary Period each life group is so closely linked to that which went before and followed after, that there is no break of sufficient importance to be used as a starting-point in our special inquiry into the Ancient History of Man. We shall therefore be compelled to treat in outline the principal changes which took place in this country from the beginning of the Tertiary Period down to the time when man first appears on the stage, and to see how they are related to the varying conditions of life on the Continent."

He then gives the following classification of the stages of the Tertiary Period :—

	Characteristics.
I. Eocene; or that in which the Mammalia now on the Earth were represented by allied forms belonging to existing orders and families.	Living orders and families present.
II. Miocene; in which the alliance between living and fossil mammals is more close than before.	Living genera.
III. Pliocene; in which living species of animals appear.	Living species.
IV. Pleistocene; in which living species are more abundant than the extinct. Man appears.	Living species abundant. Man appears.
V. Prehistoric; in which domestic animals and cultivated fruits appear, and man has multiplied exceedingly on the Earth.	Man abundant. Domestic animals. Cultivated fruits.
VI. Historic; in which the events are recorded in history.	Historical record.

(p. 14.)—He says: "The invasion of Europe by the Placental Mammals is the great event which is the natural starting-point for our inquiry into the ancient history of man, since the conditions by which he was surrounded on his arrival in Europe form part of a continuous sequence of changes from that remote period down to the present day."

(p. 18.)—He gives a sketch map (fig. 3) of the geography of north-western Europe in the Eocene Age, and having given the reasons which enabled him to give its outline he says:

(p. 23.)—"From these considerations (zoological, botanical, and geological), Eocene Britain (and Ireland) may be taken to have formed part of a great continent extending north and west to America by way of Iceland and Greenland, while to the north-east it was continuous with Norway and Spitzbergen. It extended also to the south-west across what is now the Channel to join the western parts of France. This great north-western continent or 'Northern Atlantis' as it may be termed, existed through the Eocene and Miocene Ages, offering a means of free migration for plants and animals, and it was not finally broken up by submergence until the beginning of the Pleistocene Age."

(p. 43.)—As regards the continuity with North America he states: "The researches of Professor Heer into the forest vegetation of the Continent, Britain, Iceland, Spitzbergen, Greenland, and Grinnell-land prove that the whole of this portion of the Earth's surface was dry land in the early Tertiary Period, offering free means of migration to plants and animals from the Polar regions into America on the one hand, and into Europe on the other. The 500 fathom line indicates the probable coast line during both Eocene and Miocene, and the rapid increase of depth in the Atlantic to its west would allow of a considerable depression taking place without altering in any important degree the position of the sea margin.

(p. 44.)—" Professor Heer places his ' Atlantis' to the south-west of the line represented in the map (fig. 6), but the enormous depth of the North Atlantic renders it very improbable that there was dry land in that region at a time, geologically speaking, so recent as the Miocene Age " (reference will be again made to this remark further on).

" The principal mountains in the British Isles were in their present positions in the Miocene Age, but were considerably higher, (probably) double what they are now."

As bearing on the fact of the former extension of the land to America and towards the north-east of Europe it is of interest to cite the following note on the "Report of Messrs. Newton and Teall on the Lava sheets of Franz-Josef Land" from *Nature*, vol. 57 (Nov. '97 to April '98), p. 324: " The immense lava sheets that cover an area of some 200,000 square miles in the Deccan of India have been looked upon as the greatest examples of Vulcanism in the world, but an even more extensive outpouring of similar material must formerly have been evident in the northern hemisphere if we can accept the conclusions reached by Messrs. Newton and Teall from a study of the geological collections made in Franz-Josef Land by the Jackson-Harmsworth Expedition (see Quart. Journal Geolog. Soc. December, 1897). That Archipelago is formed of the fragments of an ancient basalt plateau which must have stretched far beyond its present limits. Similar igneous rocks are found in Spitzbergen, Jan Mayen, Iceland, Greenland, the Faröes, the Hebrides, and north Ireland; and the authors are inclined to regard all these areas as the isolated fragments of a formerly continuous land area, the greatest part of which has sunk to form the northern portion of the North Atlantic Ocean. The period of this outpouring was probably the end of the Cretaceous and beginning of Tertiary times. The period seems to have been distinguished by similar occurrences in other parts of the world, for the great lava flows of the Deccan and of Abyssinia are of the same age." " In Auvergne, in the Miocene Period, the volcanoes burst through the granitic and gneissose plateau of central France " (Geikie, " Text-book of Geology " (1893), p. 203).

(p. 66.)—Boyd Dawkins says: "There is no proof of the presence of man in Europe during the Miocene Age."

In this respect it may be worth citing the following from an article in the *Nineteenth Century*, "On the Cradle of the Human Race," by Samuel Waddington:—

"Others see reason to believe that there is little or no doubt that the human race has existed on the face of the Earth for more than one million or even two million years.

"Darwin, it will be remembered, was of opinion that man may have existed in the Eocene Period; while Mr. Wallace holds (*Nineteenth Century*, 1887) that he certainly did exist in that period. Professor Huxley also appears to have held this view, for he observes that the first traces of the primordial stock whence man has proceeded need no longer be sought by those who entertain any form of doctrine of progressive development in the newest Tertiaries, but that they may be looked for in an epoch more distant from the age of the *Elephas primigenius* (Mammoth) than this is from us."

"The remoteness of the date," observes Sir John Evans, "at which the Palæolithic Period had its beginning almost transcends our power of imagination"; and Professor Ratzel in his "History of Mankind," states that a regular workshop for the manufacture of chert flakes which was discovered on the banks of the Mississipi in Minnesota, dates from the Interglacial Era, and that hunters chased the long-extinct beasts of the Drift Age in Mexico and in Argentina.

He (Mr. Waddington) asks, "But how long ago is it since the commencement of the Eocene Period?" and taking into consideration the statements of Lord Kelvin as to the probable time since the solidification of the Earth, he says: "The date of the beginning of the Eocene Period cannot therefore be estimated at less than four million years before the present time.

"When the great Mastodon, now in the British Museum, was found by Dr. Kock in the Ossage Valley, Missouri, a number of stone arrowheads and charcoal were found near it, and one of the arrowheads lay underneath the thigh-bone of the Mastodon, and in contact with it. The animal was found, it will be remembered, at a depth of 20 feet under several alternate layers of loam, gravel, clay, and peat, with a forest of old trees on the surface."

(p. 72.)—Boyd Dawkins sketches out the Geography of Britain (and Ireland) in the Pliocene Age (fig. 10), and says: "The North Sea, which was small in the Miocene age, and did not touch our present coast line, was now gradually enlarged at the expense of the land, and ultimately a direct communication was made with the Arctic Sea, by the sinking of the land, extending from the Scandinavian

Mountains to the British Isles, to Iceland and Greenland on the one hand, and to Spitzbergen on the other."

This depression by which the Arctic became continuous with the North Sea, caused it also to become connected with the Atlantic.

(p. 73.)—He says: "The Atlantic line at that time may be taken to be marked by the steep slopes passing downwards from the 100 fathom line, to the 300 or 400 fathom line, which imply that a land barrier was in that position for a very long period.

"It would make very little difference in the map of Pliocene Britain (and Ireland) if we were to take the western coast line to be marked by the 300 fathom instead of the 100 fathom line."

(p. 75.)—He shows the evidence of icebergs at that period off the coast of Great Britain, and the submergence of the tract of land uniting Ireland with the continent of Miocene Europe, by which currents of cold water from the Polar regions obtained free access to the North Sea of the Pliocene Age, from which they had been before shut out by a barrier of land.

(p. 93.)—He states that, as evidence stands at present, the Geological record is silent as to man's appearance in Europe in the Pliocene age.

(p. 94.)—Speaking of the Pleistocene Age, he says: "New Mammals now appear belonging for the most part to living species. Their remains were associated with human implements in such a manner as to show that man was a member of the fauna which characterises the Pleistocene Period of this quarter of the world."

(p. 110.)—Describing the great geographical and climatal changes of the period, he says: "Britain must also have formed part of the mainland. Ireland must also have been united to Britain, to have allowed of the groups of animals (mentioned by him) finding their way so far to the west. The elevation above the present sea-level necessary to account for this distribution of the animals, is not less than 600 feet or 100 fathoms" (fig. 24). The Straits of Gibraltar could not have been in existence when the African elephant ranged as far north as Madrid, and the Caffir cat, African Lynx, and spotted Hyæna sought their prey in the Iberian Peninsula.

(p. 112.)—He says: "From these considerations, it is evident that Pleistocene Europe must be looked upon as intimately connected with Africa on the south, and with Asia on the east, and that it offered no barriers to the migration of Asiatic and African animals as far to the west as Britain and Ireland."

(p. 113).—He says: "From the distribution of the Pleistocene Mammals, we may infer that the climate was severe in the north and warm in the south; while in the middle zone, comprising France, Germany, and the greater part of Britain, the winters were cold and the summers warm, as in Middle Asia and North America. There were secular changes of climate in Pleistocene Europe, and while the cold was at its maximum, the Arctic animals arrived at their southern limit; and while it was at its minimum, the spotted Hyæna, and the Hippopotamus, and other southern animals roamed to their northern limit."

The climatal and geographical changes which then took place in Britain were marked by Glacial phenomena, which are summarized as follows:—

(p. 115.)—"(1) *The first Glaciation* was a period of elevation."

(p. 116.)—"The ice at that time was sufficiently thick to have overridden Schihallion in Perthshire, at a height of 5500 feet, and the hills of Galway and Mayo at 2000 feet."

(p. 117.)—"(2) *The Icebergs*—A period of depression.

"(3) *The depression continued.* The glaciers disappeared, and the sea beat upon an archipelago of islands, which gradually sank beneath the sea to a depth of from 2300 feet below their present level on the flank of Snowdon, to 1200 feet at Vale Royal, on the road between Buxton and Macclesfield, and to about 1400 feet in Scotland.

"(4) *A reversion to a severe climate.*

"(5) *Period of elevation.* The climate becoming temperate, there followed an upward movement of the land, until the Upper Boulder Clay became dry land, and Britain and Ireland became part of the mainland of Europe as represented in the map (fig. 32). The climate was less severe than in the preceding period, and was gradually again becoming temperate.

"As the Upper Boulder Clay deposited on the sea bottom became lifted up, it was gradually covered by forests of yew, Scotch fir, oak, ash, and alder, in which the Pleistocene Mammalia found ample food in the eastern and midland counties."

As regards the Glacial Period in Great Britain and Ireland, it may be well to cite here the opinion of the eminent geologist, Professor Lapworth, given in his "Intermediate Text-book of Geology," 1899.

(p. 385.)—"That the glacial conditions of Britain and Western Europe were accompanied by a certain amount of depression is generally acknowledged, but whether that depression was excessive and general, and was broadly coincident with the Middle Glacial times, or whether it was relatively insignificant, repeated, and local, is yet a matter of dispute."

(p. 125.)—Boyd Dawkins says: "In all probability the geographical conditions of Britain and Ireland at the time of the River Drift (Pleistocene) Hunters, were identical with those of the Late Pleistocene (fig. 32, p. 150), when our country formed part of the Continent.

(p. 148.)—"The remains of the late Pleistocene animals lie scattered over a large area in Britain, and it is necessary to conclude, from their presence, that our country formed part of the mainland of Europe at that time."

(p. 150.)—"The Geography of Great Britain (and Ireland) in the late Pleistocene Age is indicated by the map (fig. 32, p. 150)"; and he says:—

(p. 151.)—"It may be concluded that Britain (and Ireland) stood at least 600 feet above its present level, and so that the Severn R. united its waters with the rivers of the south of Ireland."

(p. 152.)—He then defines the *Range of the late Pleistocene Mammals over Britain and Ireland*:—"In Ireland the Mammoth has been found in the Counties of Cavan, Galway, Antrim, and Waterford, and in the Shandon cave near Dungarvan, in the last of these counties along with the grizzly bear, wolf, fox, horse, stag, and alpine hare. This irregularity in the distribution of the animal remains is intimately connected with the geographical and climatal changes which were going on in the obscure and complicated portion of the late Pleistocene Age, known as the *Glacial Epoch*, and it is highly probable that all the Irish Mammalia mentioned above are pre-Glacial."

(p. 153.)—"We must further realise that all the climatal and geographical changes known as Glacial, happened while the Late Pleistocene Mammalia were living in the regions not covered by glaciers, or overwhelmed by the sea, and that they wandered to and fro, as the barriers to their migration were altered."

(p. 169.)—He says: "The Palæolithic Hunter of Mid and Late Pleistocene River deposits in Europe belongs to a fauna which arrived in Britain before the lowering of the temperature produced glaciers and icebergs in our country. He may therefore be viewed as being *probably pre-Glacial*. When the temperature was lowest, he probably retreated southwards, and returned northwards as it grew warmer, precisely in the same manner as the Mammalia on which he depended for food."

(p. 171.)—"It may therefore be concluded, he says, that man was probably pre-Glacial and Glacial in Europe, but was certainly post-Glacial in the area of the North Thames."

It may be worth while to cite here the views put forward by Lapworth, in the work already cited on the Glacial Period.

(p. 352.)—"During the last half century, abundant evidences have been obtained of the existence of man as far back as the final stages of the Glacial period; and the glacial and post-Glacial formations have consequently been separated off from the Tertiary, and erected into a distinct series by themselves, which has been termed the *Quaternary*, while the period of Geological time which they represent, has been denominated *Anthropozoic*."

(p. 378.)—"The recent deposits were formerly referred to as the *Human*, as it was supposed that they alone afforded evidence of the existence of man, but the discoveries of late years, have made it clear that man existed in Pleistocene times, at any rate, in the later stage of the epoch, if not throughout the whole."

As bearing on this question, it may be of use to cite here the opinions of the eminent French geologist, de Lapparent, as stated in the last edition of his "Traité de Géologie," vol iii., 1900, in his critical review of the general characteristics of the Tertiary Era.

(p. 1632.)—He considers the question of the *Establishment and Vicissitudes of the great Glaciers*, and says:—"It would seem that independently of a first or primary Pliocene phase, there were, as well in America as in Europe, two other great Pleistocene phases of extension of the glaciers. These phases were separated by intervals of time, during which the climate was at least as favourable as at present, and the surface of the land became clear of ice, even into the very hearts of the mountain valleys. The greatest extension took place anteriorly to the development of the Palæolithic civilization which made its appearance during inter-Glacial Periods, when the *Elephas primigenius* commenced to associate with the *Elephas antiquus*.

"The first mentioned species, accompanied by a fauna, on the whole of a colder climate than the previous one alone, was in existence during the succeeding extension to which followed, even if it did not accompany in part, the deposit of the great *Loës*. At that time a period of dry cold supervened to interrupt the active flow of the rivers. Man then took refuge in the caves and under rock-shelters, whilst in the meantime became developed in our part of Europe, first the *Equidæ* and then the *Reindeer*, an animal known to dread fogs whilst supporting easily dry cold.

"Before the end of the 'Magdalenian Civilization' characteristic of the period, the humidity of the atmosphere reappeared, without however being accompanied by any earth movements sufficiently marked to have given rise to renewed energy in the erosive action of the water-courses.

"The Reindeer was almost completely driven north, and the Neolithic civilization came into existence everywhere. It is probable however, that the phenomena were more complicated, and that in addition to the great Glacial Periods already indicated, it would be proper to add intermediate phases, since every day's experience more strongly causes it to be recognised that the relations between the morainic deposits is more or less complicated."

(p. 1634.)—He says: "It is therefore logical to admit that successive movements of emersion of the continents which took place suddenly (par saccade), marked the phases of the activity of the water-courses."

Discussing the *probability of a rapid transition from the age of the Reindeer to that of the Turfbogs,* he says: "Whatever may have been the exact course of events in our part of Europe, the transition from the regimen of great water-courses, to that of the reindeer, must have taken place rapidly. Otherwise, the rivers which at first carried only coarse gravel, would have little by little filled up their principal channels with silt, as has been justly remarked by Belgrand. On the contrary, the principal channels which during the Pleistocene Epoch hardly sufficed to carry the river floods, must have been dried up suddenly, thus laying bare the horizontal surface of gravel over which a thin stream continued to meander. Consequently, when later on, a sufficiently humid regimen reappeared, it was the peat which undertook to fill up the main water-courses, wherever the permeability of the slopes secured for the rivers a regimen exempt from violent floods. With the bogs commences the actually existing regimen. During the period of dry cold, the fauna of the Mammals was that of the Siberian steppes. The humidity of the age of the bogs by favouring the development of timber, determined the incoming of a forest fauna. The temperature henceforward undergoes but slight vicissitudes, and with the exception of some alternations of invasion and retreat of the sea in the Flemish regions, the contours of the continents have become fixed, and the story of succeeding events belongs rather to Archæology and to History than to Geology."

At p. 247 of his work already cited Boyd Dawkins says: "*The*

Pre-Historic Period covers all the events which took place between the Pleistocene Age on the one hand, and the beginning of history on the other."

(p. 248.)—He says: " The Pre-Historic Period is separated from the Pleistocene by a long interval, during which not only great changes in the zoology of Great Britain (and Ireland) took place, but also corresponding changes in the geography.

" At the close of the Pleistocene Age (fig. 32), the valleys which united Britain to North France, Germany, and Scandanavia, as well as to Ireland, were gradually depressed beneath sea level, and the North Sea, the British Channel, the Irish Sea, and the Western Atlantic Coast line generally, became very much as we find it now (see fig. 95, p. 254). An examination, however, of the submerged forests and peat bogs, proves that the downward movement *had not ceased until a late period in the Neolithic Age*."

(p. 250.)—He shows that, "In West Somerset and at Minehead, we may infer that man was living in this region during the time that a dense forest overshadowed a large portion of what is now the British Channel, and before the deposit of the blue fresh-water clay, and the marine silt, at a time not later than that marked by the layer of peat or vegetable soil in which the prostrate trees are embedded."

(p. 251.)—"The submerged forests are merely scraps spared by the waves of an ancient growth of oak, ash, and yew, extending in Somersetshire underneath the peat and alluvium, and joining the great morasses of Glastonbury, Sedgemoor, and Athelney, in which Neolithic implements have been met with by Mr. Stradling.

" In Torbay as well as in North Devon and Somersetshire, man was in possession of the country when the land stretched farther out to sea than at the present time. In this particular case (Torbay), Mr. Pengelly estimates the submergence to have been not less than 40 feet, since the forest was alive."

Similar proofs of submergence are to be met with on our coasts, wherever the land dips gently under the water-line.

(p. 253.)—He says: "It is worthy of remark that the enormous, trunks of the trees prove that the Scotch firs, oaks, yews, willows, and birches, of which the forest was in these places mainly composed, must have grown at some distance from the ancient coast line, since the westerly winds sweeping over Lancashire from the Atlantic at the present time prevent the free growth of vegetation on every unprotected spot on the coast. The prevalent winds, however, are proved to have been very much the same, since then as now, by the position of the trees, which lie prostrate, with their heads pointing towards the east.

"The depression of land throughout Great Britain and Ireland since the trees flourished could not have been less than from 30 to 40 feet. The ten-fathom line, therefore, considered by Sir Hy de la Bèche to be roughly the boundary of the land at that time, may be taken to represent the sea margin (of that time) with tolerable accuracy."

(p. 254.)—"This forest growth is proved to belong to the Neolithic division of the Pre-Historic Period by the presence of animals originally domestic, and introduced by the Neolithic tribes, the Celtic short-horn, and the sheep or goat, as well as by the absence of the Pleistocene Mammals."

(p. 256.)—He cites Dr. Jas. Geikie's work on the geography and climate of North Britain:—"When these buried trees darkened the now bleak islands (Orkneys and Shetland) with their greenery, the land stood at a higher level and the neighbouring ocean at a greater distance. To have permitted this strong forest growth we are compelled to admit a former elevation of the land, and a corresponding retreat of the ocean.

"The same inference may be drawn from the facts disclosed by the mosses of Ireland and England. On the coasts of France and Holland peat dips under the sea and along these bleak maritime regions of Norway, where now-a-days the pine tree will hardly grow, we find peat mosses, which contain the remains of full-grown trees, such as are only to be met with in districts much further removed from the influence of the sea." (See "Great Ice Age," c. xxvi.)

(p. 263.)—He says: "Such changes in the Mammalia and in the geography of Great Britain (and Ireland), in the interval separating the Pleistocene from the Pre-Historic Period, *could not have taken place in a short time*; and when we reflect that comparatively little change has taken place in this country during the last 2000 years, it is obvious that the one period is separated from the other by a lapse of many centuries, of how many we cannot tell."

(p. 265.)—He says: "It may be concluded that the former period was, beyond calculation, longer than the latter."

(p. 482.)—He says: "Britain, at the beginning of the historic period, differed considerably from the Britain of to-day, although there is no reason to suppose that any vertical movements have altered the relation of sea to land. The dash of the waves for the last 1900 years has destroyed large tracts of land, where cliffs are composed of soft and incoherent materials. The inroads of the sea on the south coast have been so great, in some places, such as Pevensey and Payham, in Sussex, that it is by no means improbable that the Isle of Wight may have been united at low-water to the adjoining coast during the Roman occupation. (It was an island in the days of Claudius)."

(p. 483.)—He says : "The rainfall, at the beginning of the Historic Period in Britain, must have been greater than it is now, because of the large extent of forest and morass. The surface of the country was densely covered with trees."

(This relatively greater rainfall may be taken as implying, amongst other causes, a relatively greater height of the mountain parts, in the interior, since such greater height would necessarily favour a greater amount of condensation, and, consequently, of rainfall).

These many extracts from Boyd Dawkin's work, and from the other authors mentioned, show us not merely the former varied geographical conditions of Great Britain and Ireland, relatively to the Continent and to one another, but also allow us to appreciate the immense interval of time that must have elapsed since the commencement of the Tertiary Period, and consequently how very small the Historical Period must appear in comparison therewith, and therefore how valuable all the data that can be collected either in the form of traditions, or as observations and historical records relative thereto. The early traditions regarding this country, which appear in O'Flaherty's "Ogygia" and in the "Annals of the Four Masters," merit, in this respect, careful and considerate attention.

Thus the commencing lines, "The age of the world to this year of the Deluge, 2242: Fifty days before the Deluge, Cæsair came to Ireland with fifty girls and three men; Bith, Ladhra, and Fintain, their names."

This passage, which is fully commented on in the notes to O'Donovan's edition, from the purely scholarly and literary point of view, is capable of assuming another aspect if taken in connexion with the series of submergencies of lands and islands, which formed part of the great northern continent, or group of islands, considered in the Report of Messrs. Newton and Teall, "On the Lava Sheets of Franz-Josef Land," already referred to. Ireland was evidently affected by the series of volcanic movements, which seem to have lasted from the Miocene Period onward, and of which series Iceland is still an important and active centre. It may be, therefore, that the "Deluge" referred to in the Annals represents the echo of a tradition from Pre-Historic times of one of these sudden and catastrophic volcanic movements (such as that of Krakatoa in 1883) which affected Ireland and gave rise to a remarkable depression which, if sudden and accompanied by a series of tidal waves from the ocean, might well be tantamount to a deluge. One has only to read of the recorded appearance and destructive effects of such waves in modern times to recognise how truthfully they are described as "Deluges," particularly by the survivors who have witnessed the catastrophe and suffered from it. The details given in the Annals as to the places of their deaths and interments rather tends to prove that the "Deluge" was not such as to have prevented people from surviving and living on the island, which so far favours the supposition of a sea-wave or subsidence with sea-wave. Too much stress cannot be laid on this view of the question, since it bears a certain relation to the submersion of the Island of "Atlantis," as mentioned by Plato, and the two together might be taken as connecting links in that chain of events implied by the breaking-up and submersion of different parts of that Great Lava Plateau spoken of in Messrs. Newton and Teall's report. It is further interesting to note that a series of modern archæological discoveries, resulting from the excavations so successfully and scientifically carried out in Egypt and in Asia Minor, as also in Mesopotamia, and now being actively pursued in many other quarters of the East, have resulted in pushing back the record of time so, that already dates of 7000 B.C. are spoken of, and we may well foresee that further researches will in not many years hence push the antiquity of human records back to 10,000 B.C. There even appears in the *Scientific American* Supplement of January 26th, 1901, p. 20960, an article entitled "Archæology in the Past Century," by Prof. W. M. Flinders Petrie, D.C.L., LL.D., of University College, London, in which he says:—

"We, therefore, have passed now at the end of this century to a far wider view of man's history, and classify his earlier ages in Europe thus:—

(1st). *Eolithic*—Rudest massive flints from deposits 600 feet up.

(2nd). *Palæolithic*—Massive flints from gravels 200 feet up and less; (*Achulien*).

(3rd). ,, Cave-dwellers, flints like the preceding and flakes; (*Moustérien*).

(4th). ,, Cave-dwellers, flints well worked and finely shaped; (*Solutrien*).

(5th). ,, Cave-dwellers, abundant bone-working and drawing; (*Magdalénien*).

(6th). *Neolithic*—Polished flint working; pastoral and agricultural man.

"What time those periods cover nothing yet proves. The date of 4000 B.C. for man's appearance, with which belief our century started, has been pushed back by one discovery after another. Estimates of from 10,000 to 200,000 years have been given from various possible clues. In Egypt an exposure of 7000 or more years only gives a faint brown tint to flints, lying side by side with Palæolithic flints that are black with age. I incline to think that 100,000 B.C. for the rise of the (2nd) class and 10,000 B.C. for the rise of the (6th) class will be a moderate estimate."

Thus the period of time stated to have elapsed since the submersion of the Atlantis Island, as mentioned by the Egyptian Priest to Solon, according to Plato's narrative, was 8000 years before his time; this up to the present, has been treated as fabulous and as throwing discredit on the statement, but it now becomes not merely credible, but harmonises with the date which Flinders Petrie assigns for the (6th) period above-mentioned of Human History, that is about 10,300 years ago. It is of importance to point this out, since the submersion of the Atlantis Island may, as already stated, be but one of a series of volcanic and seismic movements in the Great Lava plateau of North Western Europe, having been marked by immersions of parts of the plateau, the formation of islands, the further immersion and destruction of these with accompaniment of great tidal waves comparable in their destructiveness to deluges as already stated.

In connexion with this question there is room for citing the work of Sir Jos. Prestwich, "On certain phenomena belonging to the close of the last geological period, and their bearing upon the tradition of the Flood" (1895). He says (p. 72): "In any case these tentative estimates, are in accordance with the conclusion I have arrived at on other grounds, that the Glacial (including the post-Glacial) Period, together with Palæolithic man came within 10,000 to 12,000 years of our time."

Assuming, as argued by Boyd Dawkins, and as indicated by his map (fig. 32), that at the close of the Pleistocene Age, Great Britain and Ireland were still in connexion by land one with the other, and with the continent of Europe, and that subsequently a series of depressions intervened which resulted in the isolation of these countries, it is reasonable to accept that these changes took place relatively slowly and successively, and that they were contemporaneous with changes in the Atlantic coast line, probably in connexion with the volcanic phenomena of the Icelandic, Greenlandic, and Franz-Josef group, all which had for result the present general coast outline of these countries.

It may be asked would the 100 fathoms line as supposed by Boyd Dawkins truly or approximatively represent this Atlantic coast line at the end of the Pleistocene time? and are there not grounds for admitting the existence of a more extended western land and of adjacent islands, which could have afforded the shelter necessary for the forests which covered these countries prior to the growth of the bogs.

This query is in some degree met by the results pointed out in an article by Dr. Reusch in "Naturen," cited in *Nature*, vol. 63 (Dec. 13th, 1900), p. 160, in which he calls attention "to the changes of level that have taken place in Iceland in recent geological times viz. since the Ice Age." He says: "In 1896 the Danish Ingolf Expedition investigated the sea bottom between Jan Mayen and Iceland. In examining the dredged material Herr A. S. Jansen made the observation that almost everywhere on the bottom of the deep ocean lie shells of dead Molluscs of well-known shallow-water forms, side by side with deep-water forms. It was very remarkable to dredge up from depths of 500 fathoms to 1300 fathoms *Yoldia Arctica* which now lives at Spitzbergen, and in the Kara Sea at depths from 5 to 100 fathoms. Dr. Reusch suggests that these remains of Arctic life forms cannot have been carried there by drifting ice, but that the sea bottom, in comparatively recent times during the Ice Age, must have been much nearer the sea level than now. At that time the Arctic shallow-water forms must have lived there '*in situ*'; then a sinking of the sea bottom has taken place which can be estimated at not less than about 2500 metres (about 1355 fathoms). It is easy to see that these results of the Danish naturalist have an important bearing upon the phenomena of the Ice Age." It is evident that from these results, there may be presumed a much greater extension of the Western European plateau and of its resulting islands than Boyd Dawkins was prepared to admit. Whatever the chain of events was that gave rise to the depression of the land, it is reasonable to assume that the causes thereof were more active on the Atlantic side of Ireland than on the eastern coast, and that the surface of land affected thereby was more extensive. The breaking up of the land and accompanying island groups during the Pre-Historic Period necessarily occupied a considerable time, and allows us to admit that from the coast of Spain, northwards to Ireland, and even farther, a great number of islands, more or less inhabited, and of greater or less extent, existed during a certain time, and had not finally been worn away and submerged in the Atlantic before the dawn of Irish traditional history. Thus we see room for the tradition of the Island of Brazil (with reference to which a very interesting paper was published in the Royal Dublin Society's Proceedings, N. S., II. 1880, p. 173) and for a Rockall far more prominent and extended than the present island, which now can hardly be approached, so bold and precipitous are its coasts.

As to the probable existence of other islands in the North Atlantic, we can only arrive at a conclusion relative thereto by the aid of a bathymetric chart of that ocean (that is, a chart coloured according to the relative depths by means of contour lines of equal depth), and keeping in mind the remarkable conclusions arrived at, in Dr. Reusch's article already cited.

As regards the coast of Ireland in general, and the changes they have undergone during past ages, the only data that can at present be availed of, are the records of the various Geological Surveys made of them, and of the parts of the coasts of Great Britain which are as fully exposed to the action of the Atlantic waves and storms as are the Irish coasts, as well as of the adjacent island groups, the Hebrides, the Faroë, Orkneys, and Shetland groups. Certain descriptions of the maritime counties both in Ireland and in Great Britain also furnish observations and have been availed of. These records have up to the present not been brought together and presented in a collected form, and in the present paper it is proposed to so present them as a basis for a more complete recension of all the data bearing on the question of the wear of the Irish coasts. As in regard to many parts of the Irish coast, the data are meagre, if not entirely wanting, while for much of the coasts of Scotland, Wales, and England such data are available in greater or less sufficiency, it has seemed reasonable to employ these data when concerning parts of the coasts which are directly exposed to the Atlantic Ocean; since it is evident that whatever has been the destructive action of the waves and storms upon these, it cannot be supposed to have been less on those parts of the coasts of Ireland which are more directly and more immediately exposed to the full action of the Western Ocean storms. Hence the indications existing as regards the wear on the Scotch and Cornish coasts can to a certain extent make up for the meagreness or absence of details as regards the western, north-western, and south-western coasts of Ireland.

Sir Charles Lyell's "Principles of Geology" (1872) supply some very valuable information in these respects, offering excellent terms of

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comparison for an appreciation of the wear that these coasts have undergone, and consequently merit detailed citation. Under the heading "*Destroying and Transporting Power of Currents*" and subheading "*Action of the Sea on the British Coast, Shetland Islands, &c.*," he says (p. 507, vol. i.): "The northmost group of the British Isles, the Shetlands, are composed of a great variety of rocks, including granite, gneiss, mica schists, serpentine, greenstones, and many others, with some secondary rocks, chiefly sandstones and conglomerates. These islands are exposed continually to the uncontrolled violence of the Atlantic, and no land intervenes between the western shores and America. The prevalence therefore of strong westerly gales causes the waves to be sometimes driven with irresistible force upon the coast, while there is also a current setting from the north. The spray of the sea aids the decomposition of the rocks and prepares them to be breached by the mechanical force of the waves. Steep cliffs are hollowed out into deep caves and lofty arches; and almost every promontory ends in a cluster of rocks, imitating the forms of columns, pinnacles, and obelisks."

(p. 509.)—"In some of the Shetland Islands, as on the west of Mickle Roe, dykes or veins of soft granite have mouldered away, while the matrix in which they are enclosed, being of the same substance but of a firmer texture, have remained unaltered. Thus long narrow ravines, sometimes 20 feet wide, are laid open, and often give access to the waves."

After describing some huge cavernous apertures, into which the sea flows for 250 feet at Lœness, Dr. Hibbert, writing in 1822, enumerates the other ravages of the ocean: "But the most sublime scenes are where a mural pile of porphyry, escaping the process of disintegration that is devastating the coast, appears to have been left as a sort of rampart against the inroads of the ocean. The Atlantic, when provoked by wintry gales, batters against it with all the force of real artillery, the waves having in their repeated assaults forced themselves an entrance. This breach, named the Grind of Naver (fig. 47) is widened every winter by the overwhelming surge that, finding a passage through it, separates large stones from its sides, and forces them to a distance of not less than 180 feet. In two or three spots the fragments which have been detached are brought together in immense heaps, that appear as an accumulation of cubical masses, the product of some quarry" (Hibbert, "Description of the Shetlands." Edin., 1822).

"There are localities in Shetland in which rocks of almost every variety of mineral composition are suffering disintegration. Thus the sea makes great inroads on the clay-slates of Fitfel Head, on the serpentine of Vord Hill, in Fetlar, and on the mica schists of the Bay of Trieste, on the east coast of the same island, which decomposes into angular blocks. The Quartz Rock, on the east of Walls, and the gneiss and mica schist of Garthness suffer the same fate."

(p. 511.)—Lyell says, under the heading "*Destruction of Islands*": "Such devastation cannot be incessantly committed for thousands of years without dividing islands, until they become at last mere clusters of rocks, the last shreds of masses once continuous. To this state many appear to have been reduced, and innumerable fantastic forms are assumed by rocks adjoining the islands, to which the name 'Drongs' is applied, as it is to those of similar shape in Feive. The granite rocks (fig. 48) between Papa Stour and Willswick Ness afford an example; a still more singular cluster of rocks is seen to the south of Hillswick Ness (fig. 49), which presents a variety of forms as viewed from different points, and has often been likened to a small fleet of vessels with spread sails. Midway, between the groups of Shetland and Orkneys, is Fair Island, said to be composed of sandstone, with high perpendicular cliffs. The current runs with such velocity that during a calm, when there is no swell, the rocks on its shores are white with the foam of the sea driven against them.

"The Orkneys, if carefully examined, would probably illustrate our present topic as much as the Shetland group. The north-west promontory of Sanda, one of these islands, has been cut off in modern times by the sea, so that it became what is now called Start Island, where a lighthouse was erected in 1807, since which the new strait has grown wider."

As regards the Orkneys, the following is taken from the *Ordnance Gazetteer of Scotland*, under that head:—

"Except in the Pentland Firth, where the depth of the sea reaches 40 fathoms, the water in the straits between the islands and their immediate neighbourhood is nowhere deeper than 20 fathoms; a rise of 120 feet in the sea-bottom would unite the whole group, except Sivona and the Pentland Skerries, into one mass of land, which would be separated from the mainland of Scotland by a strait of from 2 to 3 miles broad, where the Pentland Firth is. If these sounds are, however, of moderate depth, their number and the broken and winding outline of the coast are evidences of the hard struggle that constantly takes place between the land and the Atlantic surge."

"The intricate, indented coast-line, worn into creeks, and caves, and overhanging cliffs—the crags, and Skerries, and sea stocks, once a part of the solid land, but now isolated among the breakers—the huge pile of fragments that lie on the beach, or have been heaped up far above the tidal-mark—tell only too plainly how vain is the resistance even of the hardest rocks to the onward march of the ocean. The rate of waste along some parts of those islands is so rapid as to be distinctly appreciable within a human lifetime. Thus the start-point of Sanda was found by Mr. Stevenson, in 1816, to be an island every flood tide; yet, even within the memory of some old people then alive, it had formed one continuous tract of firm ground. Nay, it appears that during the ten years previous to 1816 the Channel had been worn down at least 2 feet.

"Some few years back (about 1874), when the Channel fleet were in the north, they attempted to pass to the westward through Westray Firth, in the teeth of a strong spring flood; but all the Queen's horse-power and all the Queen's men could not do it, and they had to turn tail.

"Short storms of great violence are not the worst, being surpassed by the long continuance of an ordinary gale, and during great storms the devastation and ruin is very great. During a peculiarly severe storm, in 1862, in Stornna (in Caithness), in the Pentland Firth, the sea swept right over the north end of the island, lodged fragments of wreckage, stones, seaweed, &c., on the top, 200 feet above ordinary sea level, and then rushed in torrents across the island, tearing up the ground and rocks in their course towards the opposite side. The heaviest rains and the most prevalent and strongest winds are from the south-west and south-east."

As the west coast of Ireland is largely made up of the same classes of rocks as those forming the Hebrides, the Shetlands, and the Orkneys, and is more fully and directly exposed to the force of the Atlantic waves, it is reasonable to assume that all that has been herein stated as to the destructive force of the ocean on these islands holds good, even more strongly, as regards the western coast of Ireland—the "Wild West," as it has been called—and we may admit that wear and waste is going on there incessantly, even although we have no observations in support thereof.

As regards the coast of Britain, from the coast of Wales southwards, more has been observed and noted, and the resulting wear recorded would tend to show what must have been the waste along the south-western and southern coasts of Ireland, even although we had no records regarding them.

There is a very interesting article, by D. Mackintosh, Esq., F.G.S., in the *Quart. Journ. of the Geolog. Soc. of London*, vol. xxiv., 1868,

p. 279, "On the mode and extent of the encroachment of the sea on some parts of the shores of the Bristol Channel." He says: "In a paper read before this Society, November 8, 1865 (see vol. xxii., p. 1), Mr. Goodwin Austin brought forward very satisfactory reasons for concluding that the area of the Bristol Channel was dry land during the (now submarine) Forest Era, and that it must afterwards have subsided to a depth of at least 120 feet, as a submerged land is now found at that depth under the sea level. Whatever relative changes in level the land and sea may have subsequently undergone, it is obvious that the general tendency of the "waves" and "ground sea," or "Atlantic drift," which is sensibly felt beyond Watchet (18 miles west of Bridgewater), has been to destroy the contour of the gradually rising shores by wearing them back into cliffs. As a consequence, the extent of the encroachment since the forest area went down may in some localities be approximately ascertained."

He then gives a section of the coast-line near Watchet, and examines the relation of the cliffs to the exposed shore, and says: "It will be obvious that the sea has recently had no small share in the denudation of the Bristol Channel, whatever may have been the cause of the original excavation."

As evidence of the "recent rate of encroachment, he says: "I learned from a very old fisherman at Watchet, whose veracity no one seemed to doubt, and whose statements concerning the encroachments of the sea were directly or indirectly corroborated by others, that not more than 150 years ago a brewery, belonging to a Mr. Davies, stood at a distance of at least 200 yards from the present cliff, east of Watchet harbour, and that the rocks under its site are still recognised. There was likewise a village (or hamlet?) called Easenton, to which the fisherman's great-grandfather was in the habit of going for a mug of beer, the site of the furthest east part of which is now about one-fourth of a mile from the coast."

He adds a note: "I found the following record among the documents of a solicitor of Williton:—'North of Racloze, a part of Watchet in 1662, a barn and other buildings, with orchard and garden beyond; in 1751, all gone to sea.' To the west of Watchet the sea is encroaching on a high ridge and undermining large blocks of sandstone, interwoven with alabaster, which it carries away entirely, or scatters and piles in a strange confusion. The configuration of the sea-bed, under and for some distance from the cliffs, very much resembles the uneven ground at the base of many inland escarpments."

(p. 281.)—"*Encroachments on Weston-super-mare.*—The sea is converting slopes into cliffs, where it is not silting up flat areas from Brean Down to a considerable distance northwards. Near Weston the sea is forming a line of cliffs on the north-western side of Weorle Hill. At Bernbeck cove its encroachments have disclosed, or rather nearly destroyed, the last remnants of a genuine raised beach."

Professor John Rhys, M.A., of Oxford, in his "Celtic Folklore of Wales and Isle of Man," has some interesting legends as regards the waste on the Welsh coast, in vol. ii., p. 401, under the heading, "*Triumphs of the Water World.*" He says: "More than once in the last chapter was the subject of submersions and cataclysms brought before the reader, and it may be convenient to enumerate here the most remarkable cases, not to mention that one of my informants had something to say (p. 219, vol. i.) of the submergence of Caer Arianrhod, a rock now visible only at low-water between Celynnog Fawr and Dinas Dintte, on the coast of Arfon; but, to put it briefly, it is an ancient belief in the principality that its lakes generally have swallowed up habitations of men.'

(p. 403.)—"Perhaps it is best to begin with historical events, namely, those implied in the encroachment of the sea and the sand, on the coast of Glamorganshire, from Mumbles in Gower to the mouth of the Ogmore, below Bridgend. It is believed that formerly the shores of Swansea Bay were from three to four miles further out than the present strand, and the oyster-dredges point to that part of the bay, which they call the "Green Grounds," while trawlers, hovering over these sunken meadows of the Grove Islands, declare that they can sometimes see the foundations of the ancient homesteads, overwhelmed by a terrific storm which raged some three centuries ago. The old people sometimes talk of an extensive forest, called *Coed Arian* ('Silver Wood'), stretching from the foreshore of the Mumbles to Kenfig Burroughs, and there is a tradition of a long lost bridle-path used by many generations of Mansels, Mowbrays, and Talbots, from Penrice Castle to Margam Abbey. All this is said to be corroborated by the fishing up, every now and then, in Swansea Bay, of stags' antlers, elk horns, those of the wild ox, and wild boars' tusks, together with the remains of other ancient tenants of the submerged forest. Various references in the registers of Swansea and Averavon mark successive stages in the advance of the desolation from the latter part of the fifteenth century down. Among others, a great sandstorm is mentioned which overwhelmed the borough of Cynffig, or Kinfig, and encroached on the coast generally; the series of catastrophes seem to have culminated in an inundation, caused by a terrible tidal wave, in the early part of 1607.

"To return to Kenfig: what remains of that old town is near the sea, and it is on all sides surrounded by hillocks of finely powdered sand, and flanked by ridges of the same fringing the coast. The ruins of several old buildings, half buried in the sand, peep out of the ground, and in the immediate neighbourhood is Kenfig Pool, which is said to have a circumference of nearly two miles. When the pool formed itself I have not been able to discover."

(p. 404.)—"On this coast is another piece of water, namely, *Crymlin* or *Crumlin Pool*, now locally called 'the Bog.' It lies on Lord Jersey's estate, at a distance of about one mile east of the mouth of the Tawe, and about quarter of a mile from high-water mark, from which it is separated by a strip of ground known as Crymlin Burrows. The story about this pool, also, is that it covers a town buried beneath the waters. An article of the *South Wales Daily News*, of February 15th, 1899, says of Crymlin: 'It is said by the old people that on the site of this bog once stood the old town of Swansea, and that, in clear and calm weather, the chimneys, and even the church steeple, could be seen in the bottom of the lake.' The lake was at one time much larger than at present."

(p. 416.)—"The writer of an article in the *Monthly Packet* for 1859 gives a sketch of the story of the country overflowed by the neighbouring portion of Cardigan Bay, mentioning, that once on a time there were great cities on the banks of the Dovey and the Disynni. 'Cities with marble wharfs,' the author says, 'busy factories, and churches, whose towers resounded with beautiful peals and chimes of bells.' The author goes on to say, that Mausna is the name of the city on the Dovey; its eastern suburb was at the sandbank now called Borth, 'its western stretched far out into the sea.' The name Borth stands for 'Y. Borth,' *i.e.* 'the Harbour.'"

Passing from the south of Wales and the Bristol Channel to the peninsula of Devon and Cornwall, which is beaten by the waves of the Atlantic in all their force, we find in Sir Henry de la Bèche's Report on the Geology of Cornwall, Devon, and West Somerset (1839) a very interesting chapter on the "*Action of the Sea on the Coast*," from which the following citations are made:—

(p. 435.)—"As about 472 miles of coast, exclusive of estuaries and minor irregularities, are in the district under consideration exposed to the action of the sea, considerable facilities are afforded for the study of this action, more especially as the rocks brought within its influence are very different, and the conditions under which they are exposed are also variable. We soon perceive that the streams of the tide, to the movement of which so much abrading power has been attributed, have very little influence upon this coast; that it is chiefly in those places where the tides have little strength, but where the softer rocks prevail, and the exposure to the prevalent winds, and hence to breakers, is considerable, that the chief loss of land by the action of the sea is greatest. In fact, the tides rarely run beyond one or two miles per hour, except round the headlands, which are nearly all composed of hard rocks, the softer parts of the coast having been hollowed out by the breakers, during the lapse of ages, into creeks, coves, and bays, so as to be removed from the main stream of the tide."

It would be difficult to form a correct idea of the geological time during which this coast has taken its present form, when we perceive so many hard rocks worked into creeks and coasts, and learn as indeed from their aspect we would expect, that no appreciable change has been observed in them during the memory of man, we can readily believe that the present condition of this coast is due to no ordinary lapse of time as reckoned by him.

(p. 436.)—"The hard quartzose and trappean rocks of Trevose Head, the greenstone and trappean rocks of Pentire Point, near Padstow, the hard slates of St. Agnes Head, the compact sandstones and hard slates of Godrevy Head, the greenstone of St. Ives Point, the greenstone and hardened schistose rocks of Gurnards Head, and the granite of the Land's End—may be readily supposed incapable of being appreciably wasted by the action of the streams of tide which pass over them. In like manner the granites of many other points in the Land's End district."

(p. 437.)—"A very short experience of the destructive effect of breakers will be sufficient to afford evidence of the form which a coast must take according to the variable manner in which it may be exposed to them; so that after the lapse of ages any given coast will readily show, from the wearing away of the softer rocks into creeks, coves, and bays—the harder being gradually left to protrude as points and headlands—that it has been scooped out according to the unequal resistances of the rocks on the one hand, and the variable power of the breakers on the other, due allowance being made for the original form of the land, and the indentations produced by the entrance of the sea, at its high-water level, into valleys, producing estuaries."

(p. 438.)—"It rarely happens that breakers do not fall on the western part of the coast, even in the calmest weather, undulations from the Atlantic, produced by gales of wind on some part of it, not too distant, to allow the waves so caused entirely to subside before they meet the land, rolling in upon the shores, and often breaking with a heavy crash on them, causing, probably, as much abrasion as the waves at any other time. These are technically known as 'ground swells,' as they tear up the beaches exposed to them, hold abundance of pebbles or sand, as the case may be, in mechanical suspension, and even seem, as it were, to rise from the bottom of the sea, hurling the mechanically-suspended substances upon the beach or against the cliffs with a heavy grinding noise, frequently heard far inland. As these 'ground swells' very often roll in from the westward, the coast from Morte Point to the Land's End is much exposed to it, particularly towards the latter place. When, as it often does, the Atlantic or ground-swell rolls from the south-westward, a large portion of the southern coast, otherwise protected, is exposed to it; generally the formidable breakers caused by the swell, even in calm weather, do not extend beyond the Prawle and Start-Points."

(p. 439.)—"The ordinary breakers are well known to be the crash of the waves produced by winds blowing on the coast, and according to the exposure of the coast to open sea, other things being equal, are their magnitude and destructive powers.

"In many situations common atmospheric influences so combine with the action of the breakers to produce the destruction of the cliffs, that it may be difficult to say whether the loss of land may not be more due to the one than the other; in most places, however, the breakers nearly cause the whole loss, leaving isolated rocks to show, to a certain extent, the destruction they have caused. The cliffs, from Trevose Head to new quay, may be selected as affording a good example of the destruction of a coast by the action of heavy breakers."

(p. 440.)—"The rocks between Teignmouth and Lyme Regis suffer much loss from the action of the breakers upon them to an extent that, if the latter possessed the average force of those which wear away the coast last mentioned, very considerable inroads would be made upon them, and the bay would be much enlarged northwards in the course of a few thousand years. Independently, however, of the loss by landslips, the Lias cliffs near Lyme Regis are readily seen to be washed away by the breakers, as may easily be observed between Charmouth and that town, as also to the eastward of it. Considerable waste of this coast has thus been occasioned within the memory of persons now living—a waste first recorded, we believe, by De Luc, and one which is still proceeding at a considerable rate, the fall of the cliffs being frequent, particularly in bad weather. Much loss of coast is sustained near Sidmouth, particularly in the direction of High Peake, the small green-sand cap on the top of which will disappear at no distant date, geologically speaking, and be only known to have existed from the geological maps now constructed of that part of the country."

(p. 441.)—"The isolated Red Sandstone and Conglomerate rocks on several parts of the coast, the evidence of its former boundaries between Sidmouth and Teignmouth, are often worn away by the breakers in a manner well illustrating the unequal resistance offered by different portions of them. One of these isolated masses, named 'the Chit Rock,' which long rose above a ledge on the west of Sidmouth, was a few years since upset, in consequence of a central part of it having been finally worn so thin that the upper portion was knocked off by the breakers in a gale of wind."

Near Watchet, East Quantockshead and Little Stoke, the Lias red marl and sandstone of the coast suffer much annual loss—not so considerable a loss as they would sustain if exposed to the action of heavier breakers than now reach them, even to such as now batter and wear away similar rocks near Lyme Regis and Sidmouth, but sufficiently to become well marked.

The minor effects of the breakers are easily seen on every part of the coast, the harder rocks resisting their action, while the softer are worn into caves, creeks, and coves, of every variety of form.

(p. 442.)—"The sea, by its action upon rocks of unequal hardness and the fall of some compact portions of them, or of large indurated nodules contained within them, often raises a barrier against itself, and the lower portions of cliffs become protected for a time; beyond that they would remain otherwise firm, even in some cases producing points of land composed of these blocks or more indurated masses of rock. (*Note*).—Indeed it may be said, on this head, that beaches generally, more especially shingle beaches, are only the harder part of abraded cliffs reduced to somewhat smaller dimensions)."

(p. 443.)—"Having thus briefly adverted to the destructive action of the breakers on this coast, we should notice the protection afforded by the common beaches thrown up in front of low lands." (The author then enters into considerations regarding the formations and influences of these beaches and the formation of dunes.)

Under the heading of "*Cornwall*," "Lewis' Topographical Dictionary of England" says (p. 516): "The sea has considerably encroached upon the coast within the last sixty years (1771 to 1831), in the hundreds of Stratton and Lesnewth, especially near Bude Harbour, where the waves are rapidly wasting the sandhills."

As a considerable extent of the north-western and western coasts of France are fully exposed to the action of the Atlantic storms and breakers, and consequently to waste, it will be of interest to note what is said relative thereto in the "Dictionnaire de Géographie Universelle de Vivian de St. Martin"; and for that purpose the coasts of the different departments exposed to the Atlantic action will be considered in their succession from east to west—that is, Calvados, Manche, Ille-et-Vilaine, Côtes du Nord, Finisterre, Morbihan, Loire Inf^{re}., and Vendée.

Speaking of the "Configuration physique" of the Department of Calvados, the Dictionary says: "Les côtes du département offrent un développement de 120 kil.-carrés formant une courbe rentrante peu sinueuse, bordée de falaises dont la mer ronge insensiblement le pied, et d'un difficile accès à cause des nombreux rochers, débrîs d'un rivage, que les souvenirs historiques constatent s'être plus avancé en mer autrefois qu'aujourd'hui. Les rochers de *Calvados* ont donné leur nom au département; ce mot de Calvados, est le corruption de l'Espagnol *Salvador*, et 'le Salvador' était un vaisseau de l'invincible Armada qui se brisa sur cet écueil."

Speaking of the coasts, the Dictionary says: "Cette côte a subi des révolutions dont les vestiges sont visibles sous les eaux et dans l'intérieur des terres. Le plateau du Calvados n'est pas autre chose que la base d'un prolongement des falaises du Bessin qui a été rasé par la mer. On ne saurait guère chercher ailleurs que dans ces falaises détruites, la source des atterrissements qui ont comblé les anciens golfes de l'Orne et de la Dives.

"La forêt de Hautefeuille, disent encore les traditions locales, ombragait au commencement du XVI^{me} siècle la large lisière sur laquelle s'épandent aujourd'hui les marées audessus de Bernières et de Langrane. De nombreuses et puissantes racines s'enfoncent en effet dans les fissures des rochers mis à nu. Les commissaries du Cardinal de Richelieu trouvèrent, à défaut de la forêt, un petit port à Bernières; la Seulles y debouchait en s'inflechissant à l'E., et de vastes marais s'étendaient à l'ouest jusqu'à Anelles à 12 km. de distance.

Depuis la mer a dévoré le port et les marais; elle a racourci le cours de la Seulles de 3 km., et il ne reste plus du hâvre de 1640, qu'une serie de bas fonds où la retraite de la marée laisse de longues flaques d'eau. Il est du reste permis de voir un indice de transformations bien plus vastes, dans les vestiges de retranchements romains qui, de Réviers à Tailleville et à St. Aubin enveloppent Courseulles. La charrue met souvent à découvert dans leur vate enceinte des briques, des fragments de poterie antique, et des médailles. Il est peu probable que les Romains se fussent si fortement installés sur ce point s'ils n'avaient eu qu'une insignifiante station navale à protéger, et l'ancienne configuration du rivage donnait sans doute à leur établissement militaire des raisons d'être qui n'existent plus. La côte est encore rongée par le flôt; mais, à mesure que les dentelures s'en emoussent, elle donne moins de priseaux courants.

The same Dictionary, speaking of the English Channel (the "Manche"), says: "La triple action des météores, des courants et des vagues de marée, continue de ronger incessamment les rivages du grand détroit. Batz, Traigoz, les sept Îles, Bréhat, sont les restes d'un littoral disparu. Au N. les Scilly Is., le cap Land's end, le cap Lizard, se dressent dans une mer toujours agitée par le flôt et le jusant. Les météores fissurent en haut les rochers que la mer sape en bas, et d'énormes blocs s'écroulent dans les flôts et y forment des écueils. De quelques uns de ces écueils l'imagination populaire a fait les 'Armed Knights' (les chevaliers armés), défenseurs des continents; mais à leur tour ils cédent à la pression des vagues et s'engloutiront tout à fait. À l'est des granits résistants de Treguier, les côtes ont été fortement entamées par le flôt, et des péninsules comme Herviant, Verderlet, Cezembre, sont devenu des îles.

"Dans le sud de l'île de Jersey des roches et des grêves, que servaient de fondement à des terres disparues, s'etendent à marée basse. jusqu'à 3 k./metres du rivage.

"Les falaises de Normandie composées de matèriaux beaucoup moins durs que les promontoires de la Manche occidentales sont plus facilement entamées. Le recul des falaises de la Seine Inférerieure et du Calvados est d'environ 25 à 30 c/metres en moyenne par an. Sur les côtes de l'Angleterre situées en face, l'erosion est plus rapide encore. *La masse totale des rochers que la Manche Orientale brise chaque année est évaluée à environ* 10 *millions de m./cubes.*[1] En 1862 pendant une

[1] Maréchal, "Ann. des ponts et chaussées."

tempête les rochers de la Hêve se sont éboulés sur une épaisseur de 15 mètres. Dans les ages antérieurs l'Angleterre était rattachée à la terre ferme, par un isthme à jonction qui a été graduellement rompu par le choc et la pression des vagues. Plus à l'est au Pas de Calais, la falaise du cap Gris-nez récule en moyenne de 25 mètres par siècle À l'ouest de Dover, la falaise de Shakespeare d'après Mr. Beete Jukes a reculé de 2 k./mètres depuis le temps de Jules Cæsar.

"Mais le flôt qui détruit, édifie aussi, et à l'extremité orientale de la Manche on peut constater un des examples les plus frappants de l'influence des marées sur la forme des rivages. 'Une plaine basse et marécageuse dite, Romney Marsh,' qui se termine à la pointe de Dungeness s'est formée par l'arrêt du courant de marée qui vient de la Mer du Nord. Le flôt de l'Atlantique arrache à la base des falaises crayeuses de Hastings des débris siliceux qui ne pouvant passer la pointe de rencontre des marées, s'arrêtent le long du Romney Marsh et le prolongent continuellement en mer. La pointe Dungeness s'accroit d'environ 0^{m} 50 par an.' Ailleurs la mer a procédé par envasement, en déposant des débris d'algues et d'animalcules mélés au sable et à l'argile, et c'est ainsi qu'elle a fait avancer le profil des rivages dans le golfe de Carentan, à la racine de la péninsule de Cotentin."

The same Dictionary speaks as follows of the coast of the Department of "Ille et Vilaine":—

"Le plus élevé (plissement de terrain) de tous, Haute-Forêt, n'a que 255 m.; dominant les sources de l'Aff, affluent de l'Oult, il se dresse près des frontières du Morbihan, dans la forêt de Paimpont, dont les 6070 hect. sont un faible débris de l'antique et célèbre forêt de Brocéliande. Toutes les collines du pays, tous ses plateaux, tout cela fut jadis une forêt immense, qui de plus en plus s'éfface.

"De ces bois sans fin faisait partie, du temps de Romains, le *Scissiacum nemus*, la forêt de Scissey, envahie brusquement par la mer en 709 dit on, et devenue alors une grève marécageuse qu'on a desséchée, et remplacée par une plaine humide de 15,000 hect. appartenant à 23 communes. C'est le marais de Dol, entre le massif de Dol et celui de St. Malo; 'Petite Hollande,' ayant ses dignes parfois ébréchées par les assauts des flots, ses canaux, ses moulins à vent, ses marais, ses brumes grises. C'est en perçant, pendant les grandes marées d'équinoxe, un cordon littoral allant des caps de Granville au Grouin de Cancale que la mer recouvrit les terres basses du *Scissiacum nemus*. Ce fut la plus grande perturbation qui se soit produite sur la côte de la France. La digue qui protège le marais de Dol domine d'un mêtre et demi les plus hautes marées d'équinoxe. De l'embouchure du Ginoult à la pointe de Château Richeux la rivage reste plat, mais à cette pointe commence la fameuse côte de Bretagne, l'une des plus déchiquetées, des plus sauvages, des plus sombres, des plus orageuses du monde entier. Le littoral n'est pas moins déchiqueté qu'à l'est et les terribles êcueils dont la mer est parsemée, le rendent très dangéreux pendant les mauvais temps."

Speaking of the Departement de Finisterre, this Dictionary says:—

"Comme l'indique son nom, le Finisterre forme au sein de l'Océan l'avant garde du Continent Armoricain, les deux points de Raz et de St. Mathieu, celle-ci granitique, celle-là gneissique, s'avancent dans les flots et soutiennent vaillamment leurs premiers assauts; des roches de schiste, moins résistantes, ont cédé sous l'effort de la vágue furieuse, et y a creusé la rade de Brest et la baie de Douarnenez. Fouettées 4 fois par jour aux deux marées montantes et aux deux jusants, secouées souvent par des vagues de tempêtes, les extremités de la peninsule sont assaillies par ces terribles agents de destruction. De là toutes ces petites îles violemment séparées de la terre ferme, ces pans de mur, à demi-ensévilis sous les sables, et ces traditions de villes détruites qui temoignent partout des progrès de l'Océan. À l'aide des jalons de granit épars sur les bas fonds, on peut, avec quelque certitude fixer à 25 km. le minimum des envahissements de l'Atlantique depuis l'antiquité. Dans la baie de la Forêt, sur les côtes de Penmarch, du Raz, du Conquet des constructions et des troncs d'arbres témoignent des pertes récentes qu'a fait ici la terre ferme."

Describing the Department of the Loire Inférieure the same Dictionary says: "Le '*sillon* de Bretagne' est élevé presque partout de 60^m à 80^m;—seulement à 91^m de hauteur suprême près du Temple de Bretagne. Entre Saveney et Port Château il commande *les Brières*, marais souvent inondés, prairies tourbeuses, dont la plus vaste, est la *Grande Brière*, entre Loire au S. la Vilaine au N. et les hauteurs de Guernande qui la séparent de l'Atlantique à l'Ouest. Longue de 15 km., large de 10 km., elle a bien 8000 hect. à l'altitude moyenne de 3^m. Ancienne forêt mouillée, pleine encore de troncs noircis par un long séjour dans le tourbe, on la voit tour à tour et suivant la saison, nappe sans profondeur, où l'on chasse les oiseaux d'eau, prairie où pait le mouton, et d'où les Briérons tirent par milliers de tonnes la tourbe—entre la grande Brière et les 'bogs' d'Irlande, il n'y a point de différence—des forêts qui croissaient autrefois sur le sol envahi par les toúrbes, ont été étouffées, et les arbres tombés pour la plupart, dans la direction du vent principal, se montrent encore parfaitement conservés sous la couche à demi carbonisée des sphaignes; leur bois devenu aussi noir, aussi dur, que l'ébène, est assez bien conservé pour être débité et transformé en parquet.

As regards the Départment de Vendée, the Dictionary says:—"Là dans ce que nous nommons maintenant la Baie de Bourgneuf entre la côte de France et Noirmoutier, elle a deposé, dépose et déposera, des alluvions jusqu'à comblement, devant le continent toujours accru, à l'abri de la roche, et du sable de l'île, qui s'élève en briselame contre les vagues du grand large. Il n'y a présentement ici qu'une seule terre en mer, Noirmontier, mais quand ce remblaiement commença, le rivage regardait trois îles, Noirmoutiers, au N.W., Retz, rocher de schiste au S.E., et entre les deux, l'île de Monts. Ce que l'Océan laissa tomber ici, ce qui y tom e encore, c'est la ruine des caps bretons, la vase de la Loire, les menus fragments des caps de Noirmoutiers, et quelques boues des ruisseaux du rivage. De plus le sol s'exhausse, du moins on le croit. Tout endiguement à part, la France a gagné durant les deux dernières siècles quelques 700 hectares dans la Baie de Bourgneuf, ainsi appelée de la ville de Bourgneuf en Retz (Loire Inf.) jadis riveraine, tandis que 2 k.m. de plaine basse et de marais salants, la séparent du flot à cette heure; de même Beauvoir-sur-mer est à 4 km. de la mer."

If it were merely wished to establish the general fact of the wasting action of the sea on the coasts of Great Britain and Ireland many more examples of such wasting action could be cited from Lyell's "Principles of Geology," particularly the excellent details as regards the north-east of Scotland and the east and south-east of England. The main object in making the citations already given, has been to allow of a more just appreciation of the action of the Atlantic waves on the coast of Ireland, and of the consequent waste which must have been, and is incessantly going on day by day, although unobserved and unrecorded for the most part. Turning, therefore, to the examination of the coasts of Ireland, that of the eastern side will be considered first, commencing with the coast-line of Wexford.

The *National Gazetteer* (1868) says of the coast: "The coast is generally low and shingly from Kilmichael Point, in the north-east, to Wexford Harbour, a distance of nearly 30 miles, and is skirted along the entire line by a series of sand-banks marked at their northern extremity by the Arklow ship-light."

Dr. Joyce, in Philips' "Atlas of Ireland" (1833), says of the

"*Coast-line*": "The coast is low, and for the most part sandy, interrupted in a few places by fringes of rock; it is unbroken from Kilmichael Point to the Raven Point; but from this to Waterford Harbour it is much indented by inlets."

In the Proceedings, Roy. Ir. Academy, Series ii., Science, vol. iii. (1877–83), Mr. George H. Kinahan published a Paper on Sea-beaches, especially those of Wexford and Wicklow, of which the following are extracts:—

(p. 191.)—"During the time I have been engaged on the Geological Survey of Ireland (over twenty years) I have had, when stationed in maritime districts, favourable opportunities of observing the sea-beaches. This has been especially so during the last six years while I have been engaged in examining the counties of Wicklow and Wexford, and in these years the observations made were both numerous and minute."

(p. 192.)—"The western Saltee current runs north-east to Kilmore Pier, where it turns westward, and forms the 'counter tide' that meets the Hook current at the Keragh Island. At the meeting of these two currents a shoal has accumulated. Under ordinary circumstances the current from Hook carries the beach with it only to the neighbourhood of Keragh, as proved by the fact that the stones from Hook promontory are rarely found beyond Keragh. The 'counter tide' west of Kilmore carries the beach north-west along Ballyteige Bay, and during the last 40 years (since the Ordnance Map was made) has lengthened the Ballyteige sand-hills more than 200 feet."

(p. 193.)—"The Cahore shingle beach is about 3 miles long, and is largely composed of fragments of the Greenore and Carnsore rocks; with these there are others from the cliffs along the Blackwater coast. Opposite Courtown (north of Cahore) is the '*nodal*,' or 'hinge-line,' of the tides on the south portion of the Irish Sea, where the rise is least and the current greatest. The refuse from the shipping at Courtown Harbour, such as bits of brick, tile, slate, coal, &c., are principally stranded along the beach a few miles south-west of Kilmichael Point. On this beach, Greenore and Carnsore rock fragments are not uncommon; but in the two small bays to the north of the Point the gravel and shingle is made up almost solely of the local rocks, many of the fragments being more or less angular. The débris from the shipping at Arklow is principally beached on the strand south-west of Mizen Head.

(p. 195.)—"*The effects of the Wind Waves*: The waves of this class that act on this coast are of two kinds, viz., 'ground swells,' or waves generated by storms in the Atlantic or the Channel, and the waves directly due to the winds blowing on the coast. Their effects are either to pile up and fill the beaches or to cut them out. If they strike the beach at a right angle, they fill it up, forming 'fulls' or 'storm beaches, while, if they are running in a more or less opposite direction to the flow-tide, they cut out the beach."

(p. 197.)—"Consequently, during the last 40 years, the coast-line between Lady's Island lake and Kilmore has been considerably denuded away, especially in the vicinity of St. Patrick's Bridge. These beaches, during the continuous east and north-east winds of the spring of 1876, changed from their ordinary gravel into "fulls" of shingle.

"In the North Bay all winds seem to 'cut out,' this being due to the complication of the tidal currents, the beaches rarely being full except in the summer and autumn, when there are no winds. On account of the great cutting out along the beach, the marginal cliffs have been vastly denuded within the last 40 years. The '*Cahore shingle beach*,' at the north of the bay, is fullest during south and south-east gales, while it is cut out by winds from the north-east, and by 'ground swells.' After south and south-west gales it is often smothered up with fine sand blown from the adjoining accumulations of Æolian Drift.

"A little to the north of Cahore Point is Poulduff Pier, with the beaches accumulated since it was erected, while farther north are the piers and other works at Courtown.

"On the coast-line, south (fig. 4, pl. 6) and north (fig. 5, pl. 6) of Kilmichael Point, there has been considerable denudation of the sand-hills since the Ordnance Survey was made (*i.e.* 40 years ago).

"In the first-mentioned localities over 37 acres have been carried away by gales from the south-east. Here there is an exceedingly swift tidal current to the north-north-east, which, under ordinary circumstances, carries all the beach with it, and leaves no protection between the sea and the sand-hills; consequently, under these circumstances, during south-east gales, the wind-waves have full power on the latter, which they then rapidly denude away.

"(*Note.*)—(This is a most remarkable place, as in recent years the sand-hills at one time seem to be forming and at other times wasting away. Some of the old men can point out the extensions of the sand-hills prior to the Ordnance Survey, and the roads that used to lead to them, which now end at stiff cliffs; while one old man, in June, 1875, pointed out in a cliff that had only been uncovered the previous winter, an old quarry that must have been worked with *iron tools* prior to the accumulation of the sand-hills that existed there when the Ordnance Survey was made).

"Northward of Kilmichael Point, in the bay at the mearing of the counties Wicklow and Wexford, the denudation of the sand-hills has also been considerable within the last forty years (fig. 4, pl. 6), more than 20 acres in the townland of Cloon Lower and Upper having been swept away."

(p. 199.)—"It ought to be specially pointed out, that the storms which cut out the beaches may not be the same as those which denude away the marginal cliffs. A small storm, when the strand is empty, may do great damage to the coast-line.

"(*Note.*)—After very wet seasons great falls of cliffs often take place. The natives will often tell you that so many yards are going yearly, and, in proof of this assertion, will point to the waste of the previous winter, they supposing the same happens every year. The greatest falls occur at the highest cliffs, on which account the greatest waste is supposed to be taking place in those localities; but, after careful calculation, I find this not to be the case. None of the high cliffs reach an average waste of 0·75 feet per annum, and generally the loss is less than 0·50 feet per annum, while in places the low cliffs have been denuded away as much as 2·5 feet per annum. The greatest denudation on the whole line of coast between Hook and Dalkey is at the low cliff near St. Patrick's Bridge, Kilmore.

"Extraordinary high tides, unaccompanied with wind, seem to do little or no damage on an open seaboard. In March, 1867,[1] there was a remarkable high tide on the coast of Galway, the traces of which were scarcely perceptible along the open coast, even on the sand-hills; but in the land-locked bays it did considerable damage to the piers and sea-walls.

"On January 3rd, 1877, there was on the east coast a very high tide, which along the Wicklow coast was accompanied by a very moderate wind. This did considerable damage to the Dublin and Wicklow Railway between Greystones and Wicklow; not so much by the direct force of the waves as by their height, they flowing over the line, and the overflow cutting into the land side of the embankment, thus gradually eating out the beaches. Between Newcastle and Wicklow Chemical Works it encroached in many places, as much as 3 yards into the Morrough (*anglice*, the plain)."

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[1] 1867. 2. Sunspot minimum.

(p. 202.)—"Some of the big waves or 'rollers' that visit the coast, on rare occasions are due to earthquakes."

(p. 203.)—"At the Kish Bank, off Dublin Bay, an attempt was made to erect a light-house on screw piles; but it was given up, as the flanges of the piles were broken by large blocks in the accumulation of sand."

(p. 207.)—"On no coast are groynes so necessary as that now under consideration, especially in parts of Wexford and Dublin where valuable land is yearly disappearing ; yet they have been erected only in isolated spots."

In the Memoir of the Geological Survey of Ireland, accompanying sheets Nos. 158 and 159, including the district around Enniscorthy, County Wexford, by G. H. Kinahan, M.R.I.A. (1882) the following observations occur :—

(p. 32.)—"Some of the newest accumulations are the estuarine *mudlands* of the north intake in the Wexford lagoon. These mudlands are described in the published memoir to accompany sheets 169, 170, &c. To the north-east of this intake, at Curracloe and Ballinesker, both inside and outside the Æolian Drift, which is the northern end of the Raven Spit, is deep peat. That outside is cut when the tide is out, and carried up above high-water mark, to be dried and made into turf. Outside the marginal Æolian Drift hills in the Ram Channel, peat has been dredged at the 4 fathom line."

(p. 34.)—"In Ballynaclash, about ½ mile south-west of the mouth of the Blackwater there is the following section :—

"(Section No. 4.)

		feet.
8. Soil, ...		2
7. Clay, ...		1
6. Peat, ...	from 1 inch to	1
5. Blue Clay, ...	from 7 inches to	1·5
4. Peat, ...	from 1 inch to	1·25
3. Pebbly Clay, very irregular, as it is filling what seems to be a water excavation in the associated sand, } 2. Manure Sand, ...	.. .. ..	8
1. Clayey Glacialoid Drift, ...	..	30
		44·75

At this place the denudation is excessive, the cliff being altogether changed since Mr. Wyley made a sketch of it about thirty years ago (1850-52); while since 1840 a strip of land about 175 feet wide has disappeared or at a rate of over 4·25 feet per annum.

From here south-west to Ballinesker (1·75 mile) the drift is alternations of sand and marl, within places, Glacialoid Drift; also to the south of Ballyvalloo, the previously mentioned rib of Boulder Clay Drift (fig. 5). The denudation of the cliff is considerable, rarely less than 2 feet per annum; and in some places, as in the vicinity of Ballyvalloo House, it is over 3 feet.

In the Memoir to sheets 169, 170, 180, and 181 of the Geological Survey of Ireland by Mr. G. H. Kinahan, M.R.I.A. (1879), p. 14, the author states:—

(p. 15.)—"In connexion with this area, the denudation of the coast line should be described, as a considerable waste of land yearly takes place. The Ordnance maps of the country were published about 1840 or thirty-five years ago. (*Note.*—The cliffs were examined in 1875.) If, therefore, the present coast line is mapped, an estimate can be made of the annual waste of the drift cliffs. While examining these cliffs, it was observed that the effects of denudation varied according to the nature of the drift. The Glacial Drift, in general, best resisted the encroachment of the sea; but in a few places it has been considerably wasted. In such places the sea undermined the bottom of the cliffs, causing great falls, principally due to their own weight. Joints open in the marl during the dry weather; if these are perpendicular or oblique to the line of the cliff the water percolates through them, and the cliffs remain more or less perpendicular; but if they are parallel or nearly so to the line of cliff, they fill with water, causing great slips, which masses, after coming under the influence of the waves of the sea, are dissolved and wasted away. Such cliffs gave way in mass, but the slips are so extensive, that it takes years before the sea can remove the débris, thus giving time to a protecting slope to form. If marl is interstratified with sand, gravel or other drift, the waste of the cliff is usually very rapid."

To the south-west, the Baginbun promontory is margined with rocks, and very little denudation is apparent, except in the black shales at Petit's Bay, between Carnivan and Baginbun Heads. To the east of Bannow Bay, for about 3 miles, the sea cliffs, in general, have a rock foundation, over which the drift may be glacial, aqueous, or meteoric. In a few places the rocks have protected the cliffs, but in many places they have been eaten away. In the townland of Bannow, to the south of the old church, over 60 feet in depth have been cut away since 1840, or at a rate of 1·71 feet per annum. In the vicinity of Kiln Bay, and at the east margin of the townland, there has also been considerable waste, respectively, of about 2 and

2·5 feet per annum. Further eastward, at the south-west of the townland of Haggard, the waste is nearly 1·5 foot per annum, but in the east portion of the townland, also in those of Blackhall and Loftus Acre, it has been excessive, in places reaching 3 feet per annum.

"Further eastward, in the townland of Ballymadder, the denudation is less, being about 1·5 feet per annum. This is also the average in the western portion of Cullenstown. In these places, at the base of the cliff in the aqueous drift, are recent sandstones or conglomerates that resist the sea action, and thus preserve the accumulation resting on them, while at the east of the townland, opposite the end of Ballyteige Warren, there has been great waste, over 3 feet per annum. The Ballyteige Warren is an irregular ridge of Æolian Drift. Its outer margin seems to have been more or less cut away since 1840, whilst its western end has grown more than 400 feet in length. At the east of Crossfarnoge Point, to the eastward of Ballyteige Warren, shingle has accumulated west of Kilmore Quay; but a little farther eastward, north and north-east of St. Patrick's Bridge in the townland of Nemestown, there has been considerable waste, in some places as much as 200 feet since 1840, or over 5 feet per annum; at this place there seems to have been the maximum denudation on the south coast.

"Farther east-north-east, in the townlands of Ballygrangans, Bastardstown, and Ballyhealy (Wexford $\frac{51}{1}$), the waste is about 1·4 per annum, and in Ringbaun and Ballagh about 1 foot.

"Between Tacumshin and Lady's Island lakes, the denudation of the coast line has been from 5 to 50 feet in the last thirty-seven years, while the bank enclosing the latter lagoon (Lady's Island lake) has been pushed inland more than 60 feet. Eastward, in Burrow, Wexford (Wexford Sheet 53), the coast has been cut away at about a rate of ·75 foot per annum, the denudation ceasing suddenly as we approach Carnsore Point.

"At Carnsore Point and from that northwards to the old coast-guard station at St. Helen's, there has been very little general denudation of the coast, although the strand margin for the most part is drift. In a few places, the denudation is more or less considerable.

"From the old coast-guard station of St. Helen's to Greenore, and from that eastward and northward to Rosslare coast-guard station, considerable denudation has taken place. Here the cliffs are high and formed of marl. They therefore nearly invariably come down in slides, the débris of which must be removed by the sea before another slide takes place, and but for this the waste would be much more rapid. Between St. Helen's and Greenore Point, the waste has been 1 foot per annum. Between Greenore and Ballygeary pier, ·25 foot, and between the pier and Rosetown about ·50 foot. The denudation here being greatest in the townland of Hill of the Sea, ·75 foot.

(p. 17.)—"The new pier of Ballygeary exemplifies how easily, by a well regulated system of groynes, the denudation of this coast could be arrested. The pier was commenced in the spring of 1873, and in 1875 a large accumulation of sand had collected along the coast to the south-east, but especially in the vicinity of the pier where now (1878) sand-dunes are forming. This accumulation forms a foreshore that is gradually stopping the denudation of the cliff. The cliff to the westward of the pier also now suffers less from denudation.

"From Rosslare coast-guard station (Rosehill) to Ballinesker (Wexford $\frac{33}{4}$), are the banks (Rosslare and the Raven) that enclose the lagoon of Wexford Harbour. They are composed of Æolian Drift, and have been considerably altered, especially Rosslare since 1840. Opposite White House, at the land or south end of Rosslare, the coast line has moved westward or inland over 100 feet (3 feet per annum). Opposite Rosslare House, about 75 feet (2 feet per annum), and a mile and a quarter farther north, where the denudation is greatest, about 203 feet or 5·74 per annum. From this point northwards, the denudation decreases to the Bull's Perch, where it is 50 feet (1·45 per annum), but to the north thereof it again rapidly increases, being at 170 yards north of that point, 150 feet (about 4 feet per annum), the banks in places being breached, and the sea passing through it during gales from the south-east. Further north the bank originally had a very irregular outline, but now it has been considerably added to inside, while outside in places it has been cut away. The length of the bank has also increased northward. When it was examined in 1876, the Dogger Bank, off the mouth of Wexford Harbour, was of considerable size, and in part an island. This, however, has quite changed in the last two years, the island having disappeared, and consequently the form of the northern portion of the Rosslare has also changed."

(p. 18.)—"The changes in the forms of the Rosslare and Raven Banks are in a great measure due to the intaking of the north and south midlands in Wexford Harbour, as now the outflow of the water is much less than formerly; consequently the 'Flow tide' wave current from the south changed the form of the Dogger Bank from a massive shoal to the south of the entrance, into a long narrow bank that overlapped the mouth, and even the end of the Raven Bank, and changed altogether the tidal currents and the drift of the sand.

(p. 32.)—"*Tomhaggard District.*—The sections along this coast have greatly changed since they were examined thirty years ago (1858) by Wilson. They are even much changed since the above records were noted in 1873. Sometimes when 'the beaches are full,' none of the base of the cliffs can be seen, as occurred in September, 1878."

(p. 36.)—"*Raven and Rosslare Burrows.*—There is a tradition that the ancient entrance into Wexford estuary, was to the north, in the vicinity of Curracloe. This is not at all improbable, but it must have been in very ancient times to allow for the great depth of peat now accumulated at Curracloe.

(p. 36.)—"The hollows occupied by Wexford estuary are very ancient. The present outline for the most part was induced by the 25 feet sea, but since that time, while the land was lower than at present, and subsequently the shore lines underwent various modifications. The surface area of the estuary, however, has changed considerably since the time of the 25 feet sea-beach. Subsequently to the time of the 25 feet beach, the land was at least 30 feet higher than at present to allow the peat to grow. After it had again sunk, the sand-bars seem to have formed, but farther seaward than at present, as otherwise the peat would not be found under, and to seaward of them. Other submerged peaty and lagoon deposits have been recorded south-west of Greenore Point, in the neighbourhood of Ballytrent and St. Margaret's, where there are sites of small lagoons margined by sand-ridges. Under and outside the latter, being peaty accumulations. Of the latter locality, Mr. Wyly records 'Bog with trees; exposed between high- and low-water marks of spring tide.'"

(p. 47.)—"*Kilmore district.*—Further eastward the cliffs are low, and have in general Æolian Drift above, and gravelly Glacialoid Drift below. The sections given are very different to those recorded by Mr. Wyly when examining the coast about thirty years ago (1858), as the marine denudation during the intervening years has been excessive. Prior to leaving the drift, it may be mentioned that, as in all the Glacialoid Drift between Crossgarnoge Point and Tacumshin Lake, fragments of shells and flints may be found, more especially near the top and the bottom of the accumulations according as the gravels and sands lie under or over it. They are also numerous in the inlying patches and layers of sand.

(p. 48.)—"*The Saltee Islands.*—These islands lie to the south of the mainland, and are connected with it by a bar or ridge that is partially submerged and partially tidal, the latter portion being called St. Patrick's Bridge. On the east of St. Patrick's Bridge are some large blocks, the residue of the drift that has been cut away by the sea, the largest being called 'St. Patrick's boat,' from a legend connected with it. It is a remarkably large erratic."

(p. 50.)—"The bar of Æolian Drift that separates the Lady's Island lagoon from the open sea is, in places, swept over during storms and high tides. Outside the bar, during storms, the sea tears up large pieces of sandy, clay peat, similar to that at the bottom of the lake. On the east coast, between Crossfintan Point and Carna House, there is a low ridge of Æolian Drift, while north of Carna House is a submarine peat extending below low-water mark."

Wicklow Coast.—Memoir Geological Survey of Ireland, 121 and 130 (1869), by J. Beete Jukes, M.A., F.R.S., and G. V. Du Noyer, M.R.I.A. No particulars given.

Memoir Geological Survey of Ireland, 138 and 139 (1888), R. J. Cruise, M.R.I.A.

(p. 22.)—"*Raised Sea-Coast.*—All along the coast of the counties of Wicklow and Wexford, the evidences of a recent rise in the sea bed and adjoining coast are remarkably clear. These consist in the occurrence of terraces and flats formed of silt, sand, and shelly gravel, rising a few feet above the high-water line, and bounded inland by cliffs or abrupt banks (according to the nature of the material and form of the ground), which originally constituted the sea margin at the time when the terraces and flats were submerged. The actual extent of rise of the coast and sea-bed is uncertain; but the old sea-bed generally lies from six to twelve feet above the highest tides, The level is often increased by hillocks or dunes of blown sand which have been thrown up by the winds, as is the case in Brittas Bay, Arklow Bay, and other protected inlets. In the district contained in Sheet 139, examples of the raised coast are to be observed in the bays lying between the headlands, and in a direction from north to south they occur—

"(1) In Brittas Bay, between the Castle Rock of Ballynacarrig (Sheet 130) and Mizen Head.

"(2) Between Mizen Head and the coast cliffs of Kilbride.

"(3) In Arklow Bay, both to the north and south of the Ovoca River.

"(4) In the bay south of Arklow Head (see fig. 3); and

"(5 and 6) In the bays north and south of Kilmichael Point.

"The old sea margin is in these cases generally very clearly defined by banks from 10 to 30 feet high, formed either of marl or slaty strata, from the base of which the low terrace stretches seaward as far as the abrupt descent which forms the margin of the existing sea-shore. The old sea-bed is now covered either by sand-dunes, or, where these are absent, is green with coarse grass and other land plants."

Dublin Coast.—Memoir Geological Survey of Ireland, Sheets 91 and 92 (1871), by Edward Hull, M.A., F.R.S., F.G.S., and R. J. Cruise, M.R.I.A.

(p. 42.)—"*Raised Beaches.*—A raised beach is seen in detached places along the shore from Balbriggan to Lowther Lodge. North of the lodge it stands from 5 to 8 feet above high-water mark; and shells which had in most cases lost their colour, and were generally in a fragmentary state, were found therein. (List of same by Mr. Baily).

Dublin Coast.—Memoir Geological Survey of Ireland, Sheets 102 and 112 (1861).

(p. 50.)—"*Drift* (Lambay Island).—This deposit exists merely on the low ground which extends along the western margin of the island, and in no respects differs from the ordinary brown drift gravel clay, containing boulders and rounded lumps of the Carboniferous limestone which is so common over Ireland. Here, however, as we would naturally expect, this clay contains a large percentage of rounded fragments of the local porphyries, but nothing to stamp it as a local deposit. It is, however, evident that, at the period of its deposition, Lambay Island formed a part of the mainland. This clay does not extend more than 100 feet, if so much, up the flanks of the more elevated portion of the island, and beneath it the rock surfaces are rounded, smoothed, and scratched, the directions of the striæ being north-west and south-east."

(p. 66.)—"*The Drift.*—The drift over the whole of this county consists of two deposits. The first a black or brown gravelly calcareous clay, containing a large amount of rolled limestone fragments of various sizes as the lowest deposit; and the second, loose sand and gravel, consisting principally of limestone pebbles, though fragments derived from all sorts of Lower Silurian, and such kinds of rock, form a large percentage of the whole. Pebbles of granite are not uncommon in this gravel, and chalk flints and pebbles are also sometimes present. The lowest of these deposits is found over the northern portion of the district under review, but it terminates at elevations varying from 300 to 400 feet above the sea."

(p. 67.)—"*Shennick's Island, opposite Skerries*, affords an interesting proof of the extreme age of this drift clay. It measures (1860) 575 yards in length, from north-west to south-east, by about 150 in width, and is formed of thin gravelly clay, which the sea has now abruptly escarped on the north-west of the island to the depth of 46 feet. On the opposite shore, south of Skerries, the same deposit is also escarped by the sea, to the depth of 41 feet, the distance between the two being in one place close on three-quarters of a mile. This channel has, therefore, been cut by the sea long subsequent to the deposition of this clay, which, no doubt, represents the remains of what was once a very large extent of land stretching into the Irish Sea. The same fact, just noticed, has been mentioned in connexion with Lambay Island, which is two miles and a-half from the nearest point of the mainland, the deepest part of the channel being over five fathoms. The *east* face of Howth, also, affords us another proof of the existence of land having extended here far into the sea. On the top of the cliffs, from Foxhole to the north of Lough Levin on the south, a distance of 600 yards, we found this brown gravelly clay, containing numerous limestone pebbles, plastered against the rocks, and terminating at an elevation of about 100 feet above the sea, having a main width of only 70 yards."

Enough has been said to prove the great antiquity of this deposit by the amazing amount of denudation which has taken place since its formation.

On the shore, one quarter of a mile west of Malahide, there is a layer of gravelly clay, three feet thick and six feet above high-water mark, containing recent shells and fragments of granite, chalk, and flint. At low-water mark there is exposed on the beach east of Malahide, blue marly clay, containing the dead shells of a species of Pholas, &c.

Memoir of Geological Survey of Ireland, to sheets 121 and 130, portions of Counties of Wicklow and Dublin. J. Beete Jukes, M.A., F.R.S., and G. V. Du Noyer (1869).

(p. 46.)—"The area described lies wholly in the County Wicklow, except a small part along its northern border, which belongs to the County Dublin. Along the seabeach, between Bray and Greystones, there are low cliffs of marl, with limestone and other pebbles and fragments of shells, over which is a deposit of sand and gravel."

(It is in these cliffs that the action of the sea, already referred to, has been so marked, undercutting them and causing the cliff face to fall away, and be subsequently removed by the tidal action. As already mentioned, the waste has been so considerable that the railway line as originally laid down, at a slight distance from the face of the cliff, has been so endangered by the approach of the cliff face, that the line had to be withdrawn inland at some considerable expense, while costly works of underpinning and strengthening the base by stockades and groyns has been going on up to quite lately. The same remarks hold good as regards the stretch between Bray river and Ballybrack).

Memoir of Geological Survey of Ireland, sheets 91 and 92 (1891). The area included in the sheets embraces portions of the Counties of Meath, Louth, and a small tract of the County Dublin (no available particulars given).

Memoir of Geological Survey of Ireland, Sheets 81 and 82 (1871). These maps embrace the greater part of the County Louth, showing fourteen or fifteen miles of its coast-line (no particulars given).

Memoir of Geological Survey of Ireland, sheets 60, 61, and part of 71 (1881). The District described in the Memoir lies wholly in the County Down.

(p. 20.)—"*Raised beaches.*—There are numerous indications around the coast that the land has been raised in recent times. These indications occur in the form of terraces, consisting of stratified sands and gravels, often containing marine shells of the species now inhabiting the neighbouring seas, with possibly a few forms which may have disappeared. These terraces were clearly old sea-beds, and they have since been raised into land-surfaces beyond the reach of the highest tides. Such terraces are found skirting the northern shores of Dundrum Bay, partially covered and concealed by sand-hills, and extending to the foot of the high ground at Newcastle. They again appear, forming a very narrow strip along the coast at Annalong, where they have been subjected to the wasting effects of the waves; but on both sides of the entrance to Carlingford Lough, at Soldiers Point and Greenore

Point, they form considerable tracts of level land and may be conveniently examined. Of these terraces, which may be probably called 'raised beaches,' there appear to be two; the lower, rising from 3 to to 7 feet above high-water mark of spring-tides; the second, from 10 to 15 feet above the same datum. Mr. Trail has described these terraces as they occur at Greenore, where, in the stratified gravels of which they are formed, there are bands of oyster shells, together with shells of the *genera* Mytilis, Pecten, Natica, Littorina, &c. At Killowen, near Rostrevor, similar shells were found in shingle, 10 feet above high-water mark. The two terraces on the opposite shore are similar in formation.

"On the lower terrace, that of about 10 to 15 feet above high-water mark, is built the town of Warrenpoint, together with the old keep of Narrowwater, on the estuary of the Newry river.

"At Annalong Harbour the terrace is at 40 feet elevation above Ordnance datum, or a little over 22 feet above high-water line; this is, therefore, the upper terrace. The terrace bordering the coast near Dundrum is referable to the first or lower level."

(p. 21.)—"Other remains of raised beaches are to be found at intervals along the shores of Carlingford Lough to Warrenpoint from 10 to 12 feet above the water-line.

"In addition to the raised beaches, clear indications of terraces, formed out of the drift deposits are to be observed at several levels, viz. at those of 50, 75, and 150 feet. These are often more easily to be recognised when viewed at some little distance than when standing upon them. The terraces of this class are of more ancient date than those described above, and are probably referable to the period when the land was emerging from the sea, towards the close of the Glacial Period, the terraces having been formed during long pauses."

Memoir of Geological Survey of Ireland, Sheets 37, 38, and part of 29 (1871).

The area described in this Memoir lies altogether in the County Down.

(p. 42.)—*Raised Beaches.*—Skirting the shores of Belfast Lough, between Hollywood and Donaghadee, we find a deposit of marine sand gravel, the maximum elevation of which is about 20 feet above the level of high water. In this deposit, artificially formed, flint flakes were discovered some time back, of which Mr. G. V. Du Noyer, in a communication addressed to the Secretary of the Royal Geological Society of Ireland, thus writes: 'I may remark that when these singular flakes were first discovered in the district round Carrickfergus, about five years ago, their mechanical origin was questioned. Indeed I myself thought at first that they were due to the crushing by natural causes (the weight of the basalt) of the flint nodules, forming the original drifts over the atmospherically eroded surfaces of the chalk. The chippings around the edges of the flakes can, however, only be accounted for by artificial means, as they afford clear evidence of design in their forms and mode of occurrence. Subsequent examination clearly showed me that every flake, no matter how rude its form, or how sharp its edge, exhibited at one end a flat surface, transverse to the longest axes of the flake, and from this surface a blow was given at a point on it, which caused a flake to come off from the original nodule, and this flake below the point of concussion, exhibited a conchoidal fracture and a 'bulb of concussion,' features which could only be formed by, and were the result of, 'an intelligent blow.' And further on he says: 'The conclusions which my present information on this subject leads me to arrive at with regard to the origin and explanation of the mode of formation of these flint flakes are these: During the period of formation of our present raised sea-beaches, the men of that period resorted to the out-crop of the chalk for flint nodules, from which to manufacture their mallets, hand-axes, knives, rude spear- and arrow-heads, and other implements, and these are the *rejecta* of that manufacture during an unknown period, the localisation of the raw material conducing to the localisation of the worked implements, lost or rejected, and which was then covered by the sea, but which is now the land skirting the the present coast line.' These flakes are generally found close to the upper surface of the drift gravel, but at Ballyholme Bay near Bangor, they occur at a depth of from 6 to 8 feet from the surface, in stratified sand and gravel. On the beach under the cliff there is a submerged bog, with stems and roots of trees visible at low water.

Worked flint-flakes are also found on Reagh Island, in Strangford Lough, in a raised beach on the north of the island. About 1 mile north of Ballywalter, near Ballyferris Point, is a raised beach consisting of stratified sands and shells. It is about 3 feet above high-water mark."

Memoir Geological Survey of Ireland (Sheets 49, 50, and part of 61), 1871. The district considered is situated wholly in the County Down and along its eastern shore.

(p. 11.)—"The two islands of the 'North and South Rocks' lie off the eastern shore at a distance of about 2 miles, and are about the same distance apart. This outer coast has a very shallow sea-board, with numerous low sunken rocks, and being much exposed is dangerous to navigation. These islands are the most eastern limits of land comprised in the Irish survey.

"Along the western margin of Strangford Lough, the largest islands are to be found, viz., Islands, Taggart, More, Mahee, and Reagh, while many smaller ones are thickly dispersed all round. Extensive sandy and slob-lands occur surrounding these, the islands themselves being composed chiefly of rounded drift-hills, tailing off down to the water's edge. Some of these, on their exposed side, end abruptly in a steep escarpment, sometimes on the northern, and at others on the southern side. On none of these does rock *in situ* occur, while on those along the eastern side, the margins of the islands are formed of solid rock, with a central covering of drift. Strangford Lough is connected with the sea by a narrow strait about 5 miles long, and from half to three-quarters of a mile in average width."

(p. 12.)—"Near its exit occurs Rock Angus and several isolated rocks ('Pladdies') of a dangerous nature, and upon the bar (on which is always deep water) at times, a terrible sea breaks. Throughout the strait, a wide and deep channel exists, attaining a depth 26 fathoms off the Cloghy rocks, and 35 fathoms (or 216 feet) between Portancarlagh and Ballyhenry Bay. This strait has mostly rocky shores, and is kept clear by the scouring action of the tides, which here run with a very rapid current, at about 5 to 7½ knots an hour for ordinary tides, and up to 9 knots for some spring tides. In parts, the passage is contracted to comparatively small dimensions, the narrowest being between Isle-o'-Valla and Rue Point on Bankmore Hill, where it is only 1700 feet wide. This latter side being an obstruction of a projecting drift hill, is gradually wearing away, thus tending to widen the channel of this place. A little south of this, between Black Islands and Gowland Rocks, at low water, the passage is reduced to only 1000 feet, with a depth of 15 fathoms. Here there is a whirlpool. About half a mile to the southward occurs also a series of whirlpools of considerable size, where there is a depth of 26 fathoms, whose influence is felt for upwards of half a mile, and which are called "the Routen Wheels." Here a bad sea always prevails, and small vessels even hesitate to pass through them except at slack water. The roaring of these breakers is often heard for many miles distant. It is probably to some irregular or peculiar conformation of the bottom, with the rapid current flowing over it, that these are to be attributed. The width of the channel opposite Strangford to the southern end of the village of Portaferry, is a little under 1800 feet, or about ⅓ mile, and in part is 15 fathoms deep. The difference in time of high water at the bar and at the northern extremity of the Lough is nearly two hours."

The author gives an estimate of the quantity of water which passes through this strait in filling and emptying the Lough at each tide

(p. 13.)—"I may further remark, with regard to Strangford Lough, that we have evidences which would lead us to suppose that it differs very materially in its present state from what it originally was, that its very existence is probably due to its having been a "Geological basin" of limestone, of which traces are still to be found in the narrow skirting thereof at Castle-Espic, but which has all been removed by denudation and 'atmospheric solution,' and that instead of, as at present, being a lough connected with the sea by a strait, it was originally a fresh-water lake. (Note.—History does not state as much, but an old tradition seems to exist that such was formerly the case)."

Memoir Geological Survey of Ireland (Sheets 21, 28, and 29), (1876). The area forms a portion of the great volcanic region of the County Antrim bordering on the eastern coast.

(p. 21.)—"*Flint implements.*—Flint-flakes, celts, cores, &c., are found over the entire district, not only on that portion where the chalk is subjacent, but also on the high grounds occupied by the basalt. In many places the fragmentary chips are very abundant, such as on the chalk outcrop in Drain's Bog, as well as along the outcrop south of Glenarm, pointing out the locality where these implements were made.

Memoir Geological Survey of Ireland (Sheet 14), (1886). The district presents some of the most striking features in the scenery of County Antrim, and no one visiting it can fail to be struck with its fine headlands and deep glens opening out upon the sea-coast. The district included in the northern half of Sheet 14 extends from the River Bush, near Armoy on the west, to the sea-coast on the east at Cushendun, and southward to Red Bay.

(p. 9.)—"The coast line is, in general, bold and precipitous. North of Cushendall, south towards Glenariff, it is rather low and undulating, and exhibits some fine examples of the old sea caves of the

25 feet raised beach. They are to be seen at Red Bay Tunnel, and south of it excavated out of the New Red Sandstone—the principal one being called 'Nanny's Cave.' A little south-east of Cushendun, there are also some very fine and extensive sea-caves occurring in the conglomerates of the Old Red Sandstone. The raised beach itself ranges from the 25 feet to the 40 feet contour, and is well marked along the coast at several places between Cushendun and Glenariff, forming a slight escarpment or cliff of drift and rock along its course. The southern half of the sheet, has for its eastern boundary the shore extending from Red Bay to Glenarm Bay."

Memoir Geological Survey of Ireland (sheets 7 and 8), 1888. The district described extends along the coast of Antrim and Derry; it also includes the Island of Rathlin.

(p. 7.)—"The shore line from Portrush to Fair Head, east of Ballycastle, composed for the most part of cliffs formed of successive tiers of basalt resting on chalk, is generally bold, often inaccessible, more especially in the neighbourhood of Bengore Head, which rises to a height of 367 feet above the waters of the sea, where the celebrated Giant's Causeway makes an interesting geological feature. Striking as is the appearance of Bengore Head, it is completely surpassed by that of Benmore or Fair Head, rising 636 feet or nearly double the height of the former. This latter has a cap composed of a massive sheet of dolerite which, on the sea face, is broken up into great polygonal monoliths over 250 feet in length. At the base of this lofty cliff broken columns of basalt are confusedly strewn over the slopes to the waters edge, covering the underlying Carboniferous beds.

"The peninsula of Portrush lies in the extreme north-west corner of the county Antrim, and is fenced on its western side by perpendicular cliffs composed of a sheet of dolerite some 70 feet in thickness. The most westerly promontory is called Ramore Head. At a distance of half a mile north-east from Ramore Head, a chain of islands, sixteen in number, called 'the Skerries' commences, and extends in an easterly direction for about a mile and a half, forming a natural breakwater to the north Atlantic waves, which even in comparatively calm weather may often be observed breaking over the seaward faces of the Skerries and throwing the spray high into the air.

"The coast line at and west of Portrush consists chiefly of cliffs of basalt and dolerite, bounded at the base by a narrow uneven margin of the same rocks, indented by numerous small irregular creeks and bays. The surface at the top of these cliffs stands generally at a height of

25 to 40 feet above the sea, reaching, however, about 100 feet in the vicinity of Island Doo. This island is one of a number of outliers belonging to the basalt, which lie at a short distance out from the shore, some being separated from the mainland merely by narrow necks of water at full tide. The rocks are often traversed by fissures, some of them being open up to the surface so as to form 'puffing holes' or 'blow holes,' through which the air, accompanied by spray is projected with more or less force by the waves rushing into the cavities below. One of these occurs at Blackcastle rock close to Portstewart, the fissure here communicating with a cave which runs southward between the rock itself and the mainland. Another is found on an island south-west of Blackrock. Of the few caves that occur on this part of the coast, none are of large dimensions. Close to the ruins of Ballyreagh Castle, an opening of this nature runs in for about 18 yards, being 7 yards wide at the entrance and at most 7 feet in height."

(p. 9.)—"*Rathlin Island.*—Although so close to the mainland, Rathlin Island is very difficult of access, owing to want of proper harbour accommodation and the liability to dangerous seas due to tidal currents between the island and the mainland. The northern coast face, consisting of tabular and columnar basalt resting on chalk, is formed of bold, often inaccessible cliffs, between 300 and 400 feet in height, while along the opposite side of the island the sheets slope towards the south, and along their seaward faces, show a similar superposition of the basaltic and Cretaceous beds."

(p. 20.)—"The next westward outcrop of the chalk is to be found at low water on either side of Dunluce Castle; whence the rock gradually rises and forms a cliff at the 'White Rocks' of about 150 feet. This cliff as seen from the sea presents a varied aspect owing to the numerous caverns and fantastic forms into which the rock has been carved by the erosion of the sea, a process which is still going on."

(p. 21.)—"*Rathlin Island.*—The Chalk formation is the foundation rock of the Island of Rathlin: the thickness of the formation is about 220 feet, and is the greatest of the chalk either in Rathlin or on the mainland.

"Good sections of this division of the basalt (Lower Basalt) are exposed to view in the steep sea-cliff faces between Ballycastle and Ballintoy, in which latter direction it thins out to not more than a hundred feet or so; while in the vicinity of Ballycastle, the mass cannot be less than 350 feet thick."

(p. 24.)—"*Upper Basalt.*—Although most of the district is capped with sheets of Upper Basalt, the only good sections are to be found in the almost inaccessible cliffs east and west of Bengore Head. Here they form successive tiers of columns varying in size and sometimes in position. These tiers indicate successive outflows of lava. The most remarkable of them is the lowest of the series which caps the iron ore deposits, and forms the Giant's Causeway."

(p. 27.)—"*Rathlin Island.*—The Tertiary volcanic rocks here are well represented, and present very much the same section as they do about Bengore Head on the mainland. The best sections are seen from the sea, in the cliffs on the north side from Bull Point to the lighthouse.

"At Doonpoint there occurs a causeway in the Lower Basalt, and the longitudinal section shows vertically columnar basalt having fan-shaped and radiating columns of smaller dimensions blended into it from the top, showing that the two sheets amalgamated before cooling. Dr. Haughton notes of the rocks at Doon as follows: 'The curvature of some of the pillars is continuous through 90°, and they pass from the vertical to the horizontal position, exhibiting, however, a tendency to break at the point of greatest flexure, which has caused most of them to be broken off by the action of the sea.'"

(p. 28.)—"The Dolerite of Fair Head is probably of the same age as that at Portrush, but does not weather so rapidly. The Fair Head sheet is remarkable for its enormous thickness, presenting, as it does, an unbroken columnar face to the sea, near the 'Grey Man's Path' of 250 feet.

"At the base of the basaltic cliff at Fair Head an intrusive sheet of columnar basalt 70 feet thick occurs; and in its extension it is met with at Drumnakill Point, to the south, where the columns are scattered in all directions."

Mr. Symes regards the Dolerite of Fair Head as possibly the latest volcanic protrusion in the county Antrim.

(p. 31.)—"*Volcanic Vents.*—One of the most remarkable volcanic vents in the county Antrim is situated at the well-known island of Carrick-a-raide and the adjacent coast, a fine view of which can be had from the celebrated 'swinging bridge.' This old neck cannot be less than from 1000 to 1200 feet in diameter, and is filled up with massive, coarse, and tough grayish volcanic agglomerate, enclosing large irregular masses and smaller fragments of basalt, basalt bombs of all sizes, and chalk pieces occasionally."

(p. 34.)—"*Peat Bogs and Alluvial Flats.*—A deposit of peat projects from beneath the blown sand, and follows the slope of the strand for a short distance seaward, at the point where the county boundary terminates a little south of Portrush. It is partly covered at high water, during which, in rough weather, masses of it are torn away and carried out to sea. The peat contains hazel nuts, portions of small branches, leaves, and the elytra of beetles. The presence of this peat, within range of the sea-action, may indicate a subsidence of the land within very recent times. Similar instances are to be observed at various points of the Irish coast.

"*Raised Beaches.*—These occur at Portrush, Port Ballintroe, Rathlin Island, and the Giant's Causeway. Professor Hull has recognised the raised beaches of the county Antrim as the representatives of the '29 feet beach' of the opposite coast of Scotland."

(p. 35.)—"The shores of White Park Bay and the coast-line north-west of Ballintoy exhibit examples of the raised beaches and their associated old sea-caves and sea-stacks (see fig. 7).

"Prehistoric remains have been found in abundance on the raised beach platform of White Park Bay, consisting of worked flints, stone hammers, corn crushers, fire hearths, pottery, etc., and the bones of various animals; also 'kitchen middens' of shells and ashes.

"*Caverns.*—The Chalk at the White Rocks is penetrated by numerous caves at different elevations, but none of them extending any great distance. Under Dunluce Castle a cave runs through the entire rock; this is probably artificial, and could easily have been excavated, owing to the spheroidal nature of the rock. At the Giant's Causeway are two caves in the Lower Basalt at the sea-level; and in Rathlin Island four have been noted by Mr. Andrews, the lengths varying from 150 to 250 feet.

(p. 37.)—"Among the sandhills in the town of Portrush, a gale recently exposed a Prehistoric hearth, in which were pieces of pottery, numerous flakes, and cores of flint, and a few bones. The flakes are remarkable for their freshness; wherever else found the majority of them are porcelainized or weathered.

Memoir, Geological Survey of Ireland (Sheets 12 and 6) (1885).

(p. 5.)—"The district described lies entirely in the county Londonderry, except a small area to the north-west of Lough Foyle, which belongs to the county Donegal. The greater part of this district have been described by General Portlock in his geological report on Londonderry and parts of Tyrone and Fermanagh (1843).

"Lough Foyle occupies a considerable area in the central and western parts of this district, dividing the portion in the county

Donegal from that in the county Londonderry. The former, which is very small, is part of the peninsula of Inishowen.

"The county Derry portion of the district is characterized by the extensive plains that border Lough Foyle; the lowest of which is a raised beach, bounded on the sea-side by large tracts of reclaimed land or intakes."

(p. 6.)—"The high ground in the east of sheet 12, with its continuation in sheet 6, is underlaid by the basalt which forms the great Tertiary plateau of the counties Antrim and Derry. The boundary of this volcanic area is here, as in other parts of the district, often characterized by bold, precipitous cliffs, which, towards the north, assume magnificent proportions, and are accompanied by huge landslips of comparatively recent date. The rugged masses thus torn away, rise sometimes in sharp pinnacled forms in front of the steep face of solid rock, and are separated from it by a gap, strewn with blocks that have fallen in large numbers on either side.

"The bold outline, which thus denotes the boundary between the Secondary and Tertiary formations, passes northwards and eastwards, with a wide sweep into sheet 6, accompanied by a gradual descent towards the coast. Here, at the east of Umbra, it consists of a steeply-receding cliff of chalk and basalt, about 500 feet in height, supporting a mass of boulder clay, which stands piled up against the escarpment for a height of nearly 300 feet."

(p. 7.)—"East of Umbra the boundary of the basalt follows the coast-line for a short distance, bending out below the sea, within a mile of Downhill; while beyond this point, and as far eastward as the locality just named, nearly perpendicular crags, composed of basalt, with some beds of ash, overhang the shore, skirted for half their height by an accumulation of blown sand, resting on boulder clay, and in some parts barely upholding ponderous semi-detached masses of rock, which seem ready to fall from their position.

"From Downhill eastward to Castlerock, the cliffs directly overlook the sea, having a more irregular and rugged outline, owing to the constant and frequently violent action of the waves, which are at the present day hollowing out caves in the basalt. Similar openings, standing at a somewhat higher level, and dating back to the period of the adjacent raised beach, occur in the chalk between Downhill and Umbra; whilst, in some instances, as at Backaunaboe ('the tether-stake'), a little east of Downhill railway station, the conditions seem to point to a continuous drilling action carried on from that day to the present. The above name is given to a sharp sea-stack, composed of amydaloidal basalt, standing out from the cliff at the western end of the temple tunnel—a remnant of the northern wall of a spacious cave, the eastern portion of which is still to be seen penetrating the rock for a short distance (see fig. 1)."

(p. 8.)—"The raised beach, traces of which exist at various places around the coasts of Derry, Antrim, and Donegal, and which represent the 25 feet terrace of the western coast of Scotland, here extends inland as far as the margin of drift composing the sloping ground west of the basalt escarpment."

(p. 26.)—"*Raised Beach.*—An extensive raised beach, at an average height of about 25 feet, fringes the southern and eastern shores of Lough Foyle, extending to Bellarena and Magilligan, where it has a width of from two to four miles. It is also seen on the north-western shore in Donegal, where, owing to the nature of the ground, it is much narrower, being only a quarter of a mile wide at Quigley's Point.

"The Robbers' Cave and the Pipers' Cave, which penetrate the Chalk at about one or two hundred yards, respectively, east of the stream that joins the sea a little east of Umbra, in Sheet 6, standing at about the 25 feet contour line, belong, no doubt, to the period of this raised beach. These openings were occasionally within reach of the waves, during the prevalence of storms, till the construction of the railway presented a barrier; and the floors are now strewn with rolled blocks and pebbles of basalt and broken shells. In a place where the basalt is laid bare among the sand dunes, 400 yards east of Castlerock, at about the level of the 25 feet contour line, the surface of the rock bears clear evidence of the rounding action of the sea, and the crevices are filled with sand and shell fragments—probably remnants of an old beach."

Memoir of Geological Survey of Ireland, Sheets 1, 2, 5, 6, and 11 (in part), (1889).

(p. 9.)—"The district described forms a remarkable promontory, bounded on either side by Lough Swilly and Lough Foyle, and jutting out far into the Atlantic Ocean, where it terminates in the cliffs of Malin Head. Though not actually an island, as its name indicates, being connected with the mainland by a neck of alluvial soil, yet the name is not without significance, as pointing to the inference that within the historic, or at least traditionary, period it may have been really an island, at least during high tides. As a physical fact, the narrow neck by which the promontory is united to the mainland, though about 8 miles from shore to shore, is formed of an old sea-bed, which has been elevated into land, certainly in very recent times, and in all probability within the period during which Ireland was inhabited by Celtic tribes. It corresponds with the well-recognised '25 feet raised beach' of our northern coast. This narrow strip, along which the railway from Londonderry to Buncrana is carried, has an average elevation of from 20 to 25 feet above Ordnance datum, and only for a short distance, near Pennyburn, is the level materially exceeded, the ground rising to 50 or 54 feet above Ordnance datum, or 41 to 45 feet above mean level."

(p. 10.)—"But the island of Inishowen, thus constituted, seems to have been itself a double island, owing to the existence of a second narrow strait by which it was crossed at the period above referred to. Between Culdaff Bay, on the east, and Trawbreaga Bay, on the west, there stretches a low neck of alluvial land, deeply covered with peat; and, during the period of depression, this was overflowed by tidal waters, as the old sea-bed, consisting of sand, silt, and gravel, well seen in the neighbourhood, underlies the peat, which has grown over the surface since its elevation into land. The highest level of this alluvial tract is 50 feet above Ordnance datum, or 12 feet above high-water of ordinary tides, and of this, probably, 10 or 12 feet consists of peat. At its western end this strait communicated with the ocean both to the north and south of Doagh Island, which is at present connected with the mainland by a bar and sand-dunes forming the shore of Pollan Bay.

"(Note.)—Dr. Sigerson (Proc. Roy. Ir. Acad., 2nd ser., vol i., p. 212, *et seq.*) has adduced historical evidence in confirmation of the statement that Inishowen was an island, not only within the period of human habitation, but within that of history. In the maps of the Escheated Counties of Ireland (1609), of which facsimile copies were taken at the Ordnance Office, Southampton, in 1861, a strip of water is shown connecting the Foyle and the Swilly loughs across to the north of the 'City of Derrie,' just where the raised sea-bed occurs. Another strip of water is shown, stretching from the 'Lake of Loughfoile,' near Saint Johnstown, to the inlet of the Swilly, near Castle Hill. Derry itself stood on an island before the last elevation of the land as a strip of water, recently a morass, bounded the hill on which the old city is built, on the west. Sigerson quotes passages from the 'Annals of the Four Masters,' of the dates A.D. 1211 and 1010, in which the name island is applied to the present promontory;

thus, in the latter case, the quotation runs:—'A.D. 1010, Œngus O'Lappan, Lord of Cinel Enda, was slain by Cinel Eoghain of the Island,' *i.e.* Inishowen. Thus historical evidence concurs with that derived from an inspection of the physical conditions, that Inishowen was actually an island up to within very recent times. The raised beach referred to is in reality a representative of that of Kilroot and Larne, containing numerous worked flints, and of the 25–30 feet raised beach of Scotland, in which several canoes and other works of human art have been found." (See J. Geikie, "Great Ice Age," p. 311, &c.)

(p. 10.)—"The promontory of Inishowen, as now constituted, is exceedingly hilly, and consists largely of rocky ground, covered by heath and mountain bog. Its culminating point is Slieve Snaight (= 'Snow Mountain'), a quartzite mountain, which rises from the centre of the promontory to an altitude of 2019 feet above Ordnance datum. The most prominent feature is the grand quartzite ridge of Raghten More, which traverses the western portion of East Inishowen between Dunree Head and Pollan Bay, and reaches an elevation of 1655 feet. Thus, although of no very great elevation, this mountain ridge, owing to its position as rising abruptly from the Atlantic, and breaking off along its western slopes in a naked wall of quartzite, conveys to the mind an impression of massiveness which is not altogether dependent on its altitude."

(p. 11.)—"The coast-line of Inishowen is generally rocky and precipitous, except along the margin of Lough Foyle, and the inlets through which the principal streams make their escape into the ocean. The northern coast is particularly bold, the cliffs often rising to heights of 500 or 600 feet, and at 'the Pounds,' north of Glengad Head, to a height of 802 feet above Ordnance datum. Malin Head (fig. 1), although the most projecting point of the coast is comparatively low (125 feet); but Dunaff Head, at the entrance of Lough Swilly, presents to the Atlantic waves a bold wall of granite and quartzite of over 600 feet in height."

(p. 13.)—"*Islands.*—Several islands rising from the Atlantic lie at some distance off the coast of Inishowen. The largest of these is Inishtrahull (fig. 3), a rocky mass, nearly a mile across from east to west, formed chiefly of gneiss. Some dangerous rocks, called 'The Tor Rocks' (fig. 2), rise above the surface a mile north of Inishtrahull (= 'Island of the big strand').

"((Note.)—Inishtrahull means the 'Island of the Big Strand,' *Inish* = Island; *tra* = strand, and *h-ull*, an old and uncommon Celtic word for big or large.[1] There is actually no very big strand at the present day, as I am informed by Mr. Cruise, who geologically surveyed the island; but there is a raised beach extending right across the western side of the island, now about 50 feet above Ordnance datum, or 30 feet above high-water mark, and it is not improbable that at the time the island received its name this may have been a big strand in the ordinary sense of the word.)

"The Garvan Islands form another group of rocky islets, three in number, rising about a mile from the coast of Malin Head, and formed of quartzite, while another small islet, called Glashedy Island, lies a mile off the coast in the bay between the prominences of Dunaff Head and Malin Head. This island is formed of quartzite."

(p. 22.)—"At Glengad Head crumpled micaceous schists form a vertical cliff, 200 feet high; sections in similar beds are also freely exposed along the coast line to their junction with the quartzite."

(p. 26.)—"*Moville District.*—This tract of country is as wild and rugged as almost any part of Donegal, the coast line being bold and precipitous, except on the south-east along the shore of Lough Foyle. On the north the sea-cliffs reach a height of 400 and 500 feet, and are in but few places accessible except by boat."

(p. 33.)—"For some three miles south-west of Moville, a line of gravel cliffs at an average height of about 50 feet borders Lough Foyle, and similar though smaller deposits may be observed on the shores of Lough Swilly.

"*Raised Beaches.*—An extensive raised beach, probably the representative of the 25 feet beach of Scotland, borders the alluvial plain south-east of Inch Island, continuing to the south-west along the valley between Carowen and Burt, opening into the Blanket Nook, while to the east it occupies the valley that extends from Burnfoot, in a south-easterly direction to Pennyburn, the average height observed being 32 feet. At Farland Point, south of Inch Island, and along the coast of Lough Swilly, south-westwards, portions of a raised beach at the same elevation remain. Small portions of a raised beach are also seen on the southern and eastern shores of Inch Island, and a more extensive one stretches along the shore of Lough Swilly for about a mile and a-half north of Fahan to Buncrana."

(p. 34.)—"On Inishtrahull a fine example of a 50 feet raised beach occurs in the centre of the island. The lightkeeper informed me

[1] "Hulk" is a word still used among country people in the north of Ireland to mean a big lazy fellow.

that in the year previous to my visit, 1885, during a gale from the north, this beach was covered with water for over two hours.

" On the mainland from Malin Coastguard Station a raised beach extends for two miles to the south, being sometimes one mile wide. This beach was at one time covered with bog, which is now nearly all cut away. At Malin Watch Tower there are fine examples of the 25, 50, and 75 feet raised beaches. Along the shore to Malin Head numerous patches of the 50 feet beach may be observed between the rocks. The most important and extensive, however, of these raised beaches is that which stretches from Culdaff to Tranbreaga Bag. Its average height is about 50 feet, and most of its surface is covered with bog, which is being rapidily cut away. Another extensive raised beach stretches from Tullaghan Bay to Leenan Bay, the bog that formerly covered this beach being nearly entirely removed. As pointed out by Professor Hull, both these raised beaches are of a comparatively recent date.

"Along the south coast, between Inishowen Head and Moville, the 50 feet raised beach occurs in several places. It consists of sand and gravel, and is best seen between Greencastle and Inishowen Head. Shells of existing species are common throughout the deposit. At Tremore, Kinnoge, and Glennagiveny bogs, the 25 feet beach is represented, and contains shells at each place."

(p. 34.)—" *Kitchen Middens.*—Associated with the raised beach, mounds and accumulations of shells occasionally occur, which must be regarded as of human origin, inasmuch as flint flakes, fragments of bone, and burnt wood are often found in them. They were observed on the shore north and north-west of Ballymoney, in the Carowen district, at Fairland Point, at Inch Island, near the old castle of the South, and at Inch Road railway station."

Memoir Geological Survey of Ireland, Sheets 3, 4, 5 (in part), 9, 10, 11 (in part), 15 and 16 (1891).

The region described in this memoir includes all the tract lying between Lough Swilly on the east, Gweebarra Bay on the west, and the Atlantic coast, which connects these two inlets along the north. It is the most mountainous portion of Donegal, and from its centre rises the culminating height of the north of Ireland, the twin-peaked Errigal, which attains an elevation of 2462 feet above the surface of the ocean. Its coast line is indented to a remarkable extent, and along the west is broken up into numerous rocky islands.

(p. 8.)—" Errigal is certainly the most perfect pyramidical mountain in Ireland, perhaps in the British Islands, and is a conspicuous object far out at sea from the decks of ships approaching the north coast of Ireland from the Atlantic."

(p. 14.)—" *Sea Loughs.*—The coast between Lough Swilly and Gweebarra Bay is deeply indented by several bays and sea loughs, of which Milroy Bay and Sheep Haven are the most important. The latter is a broad bay, the entrance to which is bounded by the bold cliffs of Horn Head on the west, and by the less elevated coast of Doagh on the east."

(p. 15.)—" *Islands.*—In addition to Horn Head, which is an island, there are several islands lying off the coast of north-western Donegal requiring special notice. Of these, Tory and Aran Islands are the most important.

" Tory Island, in ancient writings Toirinis and Torach, 'the Island of Towers,' is remarkably distinct when viewed from the mainland between Dunfanahig and Cross Roads. It lies at a distance of about eight miles from the coast of Horn Head, the bottom of the sea descending to 24 fathoms. Along the north-east, the island presents a bold front of naked rock towards the Ocean; but on the south side the wide bay of Camusmore affords shelter and anchorage for ships and fishing boats. The western shore is shelving, and is lined by a remarkable shingle beach forming a natural breakwater, and giving evidence from its extent of the force and sweep of the Atlantic billows when impelled by the prevalent westerly winds.

"*Aran Island.*—This is a large island separated from the mainland by a sound about half a mile across.

" The numerous rocky islets lying off the coast between Gweebarra Bay and the Bloody Foreland are all formed of granite."

(p. 17).—" As regards the occurrence of pebbles of granite, &c. in the quartzite, and limestone, it is believed that they have been derived from rocks older than the granite (not improbably of Archæan Age), and now submerged beneath the waters of the Atlantic."

(p. 72.)—" *Bloody Foreland District and adjoining Islands.*"

(p. 73.)—" Rugged cliffs, sometimes 100 feet in height, bound Gola Island and Umfin Island, especially on the west. These are penetrated by sharp fissures, hollowed out along the joint planes, so that, in some cases, one side overhangs the sea at an angle of 70° or 80°. Natural arches also occur, as at Scoltydoogan, north of Gola Island, where a small inlet, entered by a narrow gully, communicates with the sea by means of an arched passage about 40 yards in length, at a depth of 70 feet below the surface of the ground. At Scoltaglassan, nearly half a mile east of Torglass Island, a narrow inlet between steep walls of granite, has been hollowed out by the sea along a line of fissure, now partly filled with broken rock and boulder clay. This break, which is accompanied with little or no dislocation, seems to run across the western part of the island, appearing again at Scoltnalinga north of Allagh Island. A small arch occurs in the prolongation of the same line east of Tornamullane, forming a gully with an overhanging eastern wall 50 feet high, that on the west, reaching 80 or 90 feet."

(p. 74.)—"Umfin Island has an exceedingly irregular outline, and is bounded by steep rugged cliffs, pierced by caves and natural arches. At about 50 yards from the extreme western point, one of the arches runs north-north-east, along the lines of jointing quite through the promontory. It has a length of 60 or 70 yards, and the opening forms a conspicuous feature as viewed from Gola Island. A cave 70 yards in length cuts through the northern part of the island."

(p. 74.)—"The main portion of the granite on Inishbogin (Sheet 3) is coarsely crystalline, and it is sometimes largely porphyritic. The junction with the schists is clearly traceable across the highly glaciated surfaces of the latter on the north coast of the island. At Illanamarve, the shore line is broken by deep narrow inlets, one of which is spanned by a natural arch, the apex being formed of a band of fine-grained schistose granite, 4 yards wide."

(p. 75.)—"*Rosguil District.*—The northern portions of this promontory are mainly composed of granite, which has been intruded amongst the metamorphic rocks. It has been intruded amongst quartzites generally, and along the coast of Doagh Bay, breaks across them in numerous dykes and off-shoots, which are visible in the coast cliffs.

(p. 84.)—"*Gweedore and Aranmore Districts.*—Numerous dykes of felstone penetrate the granite and metamorphic rocks, chiefly in the rugged area south of Inishfree Bay and in the western half of Aran Island. Variations of colour and character are frequently noticeable in the same dyke; and the felstone forming the dykes of this and other localities, in this portion of the district, weathers rapidly into cream-coloured or light brown kaolinized rock. North of Kincaslough, the dykes consist usually of dark-brown rock, with pink felspar crystals porphyritically developed, dark mica, and occasionally blebs of free quartz. The trend here is mostly northerly. Caves and precipitous inlets mark the point of the coast line where such dykes exist, as at Scalpnadinga and Illion in Aran Island, and at the northern extremity of Cruit, near Owey Island, a dyke of coarse-grained gray porphyritic felstone 15 feet wide, has originated a cave with a blowing hole at its inner extremity. The erosion within has been so extended as to form a natural bridge, so that the roof of the former cave forms a natural bridge over the narrow inlet to the space within as represented in the wood-cut (fig. 17)."

(p. 87.)—"*Fanad District* (*Diorite and Epidiorite*).—Commencing at the northern part of Fanad Head, we find an irregular mass of dark-bluish evenly crystalline diorite, forming a small boss. South of this boss at Bonnaweelmore, another large mass of finely crystalline diorite extends from the shore inland, apparently bedded in the quartzites, seen in cliff section. Along this coast there are several fine sea-stacks formed of these rocks, notably that of Stookmore, or Brown George, inside Swilly Beg."

(p. 88.)—"From Illanmore to Lee Point, numerous dykes and irregular masses of diorite occur, sometimes following the bedding of the rocks, and at others crossing it. They are all of a dark greenish colour with varying degrees of crystallization. At the 'Seven Arches' several dykes of diorite occur, weathering freely, but the 'Arches' are formed by the weathering of the quartzites along joint planes and planes of bedding."

(p. 89.)—"From Ardbune Point in Caffard Bay, a well-defined diorite dyke averaging 400 feet in width, can be traced almost continuously in a south-east direction, from the eastern to the western shores of Mulroy waters. It forms the elevated peak called Cashel Fort, 496 feet, a striking feature in the landscape."

(p. 93.)—"*Horn Head.*—The diorite of Horn Head occupies a considerable area of the more rugged portions of the promontory. Sections in the cliffs, which from the coast line show that this rock has been to a large extent intruded between the beds of quartzite among which it can be traced in dark bands, varying in thickness and conforming in general direction to the lines of outcrop. In cases where it has crossed the bedding horizontally, or nearly so, and the upper portion of the quartzite has been denuded away, the diorite appears in section as a cap resting on the truncated portion below. South of Traglish Point the diorite ranges up among the quartzite beds to the top of the cliff, a height of about 600 feet in a mass, 60 or 70 feet in width."

(p. 97.)—"*Bloody Foreland District.*—A very conspicuous dyke of columnar dolerite 4 yards wide cuts through the schists west of Curran's Point (Sheet 9), where it is shifted for a distance of 25 yards by a fault. It appears again to the north-west, penetrating both the schist and a tongue of granite, and forming the wall of a chasm about 20 feet deep, at an inclination of 15° from the vertical."

(p. 98.)—"A dyke of fine dolerite reaching 4 yards in width, passes by Lough Aninver on the mainland north of Gweedore Bay. It is in some parts porphyritic with large crystals of felspar."

"Two separate rocks, rising from the sea, in nearly the same line and distinguished by their dark colour, are prolongations of this dyke.

"*Tory Island.*—Tory Island in the Atlantic Ocean, is situated due north of the coast of county Donegal. It is about eight miles distant from the foreland, and lies a little to the east of north from that headland. The distance from the boat slip at Magheraroarty is nine miles, and from Dunfanaghy, around Horn Head to the same part of the Island, about 16 miles. The Islands of Inishbofin, Inishdooey and Iuishbeg lie between Tory Island and the mainland, the farthest north, viz. Inishbeg, being about half-way across.

"The Island of Tory is a narrow strip of rocky land lying with its longest diameter of nearly three miles in a north west and south-east direction."

(p. 99.)—"At its widest part, viz. at the north west extremity, it is less than a mile in width, and at the narrowest part, *i.e.* just east of Westown, or about the middle of the Island, it is only one-fifth of a mile across, its average breadth being about half a-mile.

"The natives always speak of it as Tor-i, and this would appear to be the most explicit manner of spelling, to be in consonance with the derivation of the name.

"This island was anciently the stronghold of the Formorian pirates, whose chief was Balor, 'and two of the tower-like rocks on the side of Tory are still called "Balor's Castle" and "Balor's Prison."' Of the former of these, there remains but the site. As it was situated at a very narrow isthmus which is the only passage from the main portion of the island on to the Doon peninsula (where peat is cut for fuel), it is probable that the islanders have removed the building. The highest point on the island, viz. Doon Balor, 282 feet above sea level, is situated at the north end of this peninsula and in the cliffs further south, was 'Balor's Fort.' Around Westown are several not too well preserved monuments of ancient worship—as St. Columbkille's Church, St. John's altar and cross, another altar, a grave, Temple Anvoresher, or Church of the Seven, and a Cloigtheach, or round tower. This latter is the only one that is well-marked and preserved."

(p. 100.)—"The outline of the island as seen from the south, although very much broken and irregular, presents a general inclination from the west to the east. To the south and south-east of the lighthouse at the north-west extremity, the land is very little raised above the sea level, to which it runs down by a gradual slope, being at its junction with the shingle beach which forms the south-west part of the shores, but 26 to 30 feet above the sea. The whole of the southern and south-west half of the island is comparatively flat and lowland, and rises with somewhat rapid slopes to the north and north-east terminating in precipitous cliffs, from 100 to 280 feet in height. The north and north-east coast line, in marked contrast to the south and south-east shore line, which is but slightly indented, is more irregular, being carved into a multiplicity of minor headlands and points and many varieties of inlet, creek, and cave.

"Owing to the irregularities in the sea-cliffs, the coast presents the appearance of numerous tors or isolated crags, standing up as if occurring in the centre of the island.

"Tory Peak (see fig. 21) is a most prominent feature in the outline of the island, appearing like a great tower standing about the centre of the island. It is in fact a partially detached sea-stack on the north-east coast, near the east end of the island. A wide bay is cut far into the land south of this peak at Scoltshoarsa; and the land about East Town, lying very low, permits nearly the whole of this huge mass of rock to be seen from the south. Similarly Tormore or the great Tor, which occurs at the north extremity of the Doon peninsula and which, in common with the latter, runs out to north-east at nearly right angles to the main island, appears as a massive tower, at the eastern extremity of the island, the whole of the 'Anvil,' as the ridge is called, being foreshortened into one mass. The whole of the Doon, which rises rapidly from the sea level at Port Doon to nearly 300 feet, also is foreshortened into a craggy or torlike mass."

(p. 102.)—"From the extremity of Doon Balor, a fine view of the whole island is obtained, and on a clear day nearly all the northern cliffs are seen from this position, with the lighthouse distinctly prominent at the western extremity of the island (fig. 22).

"*Granite.*—The greater part of the island consists of granite which varies greatly in texture, being at one part a massive compact durable rock, and at others, where porphyritic, much more decomposable than in the former case. At the north-western extremity at Toradardeen, the rock occurs in irregular amorphous masses. Along the sea-cliffs, the rock appears as a highly porphyritic gray granite with the weathered surface thickly studded with crystals of orthoclase. The shore is much indented.

"East of the promontory of Ardlaheen, the rock still maintains its coarsely crystalline character. A set of very distinct, nearly vertical cross-joints, running south-west occurs here, traversing the reddish and grey gneissose granite. The direction of these points nearly coincides with that of the promontories and inlets in this locality."

(p. 104.)—"Along the south-east face of Meggart Headland a basalt dyke about 2 feet thick occurs, and thins out before reaching the top of the cliff. A large basalt dyke, 10 or 12 feet wide, occurs to the north of this, and is continued into the north-west face of Morard Head, where it is weathered out and forms a cave.

'At Pollabraher ('Wolf's hole'?) the sea has cut through the small headland, forming a natural arch, and inland occurs the cave Lagrehy (or Ram's cave), which is a round or oval shaped pit, like a quarry hole, and has been formed along vertical joints running east north-east. It communicates with the sea by an underground passage, and is cut out of the granite, which has slipped in and been carried away as shingle. Torbanny, which is a small sea-stack, rises to the eastward.

"Along the western side of the island, a very well-marked shingle bank forms the margin. It consists of rounded blocks of quartz, a few of hornblendic and augitic rocks, and the rest of gray granite.

"To seaward of this bank a fringe of rocks but little elevated above the sea level, consists uniformly of grey and reddish granite."

(p. 105.)—"The quartzite in Port Doon dips generally to the eastward at angles of 20° to 30°. It is intersected by numerous vertical joints, running south 30° east, along which the island rock, Torahaur, which stands as a sentinel at the entrance of this little natural harbour, has been cut off from the mainland."

(p. 106.)—"Northward, from Port Doon, the ground rapidly rises, and the rock in the cliffs consists of white tabular and flaggy quartzite, dipping east 10° north at 20°. The coast-line is most irregular and deeply carved into bays, together with headlands and numerous sea-stacks. These cliffs end in a remarkable narrow ridge of rocks named the 'Anvil,' which terminates at its northern extremity in Tormore. A channel has been cut through by the sea at the southern end, where this ridge is connected with the mainland by a natural arch.

"Along the western shores of the Doon the rocks preserve the same general easterly dip, and exhibit various sea-stacks or tors; a rather picturesque one being Tornaweelan, which stands at the entrance to Portachalla Bay. In the southern cliffs of this bay and on the shore occurs a considerable deposit of pipe-clay, though of a very impure sandy nature. It is at least 12 feet wide, extends to the summit of the cliff, and is nearly vertical."

(p. 109.)—"*Bloody Foreland District.*—Deep deposits of boulder clay, often covered by several feet deep of peat, are seen in section in the cliffs of Bloody Foreland, and the coast lying to the east. The face of the cliffs is often cut by narrow gullies, worn by small streams, which become swollen in rainy seasons. Large blocks, fallen from the boulder clay, sometimes strew the shore, one of which, close to Meenlaragh, composed of granite was found to measure about 15 feet by 12 feet by 9 feet."

(p. 110.)—"Deposits of peat occur at several points along the coast, which lie wholly or in part below high-water level, such as north of the Gweebarra R. near Dooey Hill, and south of the estuary at the Black Strand."

(p. 111.)—"A peat deposit, evidently grown *in situ*, has been observed below high-water mark on the ocean side of Inishfree Island on its south side. Fragments of peat, washed up by the waves when more than usually large, strew the Leabgarrow strand on the east side of Aranmore, and the peasantry speak of the possibility, not very long since, of crossing to Rutland Island at low water.

"This seems, therefore, strong evidence for a recent submergence of the land to some extent. Mr. Harte in his Paper (Journ. Roy. Dub. Soc., Dublin, vol. i., pp. 25–27) speaks of 'forests that are under the sea' which 'may be very extensive.'"

(p. 112.)—"Remains of peat bogs, now covered by the tide, frequently occur along the coast, at Ballyness Bay near Falcarragh, Gortahork, and Ards Point. This submergence constitutes proof of depression of the land during a recent period.

"*Dungloe District.*—Large accumulations of drifted sand are to be met with at several points along the coast, frequently forming dunes, as at the mouth of the Gweebarra River. The drifting sand has been disastrous to a village which formerly constituted an important fishing-station on the east side of Rutland Island. The sand now almost covers the desolated habitations.

"((Note.)—Mentioned by the late Lord George Hill in the second part of his elaborate 'Hints to Donegal Tourists' (1846–7). Rutland, his Lordship stated, was a green island until forty years before the date of his publication (1806–7), was then a military station with 'good houses' and 'quite a gay place.'")

(p. 113.)—"In Skull Island (Inishcoole) human remains lie entombed in blown sand, as noticed by the late Mrs. Craik (in an 'Unknown Country': an illustrated account of a tour in Donegal).

"*Fanad District.*—Examples of raised beaches are found all round the northern coast from Ballymastocker Bay, on Lough Swilly, to Mark's Point at the 'Narrows' on Mulroy waters.

"At Ballymastocker Bay a fine example may be seen of an old sea-cliff, 1000 feet inland from the present tidal flow. It is semicircular, and about 50 feet high; the space between it and the sea is filled with sands which, in places, are becoming cemented together. Evidence of a raised beach can also be seen at Sessiagh Bay, and to the south at Doaghmore Strand."

Memoir, Geological Survey of Ireland, Sheets 22, 23, 30, and 31 (in part).

(p. 7.)—"The district described in this memoir comprises the south-westerly portion of the county Donegal, lying to the north of Donegal Bay, and stretching along its western margin into the Atlantic Ocean. Along its coast-line it is indented by numerous bays with intervening headlands."

(p. 10.)—"*Sea-cliffs and Headlands.*—The promontory of Banagh generally presents a bold and rock-bound coast to the Atlantic, deeply indented with bays and gullies, and often rising in cliffs several hundred feet above the surface of the ocean. Along the southern shore of Loughros Beg Bay, the quartzite cliffs rise from the ocean in a steeply sloping wall, 500 feet in height; and some distance further west, under the summit of Slieve Tooey, a nearly vertical wall of the same rock descends a thousand feet from its edge to the surface of the waters. At the head of Tormore Bay, still further west, the cliffs are almost equally lofty and steep; and all along the coast to Glen Head they break off with faces several hundred feet in height. Glen Head is a remarkable cliff, almost vertical, with a descent of 600 feet, surmounted by a tower, built as a watch-tower in the time of the Spanish Armada. The long ridge of quartzite, which bounds the valley of Glencolumbkille on the south, here breaks off abruptly; and along with the cliffs terminating at Doon Point, encloses a little bay, at the head of which are masses of shingle, piled up by the powerful Atlantic waves when impelled by westerly winds. The force of these waves must be sometimes prodigious; but their destructive effects on the quartzite rock, which is naturally brittle, are somewhat lessened by the occurrence of intrusive sheets and dykes of epidiorite, which help to bind together, as with bands of iron, the masses of natural masonry of which the coast is constructed. Malin More headland, formed of tough schistose rocks, though not very lofty, seems to have been able to resist the force of the waves better than the cliffs of quartzite, as it projects much further out into the ocean, than the adjoining parts formed of the latter rock; and the same statement holds good with reference to the promontory of Malin Beg to the southward. This headland is, however, somewhat protected by the group of islands formed of felstone porphyry, of which Rathlin O'Birne Island is the largest. All along this part of the coast the rocks are fissured, faulted, and thrown into numerous sharp folds.

"From Rossarrell Point, as we proceed southwards, the coast cliffs retreat inwards, and gradually become more and more lofty and precipitous till they culminate in that magnificent wall of natural masonry, which descends from the summit of Slieve League to the surface of the ocean, through a height of nearly 2000 feet, and stretches in an unbroken sweep from north-west to south-east through a distance of about three miles. The greatest elevation of this stupendous cliff occurs immediately below the summit of the mountain, which reaches a height of 1972 feet, though here the actual cliff is only 1650 feet in depth, the remaining part consisting of slopes; and from this the crest gradually descends in either direction, till at Bunglass Bay, near the southern extremity, the cliff is about 1000 feet in height. The cliff is formed of successive courses of quartzite and schist, variously coloured, yellow, red, and gray, with a gentle dip southward, or rather towards the south-east, along the northern and central part of the escarpment, but becoming highly inclined and even vertical, where the bay sweeps round to the west at Bunglass, where it is surmounted by the cliff called 'The Eagle's Nest.'"

(p. 11.)—"At the base of the vertical cliffs of Bunglass Bay a shelving shingle beach slopes downwards into deep water; and, standing on the edge of the cliff, you look down into the clear green waters of the ocean from an elevation of 800 feet, and again upwards to the cliffs above, rising to a similar height. This great sea-wall of metamorphosed strata has attained its present dimensions, both in length and altitude, by the gradual undermining of the base, where the surf is always breaking, and against which, during storms, the waves beat with terrific force, as exposed to the full sweep of the Atlantic waters. It would appear from the position of the summit of the mountain immediately over the cliff, and from the direction of the contour lines, as shown in the map, that the cliff has now reached its maximum of elevation. When the work of excavation has proceeded for some distance further, the height of the cliff will gradually lessen, owing to the fall of the ground inwards. Among the coast cliffs of Ireland, and perhaps of the British Isles, there is none which reaches in loftiness that which presents its face to the Atlantic along the western flank of Slieve League, and which forms a breakwater not unworthy of the great ocean which washes its base.

"This coast, indeed, from Carrigan Head to Donegal, consists of a succession of deep bays, with proportionately long intervening headlands."

(p. 12.)—"East of the promontory of Carntullagh lies McSwyne's Bay, separated from Inver Bay by the long and narrow promontory terminating in St. John's Point, which, owing to its form and length, is the most remarkable headland of Donegal Bay. Measured from St. John's Point to the village of Dunkineely, this promontory is over 6 miles in length, with an average breadth of half a mile."

(p. 36.)—"There is a large sea-cave directly beneath the highest point of Slieve League."

Memoir Geological Survey of Ireland, Sheets 31 (in part) and 32 (1891). The district described lies in the south-western border of the great tract of metamorphic rocks which stretch northwards into the highlands of Derry and Donegal. (No available particulars given.)

Memoir Geological Survey of Ireland, Sheets 42 and 43 (1885). The eastern and larger portion of the ground described belongs to the Co. Leitrim.

(p. 9.)—"The lowland belt stretches through the district as an undulating or boggy tract between the central mountains and the sea, most usually presenting a low line of cliffs and islets, or a sandy foreshore, to the full force of the Atlantic breakers.

"That part of the Atlantic off the coast has not any great depth in the vicinity of the land, nor does it seem to present any such abrupt irregularities in the form of its bed as diversify the shape of the ground under description. Such depths as 8, 15, and 25 fathoms, are marked on the Admiralty Chart, within distances from the coast-line, which, taken inland, would show differences in elevation equal in amount to considerably more than 200 fathoms. Drumcliff Bay is only one or two fathoms deep; and even out in the wildest part of Donegal Bay, mid-way between the Teelin and Ardboline headlands, the depth given (31 fathoms) is less than the height above sea-level of the broadest part of the Ardboline or Lissadill promontory at the foot of Benbulben. Four miles from the northern shore of this promontory land re-appears in the small flat island of Inishmurray and adjacent rocks."

(p. 27.)—"*Raised Beaches.*—Portions of the coast of Drumcliff Bay, not far from Carney, are marked on the map as raised beaches; these containing oysters, clams, periwinkles, &c., are now four or six or seven feet above high-water mark."

Memoir Geolog. Survey of Ireland, Sheet 55 (1885). A certain portion of the description refers to the arms of the sea, Ballysadare, and Sligo Bays. (No available particulars given.)

Memoir Geolog. Survey of Ireland, Sheet 54 and south-west part of 42 (1880). The district described lies almost altogether in the Co. Sligo. (No available particulars given.)

Memoir Geolog. Survey of Ireland, Sheets 39, 40, 51, 52, and northern portion of 62 (1881). The area described occupies the north-western portion of the County Mayo. It is bounded on the north and west by the Atlantic Ocean, and on the south by Blacksod and Tullaghan Bays."

(p. 7.)—"*North-eastern Portion of District.*—The tract of country to be described is that which extends from Benmore Head, west of Bunatrahir Bay, to the old coast-guard station at Porturlin.

"The physical features of this district are characterized by a bold and precipitous coast-line. To the mighty roll of the waters of the Atlantic must be attributed the varying features of headland and bay, precipice and shingle ridge, island and gorge, which give this coast its great interest to the geologist. The ocean waves, acting along lines of weakness and displacement, those of fissures, jointage planes or dykes, interesting rocks of different degrees of hardness, and in various stratigraphical positions, have carved out the diverse features of the coast-line, as we now find them. Eastward the greatest elevation attained by the cliffs is at Keady Point, where it reaches 352 feet from this on either side, the shore-line, while still precipitous, gradually diminishes in elevation. Between Glengloss Point and Belderg Harbour the cliffs range up to 189 feet high, and are sharply indented along lines of fault or of fissure. To the westward they again increase considerably in altitude, attaining 640 feet at Benwee Geevraun Point, and in continuation of Glinsk mountain to about 850 feet, although they are not so steep. Opposite the island of Illanmaster the cliffs are 790 feet high, and very precipitous. From thence to Porturlin they range in varying heights of 400 to 600 feet, with islands detached from the several headlands and fissure gorges cut into the mainland. Further westward the cliffs attain to still higher elevations."

(p. 8.)—"The Stags of Broad Haven form a group of four islands rising from the surface of the Atlantic, at a distance of upwards of a mile and a-half from the north-west coast of Mayo. One of these rises to an elevation of 316 feet, another to 312 feet, the next to 256 feet, and the lowest to 243 feet. That nearest the coast is domeshaped, while the most northern of the group is pointed. They consist of schistose rocks, and form a favourite retreat for sea-birds."

(p. 9.)—"The long north and south peninsula, locally called the 'Mullet,' which is separated from the mainland by Blacksod Bay, and an arm of Broad Haven, contains no very considerable elevations, the highest (434 feet) being towards Erris Head on the north, whilst the remainder of the peninsula is low lying and gently undulating ground. The coastline from Rossport, along Broad Haven to Erris Head and thence to Annagh Head, presents a continuous line of bold precipitous cliffs, generally inaccessible, the remaining part being low, gravelly, sandy, and rocky beaches."

(p. 17.)—"Along the shore a little to the eastward, between Nyranagh and Claddaghnahowna, at the base of the cliffs 160 feet high, the metamorphic rocks are visible at about the sea level, dipping apparently 20°, 30° east-north-east beneath the Carboniferous sandstones which overlie them unconformably, and dip from 5° to 10° only. By the breaking away of the sandstones, owing to the sea action, the schists are revealed at low tides, and in the face of the cliff adjacent, their broken uneven surface is again visible underneath the sandstones and shales."

(p. 18.)—"At the head of the small bay, between Keady Point and Benaderreen, into which the waves roll majestically, the inclined face of rock is laid bare by the removal of the outer portion up to a line of fault, which bears east-south-east, with an inclination northward at 25° from the vertical, the southern side remaining intact."

(p. 22.)—"*Peat bogs.*—Peat bogs are numerous and extensive over the whole country, particularly in the southern portion, where they are of vast extent and great thickness, and along the shores of Blacksod Bay and Broad Haven, extend even below low-water mark.

These extensive low-lying bogs contain numerous trunks and roots of large forest trees, such as the oak, fir, &c., as well as the stems, leaves, and fruit of the hazel, and other stunted varieties, which prove the existence at one time of large tracts of forest in the country, although it is now quite destitute of timber."

(p. 27.)—"Following the shore line from Belderg Harbour, westward, Horse Island is met with. It is almost completely separated from the mainland by a deep and narrow gorge, due probably to a line of fault or fissure.

"About one mile and a half further westward (of Benwee Geevraun headland) a most interesting locality occurs, where Glinsk Mountain abuts upon the seaboard near the townland boundary of Glinsk and Laghtmurragha. The cliffs attain a height of about 900 feet, and are broken into steep slopes and precipices; they are partially accessible from the top by a winding path, or from the bottom by landing from a boat."

(p. 31.)—"A more remarkable fault fissure and dyke occurs between the islands of Illanmaster 353 feet high, and the headland adjacent which is 790 feet high. This narrow cleft is cut down to the sea level, with almost perpendicular sides, through which there formerly was an open water passage, but now a ridge of shingle has accumulated in it. Traces of the dyke are visible at low water. On the opposite side of the small islet, this fissure is further continued east 25° south, as a chasm into the flanks of Glinsk Mountain, the open sides of which attain to a perpendicular height of 300 feet."

(p. 31.)—"The most remarkable of those fissures and dykes occurs adjacent to the Island of Torduff. A cleft has been formed along a line of fault into the mainland, with perpendicular sides up to 400 feet in height, and scarcely 10 feet apart in some places, but widening out at the top. Seaward it is prolonged in a rather remarkable manner; first cutting off by an open chasm with vertical walls, one island from its adjacent headland, then another—Torduff—from its headland, which is over 500 feet high, then Illaunakanoge from its headland, Fohernasmeel, almost 550 feet in elevation, and further westward, but with wider interval, the Island of Carrickduff from its adjacent headland. The view looking down this cliff with its four pairs of opposing perpendicular headlands on either side is almost unique.

Memoir Geological Survey of Ireland (Sheet 63 and north half of 74), 1880. The district described is one of the wildest and most inaccessible in Ireland, but is not devoid of many features of geological interest. It lies wholly in the County Mayo. It is bounded on the south by Clew Bay, and on the west by part of Curraun, Achill, and part of the Blacksod Bay.

(p. 17.)—"On the shores of Tullaghan Bay below high-water mark, numerous large trunks and roots of trees are to be met with resting in the bog, showing the existence of extensive forest in the locality at one time. At present the whole country is quite destitute of timber of any kind."

Memoir of Geological Survey of Ireland (Sheet 62 and northern part of Sheet 73).

(p. 7.)—"The area described embraces a small portion of the coast of west Mayo, from Ballycroy to Blacksod Bay. As also the Islands of Achill, Achill Beg, Clare, Innishbiggle, Innishgalloon, Duvillaun, Leamarch, &c.

"The whole of the Island of Achill, and a considerable portion of the adjacent mainland, is of extremely mountainous character. The Island of Achill, whose extreme dimensions from east to west are 15 miles, and from north to south 11 miles, is separated from the mainland by Achill Sound, a channel of the average width of from half to three-quarters of a mile, narrowing to about 300 yards at Bullsmouth, the Ferry, and Darby's Point, and spreading out into a large expanse of water north of the ferry between Achill and Ballycroy, containing the Islands of Innishbiggle, Annagh, &c., and sweeping away to the eastward and southward, joins Ballycragher Bay, forming with the waters of Clew Bay at Mulranny, a peninsula of that large tract of country which lies to the west of the village, of which Curraun Hill, 1715 feet high is a conspicuous feature.

"Proceeding to the west, or west 20° north, from the ferry at the Sound, the ground rapidly rises within a distance of 4½ miles as the crow flies, till it attains west of the village of Mweelin, an elevation of 1530 feet, forming there a ridge or tableland running due south for nearly 3 miles, and terminating at a height of 818 feet in Dooega Head. Its western margin descends with a nearly vertical descent of 900 feet into the sea, forming the precipitous and picturesque cliffs of Minaun. To the north of this, and east of the Protestant colony, the ground again rises 698 feet above the sea level, whilst immediately to the west abruptly rises the mountain of Slievemore, attaining a height of 2204 feet within a horizontal distance of one mile. This mountain gradually slopes to the west, and at a distance of 1½ miles from its apex, terminates at Ooghnaboo, in sea cliffs 80 feet high. Its north-east face is broken by a precipitous rift or chasm, which extends to within a few hundred feet of its summit, and runs down nearly to the sea cliff. From this out to the extreme west point of the island, viz., Achill Head, the surface of the country consists of only high hills and elevated boggy plateaux, culminating in the mountain called Croaghaun, whose summit towers nearly vertically over the Atlantic, at a height of 2192 feet. This mountain is sheared off by an enormous precipice of nearly 2000 feet, running from top to bottom of its north-west face, and forming an almost perpendicular wall to the sea."

(p. 9.)—"*Achillbeg Island.*—One and a half miles long by one mile wide is an elevated tract of land, lying about half a mile from the main island. Three hundred feet up the sharply inclined flank of the south-east face of this high ground are found large perched blocks of red sandstone, more than a ton in weight, in a condition of unstable equilibrium. Achillbeg is bisected by a broad, sandy, east and west cut, or passage, running parallel to the passage that divides the two islands, and the three eastern and western valleys, occurring at intervals of two miles each, going north on the mainland. The above passage is nearly on a level with the sea, which has evidently swept through it; its direction coincides with that of the joint planes and of the numerous eastern and western faults."

(p. 12.)—" Starting from the north-east end of the island, viz. Ridge Point; the ridge is due to the hard siliceous nature of the schists, backed up on the least weathered side, by a strip of still harder quartzite. On the west side of this the sea has encroached along the line of strike, leaving exposures of the harder portions of rock here and there. North of Doogort the coast-line is most irregular, the rock being soft and easily decomposed, and also cut by numerous faults. The bold sea-cliffs at the base of Slievemore, standing out in a semilune, are composed of a hard quartz-schist. From Dirk to Annagh the coast-line is recessed at right angles to itself. Here the rocks are not less hard, but we have a sudden change of dip along a northern and southern fault at Dirk, and the change in the outline is probably due to jointing, by which the rocks are much cut up. This increased excavation is due also to the reversed dip. From this point the seaboard projects outwards until it terminates on the north-west point of Gubroenacoragh, composed of hard quartzose schists. The flanking cliffs on the north and west coasts of this tableland, being of felspathic or micaceous schists, have been more rapidly cut away along the parallel jointings, which running north-north-west at intervals of two feet, cut the rock into slabs. In the Croaghaun cliffs the dip changes from south-south-east to north-north-east or north-east, and continues thus out to Achill Head, the master joints running parallel to the line of cliffs. Along the shores on the south, Moyteoge Head presents a barrier of quartzite to the agents of denudation, thus sheltering the inlet or bay of Keem from the south-westerly gales. The bay is formed parallel to a line of fault. Further east the headland of Gubalennaum More stands forth in the comparative impenetrability of quartzite, being carved out along the lines of jointing—the indentations of Dooagh and Keel are cut in along the line of strike."

(p. 13.)—"On the east side of Keel Bay, in the Minaun Cliffs, the strike bends more and more to the north-east, the jointing continuing approximately at right angles to the dip. From Doonty Eighter, the southern point of the quartzite cliffs of Minaun, the coast-line, as a whole, trends to the south-east, the schists becoming softer, more micaceous, steatic, and chloritic as we go south, and this portion of the coast being more exposed to the south-western gale has run at the southern end of the island away to a point. It is very noticeable that the coast-line throughout is approximately either at a very high angle or at right angles to the direction of the dip.

"Achill Sound itself appears to have been formed by a gradual subsidence of the land, the direction of the coast-line being approximatively parallel to the line of the strike of the rocks, viz. north-north-east and east-south-east, and frequently coinciding with that of the major joints. On both the eastern and western shores also, the bog is found running down on the beach, and forming banks at the level of high tide."

(p. 14.)—"*At Ooghrelleyrannell* there is a cavern cut in along the joint lines called the 'Seal Cave.'"

(p. 15.)—"*From Saddle Head to Achill Head.*—Very fibrous, and highly felspathic, coarsely crystalline gneissose schists. Cliffs dangerous, and almost inaccessible."

(p. 17.)—"At the east side of Keel Bay in the Minaun or 'Cathedral Cliffs,' the sea having excavated passages through projecting points along the joint planes, we find the coast-line and headland of hard, flaggy, and tabular quartzites, with occasional bands of argillaceous and other schists. We here notice in all the more weathered parts, *i. e.* those cut into the cliff, that the direction of the dip is at right angles to that of the most weathered face of the cliff."

(p. 18.)—"In Achillbeg Island. The coast-line here is very irregular, being cut into numerous inlets, among rapidly weathering rusty-looking schists. In the guts the sea is rapidly cutting its way between the foliation planes.

Memoir, Geological Survey of Ireland (Sheets 73 and 74 (in part), 13 and 84) (1876).

The country described includes a part of the county Mayo with a small portion of the county Galway. This tract is bounded on the west by the Atlantic, and on the north by the southern shore of Clew Bay, and on the south by Killary Bay.

(p. 12.)—"In the Atlantic, off the mainland, are some islands, the largest being Clare Island, which is about four and a-half miles long from east to west, while its greatest breadth is not more than two and a-half. To the west of this island are the steep cliffs of Knockmore, which rise directly from the ocean to the height of 1520 feet. Next in importance are Inishbofin, Inishark, Inishturk, and Cahir. Most of those islands would appear to be the peaks of submerged ridges. Cahir and Inisturk lying in a line with the ridge that extends from the Mweelrea Mountains, towards the north-west, north of Loughs Cunnel and Glencullin, and the valley of the Owennadornaun to Cross Lough; while Inishbofin and Inishark may be either on the ridge that forms the Rinvyle Promontory or on the continuation of the ridge forming the promontory called Cleggan Head, both of which are included in the district to the south."

(p. 14.)—"*Clare Island.*—On the eastern side of this rugged and wild island is the only landing-stage, which is afforded by a smooth beach. Between the western and eastern coasts the island is traversed by several ridges of moderate elevation, culminating in that of Knockmore, which, as already stated, presents a bold and steep face to the Atlantic. The northern portion of the island presents a very rugged appearance due to the unequal denudation of strata formed of different materials."

(p. 14.)—"*Islands in Westport Bay.*—These islands are remarkable for their uniformity both in shape and composition, while their summits never rise to more than about 100 feet above the level of the sea.

"Their form is apparently connected with the direction of the original glaciation of the district; but on the western side of each—save that of Inishgort, which is protected by Dorinish—marine action is making a preceptible change, leaving perpendicular cliffs, while towards the east the ground slopes to the water's edge."

(p. 27.)—"Since the great Glacial Period, but probably while glaciers existed in at least some of the sheltered mountain valleys, the sea rose at least 350 feet higher than it is at present, its waters changing the features of all the valleys that came under their influence while at the same time and subsequently atmospheric waste modified the higher pòrtions of the country."

(p. 39.)—"*Inishark*, *Inishgort*, *Inishkinnymore*, and *Inishkinnybeg*.—The first is the principal island in this group. It is bleak and wild, rocky towards the west and north-west, while there is an envelope of drift on the eastern slopes. At the north-west shore are high and almost perpendicular cliffs.

"*Inishbofin* has a general east and west strike. On an average it is four miles long and two wide; but the north and south coasts are indented with bays and at Lough Bofin from sea to sea, is not half a mile. The island consists of five hills, namely:—*Westquarter*, its greatest height being 292 feet; it forms a promontory nearly separate from the rest of the island, being connected by the previously mentioned low isthmus in which Lough Bofin is situated:—*Middlequarter*, highest peak, 288 feet; *Cloonamore*, the north east hill, having a height of 157 feet; *Knock*, the hill east of the harbour, 271 feet; and *Inishlyon*, 143 feet, which is a tidal island, and separated from the other hills during high water."

(p. 42.)—"A little north-west of Lough Bofin are north 70° west dykes, which apparently are portions of the gabbro dykes just mentioned. Further north-west and north-east of Bunnamillen Bay, are massive dykes of melaphyre; apparently portions of the same dykes, but separated from one another, and shifted by faults. These have weathered considerably and formed the deep marked fissures called 'Boher-na-collig' (Old hag's path)."

(p. 42.)—"*Inishturk* lies about five miles north east of Bofin, and eight miles from the mainland. The surface is undulating; there are four marked peaks: the north-west or signal tower hill, 629 feet; the north-east, 428 feet; the south-east, 588 feet; and the south-west 240 feet. The east and south-east coast is low; while on the west and north-west are considerable cliffs, some of which are nearly perpendicular and vary from 200 to 400 feet in height."

(p. 43.)—"*Freehill and Govern Islands*.—These rocky islets lie from one to two miles from the mainland and are composed of very felspathic, massive, purplish and greenish grits and sandstones, often pebbly and much cut up by quartz strings."

(p. 73.)—"The numerous islands in Clew Bay are saddle-backed hills of boulder clay resting on limestone. These islands are peculiarly shaped, being generally oval, with their longest axes running in an east and west direction, the most western of them having their face on the sea side cut away by the encroachments of the sea, and presenting vertical cliffs."

Memoir Geological Survey of Ireland (Sheets 93 and 94 and adjoining portions of Sheets 83, 84, and 103), 1878. The area described is bounded on the west by the Atlantic Ocean, on the north by the Atlantic and Killery Harbour, on the south by the Ocean.

(p. 8.)—"The Atlantic Ocean, which bounds so much of this area, indents its coast by fiords, bays, and creeks, some of which are of considerable size and length. The largest and most marked of the fiords are Killery Harbour and Streamstown Bay. The first is over nine miles long, and seldom, except near the east termination, over half a mile across; while Streamstown Bay is nearly five miles long, and for the most part only a few hundred yards wide."

(p. 11.)—"The central ridge ends towards the west at Inishturk, in a height of 120 feet, while the northern branch immediately west of Aughrustbeg Lough is only 78 feet high; nevertheless farther west, and apparently one of the partly submerged peaks of this ridge, is Ardillaun or High Island, with an altitude of 208 feet.

"Bordering the Atlantic Ocean on the north, and partly parallel with the northern branch of the east and west ridge just now described, is a low range of hills that towards the north-west ends in the cape called Cleggan Head. North-west of this is Inishbofin, and possibly it may be part of this ridge; however, more probably it is part of a more northern ridge (Revyte Promontory)."

(p. 13.)—"Besides the mountains now described there are isolated hills forming conspicuous and striking objects, such as Lettermore ('*the big slope*,' 1172), forming the promontory north of Ballynakill Harbour; Lackairea, '*the tangled flags*,' 1307 feet above the sea, standing over and abruptly rising from Maum Bay, and in a quarter of a mile gaining a height of 1279 feet)."

(p. 14.)—"*Islands.*—Lying off the west and south coasts, also in some of the bays, are large and small islands, and sea rocks. (*Carrig* and *Carrygeen*). The islands off the north part of the west coast are apparently peaks of the submerged parts of ridges as previously suggested, being situated on lines having a similar bearing to the parts of the ridges on the mainland, *i.e.* nearly east and west lines.

Southward of Mannin Bay and off the south coast, other arrangements seem to exist; and the islands, if they are parts of ridges, belong to systems having other bearings. South-west of Mannin are Chapel, Duck, and other small islands. These extend in a north-east and south-west direction, and may be parts of a ridge that runs from Knock, south of the mouth of Mannin Bay, to Shiprock; while the islands that lie further westward (Inishdugga, Inishkeeragh, Illaun-na-neid, or Slyne Head, &c.) may be parts of a second parallel low ridge. Off the south coast, the islands are scattered about irregularly; still, however, they may also possibly be peaks of submerged ridges, as Inishlackan, Illaunnacroagh More and Beg, Croagh-na-keela, and the Carriggeens or sea-rocks, three miles further to the south-west, lie in a line which is parallel to the ridges or lines of islands just described; while Mace Head, St. Macdara Island, and the sea-rocks called the Sherds, lie in a second nearly parallel line."

(p. 53.)—"*High Island.*—This is the most westerly land in the county Galway, and is bounded on all sides by high cliffs, which are for the most part perpendicular or nearly so."

(p. 54.)—"*Friar's Island* is also wild, rugged, and very inacessible. To the north-west in the granite, occur systems of east-and-west and nearly north-and-south vertical joints, which produce a columnar aspect when viewed from the west or north-west.

"The southern side of Cruagh is glaciated, grooved, and etched, the bearing of the ice varying from north 70° west to east and west."

(p. 58.)—"*Islands off the Rinvyle Promontory*; *Inishbroon*, off Rinvyle Point; *Illaunananima*, *Treaghillaun North*; *Crump Island.*—The exposed portions of the hornblendic rock weather freely into a rusty brown crust."

(p. 89.)—"*Islands off the South-west and South Coasts*; *Inishdugga*, *Illaunaminara*, *Lyal More and Beg*, *Inishkeeragh*, and *Illaunane*, *with numerous smaller Islands and Tidal Rocks.*—This group of islands lies to the south-west of Mannin Bay, between it and Slyne Head, many of them being joined together at low water.

"*Illaunamid*, *or Slyne Head*, *Chapel Island*, *Duck Islamd*, *Doonnawaul*, *Illaunaleama*, *and their associated carrigs and carrigeens.* These islands and rocks form the south-west extremity of the Co. Galway. *Carrickfin*, *Horse Island*, *Strawbeach Island*, *Carricknure*, *Illaunpollnamuck*, *Illaunurra*, *and the adjoining sea-rocks.*—These islands and rocks lie in and to the south-east of the bay, that is situated east-north-east of Slyne Head."

(p. 90.)—"To the south-east of Bunowen Bay, in Crompaun Bay, and south of Ballyconneely Bay, there are numerous rocks and small islands.

"*Inishlackan, Illaunnacroagh More and Beg,* and *Croaghnakeela.*—These islands lie off the mainland south and south-west of Roundstone Bay.

"*Mile Rocks and Sheds.*—These isolated sea-rocks lie to the south-west and south of Croaghnakeela, and are inaccessible except in calm fine weather."

Memoir Geolog. Survey of Ireland, Sheets 104 and 113, and adjoining parts of Sheets 103 and 122 (1871). The area contained within the limits of Sheet 113 is, for the most part, occupied by the Atlantic Ocean and the entrance to Galway Bay. The two northern islands of Aran are situated towards the western margin, and immediately to the south of it, in Sheet 122, is Inisheer, the extreme south-easterly island of the Aran group. Parts of the islands of Lettermullan and Gorumna, with the portions of the mainland that lie east and west of Cashla Bay, occur inside the northern margin.

(p. 7.)—"*The Aran Islands,* at the mouth of Galway Bay, lie in a north-west and south-east direction, being about 16 miles long from Carrickemonmacdonagha, the north-west point of Illaun-eragh (the western of the Brannock Islands), to Trawkeera Point, the eastern extremity of Inisheer. They consist of three large islands—Inishmore, Inishmaan, and Inisheer—with four small islands off the north-west point of Inishmore, called the Brannock Islands (p. 8); and on its east coast, at the entrance of Killeany Bay, Illaunatee or Straw Island; the last named being joined to the island by a sand-bank during low water. Connected with the Aran Islands there are very few detached rocks, besides these to the north-west, which are included under the general name of Brannock Islands, only three occurring off Inishmore, called Island-a-reefa, Craghalmon, and Carrickmonaghan; and one, a spring-tide rock, called Finnes, half a mile from the shore of Inisheer.

"*Sounds.*—North of Inishmore, between it and Iar-Connaught, is the *North Sound,* about $5\frac{1}{2}$ miles wide. Between Inishmore and Inishmaan is *Gregory's Sound,* from 1 to $1\frac{1}{2}$ miles wide, while Inishmaan is separated from Inisheer by the Foul Sound, which is $1\frac{1}{4}$ miles wide between the nearest points, and Inisheer, from the barony of Burren, Co. Clare, by the South Sound, about 4 miles across."

(p. 9.)—"*Mainland*; *form of the ground.*—The land on the north of the Galway Bay is intersected by numerous chains of lakes, bays, and creeks; various harbours and bays are formed by the islands and promontories. In Sheet 113, on the west of Lettermullen, are some islands and rocks. Eagle rock is the largest of the group of small islands lying north-west of Golam Head, its highest part being 35 feet above the main sea-level."

(p. 10.)—"To the north-west is *Fish Rock*, always above water; as is also Seal Rock, which is about half a mile to the southward. Lettermullen is a wild, rugged-looking island, having irregular slopes towards the south-west and south. *Gorumna Island* is the largest of the archipelago studding the extensive estuary between Greatman's and Kilkieran Bays. Between Greatman's and Cashla Bays is the long, narrow promontory which separates these harbours. At its southern extremity are two wild, rocky heads, between which is a small cove, called Doleen Harbour, to which, when the wind is not from south or south-west, small boats can resort."

(p. 12.)—"*Aran Islands.*—From the north-east shores of the Aran Islands the land rises in a series of cliffs or huge steps, which form continuous terraces (see section, fig. No. 1), while from the summit of the island there is a gradual fall south-westward, it ending, however, at the sea-board in cliffs that, at the present day, are being formed by the Atlantic Ocean.

"*Inishmore* is 8½ miles long, from its north-west point to Gregory's Sound, and of various widths, being only half a mile wide at Portmurvy, while at Kilronan it is a little more than two miles across. Viewing Inishmore from the hills west of Galway town it appears to be three islands. This is caused by two low valleys which extend across it; one west of Killeany Bay and the other south-west of Portmurvy. The latter is so low, about 50 feet above the sea, that it has been mistaken by Galway-bound ships for one of the channels into the bay, for which reason it has received the name of the 'Blind Sound.' Of it O'Flaherty says: 'About the year 1640 (1639·5 sun-spot maximum), upon an extraordinary inundation, the sea, overflowing the bank, went across over the island to the north-west.'

"(Note.)—In Mallet's list of earthquakes for 1640, there is one mentioned on the 4th of April, at 3.15 A.M., felt in France, Belgium, and Holland. Perhaps it might have been the wave resulting from this seismic commotion which caused the inundation. On the 15th of August, 1852, a large wave rolled in on the west coast of the island, drowning fifteen persons who were fishing on the rocks."

(p. 13.)—"At this sea cliff, on the north-west of the island, there are two well-marked terraces, which, with four below them observable in the neighbourhood of the village of Bungowla (see fig. 1), make in all eight terraces. Such terraces are not confined to the land now above the sea-level, as submerged terraces occur in Galway Bay on the north-east of the island.

"The sea-cliffs on the north-east side of the island are low, and are often replaced by strands or shingle beaches. On the south-west they have taken a definite character, being usually perpendicular, and often over 50 feet in height; however, at the north-west point of the island, under the shelter of the Brannock Islands, there is a heavy shingle beach, on which boats can land in fine weather.

"From the north-west point, south-eastward to Gregory's Sound, the cliffs are either perpendicular or terraced. From Mweeleenarceava, a little south of the Brannock Islands, to Doocaher, except for a short distance, at the 'Blind Sound,' the cliffs are perpendicular, although at the base of some of them, as will be hereafter mentioned, there are sea-terraces or steps below the high-water mark of spring tides. At Doocaher the cliffs are about 100 feet high, and from that towards the north-west they gradually rise to 234 feet at Corker, from which they lower by degrees to the 'Blind Sound'; but north-west of this, at Dun Ængus, there is an Ordnance height of 265 feet, and they attain their greatest altitude (300 feet), about a mile further north-west, a little south-east of Polladoo. From Doocaher towards the south-east to the point called Illaunanaur there are sea-terraced cliffs (excepting a few short breaks), which are surmounted by a rampart formed of large blocks. This is called, in Professor King's MS. account of the Aran Islands, the 'Block Beach.'

"From Illaunanaur to Portdeha, on the west of Gregory's Sound, the cliffs are perpendicular or terraced; but on the north of the latter place the Sound is bounded by a strand."

Lord Dunraven, "Notes on Irish Architecture," vol. i., p. 1 (1875–77).

"*Dun Ængusa*, on the greater Island of Aran.—Landing on Aranmor, the largest of the three islands, and commencing his walk at the southern end (the visitor) should keep along the edge of the cliffs, which gradually increasing in height as he advances, seem to form a grand barrier to the ocean that beats for ever at their feet. They are of limestone, and are marked by long parallel horizontal lines or fissures, so that where they break, they seem to shape themselves into huge masses, squared as if by giant hands. Here and there, where in bold promontories they advance into the sea, they have become separated from the land, and rise like towers from the waves. Passing upward and onward towards the highest point, the traveller will begin to perceive that this precipice is crowned with a circular wall, 'grey, weatherbeaten and wasted,' whose broken and serrated edge stands dark against the sky."

(p. 2.)—"The solitude and grandeur of the scene are unspeakable."

(p. 3.)—"Dun Ængusa or the fort of Ængus, is named from one of the sons of Hua Mór, a chieftain famed in the earliest period of Irish legendary history. It occupies an angle of the cliff, and is therefore protected by it on two sides to the north and west. It is, in plan, irregularly concentric, composed of three areas or wards, each within its wall. The interior of the fort proper is half an ellipse, 142 feet on the short diameter which rests on the cliff, and 150 feet deep, being half the long diameter, which projects northward from the cliff. The containing wall is 8 feet to 12 feet thick. The entrance is on the west-east, 90 feet from the cliff."

(p. 4.)—"The inner doorway is a rude, flat-topped opening, 3 feet 4 inches wide. Only its upper 3 feet is now visible (1870-75), the lower part being covered up with rubbish. When Dr. O'Donovan saw the doorway in 1839 it was perfect. It has since shared the mournful fate which awaits the whole structure.

"The annexed drawing made in the spot in the year 1857, by Mr. Frederick William Burton, was then a faithful representation of this doorway; but since that time a great change has been effected."

(p. 9.) —"'*Dubh Cathair*,' '*The black fort*,' Aranmor."

(p. 10.)—"Dr. O'Donovan observes that this fortification would appear from its colossal rudeness to be many years older than Dún Ængus or Dún Conor. The guide, an old man, who accompanied me to the place, informed me that he remembered the wall nearly perfect; but that a great part of it had fallen in a storm a few years ago. Scarcely any of the inside face of the wall now remains, and the force of the Atlantic waves has swept away the lesser buildings which it enclosed. One wave he described as rising in such a vast body of water above the cliff, that it overran the hollow within the wall of the fort, and flung the stones on all directions.

"*Inishmaan* is three miles long from the north-east to the south-west, and half a mile wide between Trawtagh on Gregory's Sound, to Trawbetteragh on the Foul Sound."

(p. 14.)—"The north part of the island is bounded by low cliffs, strands or shingle beaches. On the south-west from Trawtagh to Aillinera, the cliffs rise in steps, at the latter place being perpendicular, and about 200 feet high, from which, southwards, the surface gradually falls to about 40 feet at the cliff opposite Taunabruff, the south-western extremity of the island. From the south part of Aillinera, where the cliff is about 170 feet in altitude, southward to Taunabruff, and then north-east to Clogharone, the cliff is cut into sea-terraces and surmounted by a 'block beach.'

"*Inishere* is less than two miles across from the shore, north of the village of Ballyhees, to Fardarris Point, and $2\frac{1}{2}$ miles from Trawkeera Point to Tonefeehney. Captain Bedford says of this island, 'Its shores are everywhere rocky, except at its north-east side, where there is a small sandy beach called the North Strand.' "

(p. 26.)—" The subjacent rocks of the Aran Islands are limestones, with which are interstratified some thin shales and clay beds. The shales and clay seem in a great measure to have guided the denudation that carved out the terraces, for at the base of many of the well-marked cliffs, shale or clay beds occur.

" The terraces are more or less undercut, and may have been formed by marine action, but of this there is no direct proof; if they were, the force of the waves would seem to have come from the east-north-east, while, at the present day, it is from the south-west."

(p. 32.)—" *Sea Cliffs.*—Of the cliffs of the north-east and north-west of this island, scarcely more can be said than that already mentioned in the general description, but those on the south-west are peculiar, as in places they are terraced by the waves of the Atlantic. Moreover, some of them are surmounted by the previously mentioned 'block beach.' This peculiar accumulation of blocks does not occur at all on the north-east shore, while to the north-west it was only found at the point due east of the north point of Brannock Islands. On Inish-Eeragh, the westernmost of the Brannock Islands, there is also a block beach, which is thus described by Captain Bedford: 'On all but the eastern side there is a margin of massive blocks of limestone, upheaved by the violence of the sea, and which now form a sort of barrier against its farther encroachment. The highest part of the island is the summit of the upheaved beach at the north-west side, which is 36 feet above the mean level of the sea.'

" The north part of the north-west coast of Inishmore, as before mentioned, is a perpendicular cliff that either extends upwards from the sea-level, or has at its base a few steps.

" The vertical cliff seems to be caused, in a great measure, by vertical master-joints, some of which cut through all the visible beds, while others only reach the shale beds. In the former case the cliffs are perpendicular down to the sea, while in the latter there are steps or sea-terraces at the base of the cliffs. South-east of Polladoo, there are four sets of steps at the base of the cliff, and the note made on the ground is as follows:—'Cliff over 250 feet high. Two shale beds. The cliff rises perpendicularly from the highest.' South of Portmurvy there are from four to six of these sea-terraces, and the cliff is less than 50 feet high. South of Gurtnagapple, the cliffs are low but perpendicular; hereabouts nearly east and west master-joints occur about 2 yards apart, and as the sea undermines the cliff, masses of rock, tons in weight, that are disconnected by these joints, topple over and fall, forming a break-water at the base of the cliff. This breakwater extends for about ½ a mile."

(p. 33.)—"At Corker, there is a perpendicular cliff formed by east and west master-joints. In the face of the cliff there are two shale partings about 40 feet asunder, the lower being about 60 fee above half neap tide.

"South-east of Nalhea there are four or five sea-terraces at the base of the cliff; and at Whirpeas the cliff is about 140 feet higher than the level of neap tide, a shale bed occurring about 40 feet above this level. To the east of this, at Pollnabriskenagh, the limestones are traversed by east and west master-joints, and the sea yearly causes great destruction of the rock. This cliff, which is about 100 feet high, is undercut at the base. At Bensheefrontee, the point a little north-west of Doocaher, 'the block beach' sets in, and extends to the south-east point of the island, having only five small breaks in it: three at the 'cooses' or small bays in the vicinity of Doocaher, one at the 'coose' called Doughatna, and one about 40 yards wide at the Glassan Rock, in all of which places the base of the cliff is undercut, while that part which is surmounted by the 'block beach' is stepped. However, although it is undercut, and forms a cave at Doughatna, yet below the cave, there are six very low steps. The highest part of the cliff on which this beach occurs is in the vicinity of Doocaher, and about 100 feet above the sea level, while the lowest part, a quarter of a mile west of the Glassan Rock is about 35 feet. These steps at the base of the cliffs are usually from 4 to 7 in number, seemingly having been cut, one by low water of spring tides, another, by low water of neap tides, another by high water of neap tides, another by high water of spring tides. At one place, east of Carrickurra, there is a step above high water of spring tides on which the 'block beach' rests. At this place the cliff is about 50 feet high.

"The stones forming the 'block beach' are cast up during the winter gales, and some of them are of considerable size. A little south of Doughatna, the following observation was made—' Great quarrying seems to be going on here during the gales. Blocks, 30 by 15 by 4 feet tossed and tumbled about.' And again, half way between Doughatna and the Glassan Rock there is this note. A block 15 by 12 by 4 feet seems to have been moved 20 yards, and left on a step 10 feet higher than its original site. East and west of the Glassan Rock, there are two caves which run for a considerable distance inland, and connected with both are 'puffing holes.' The western puffing hole is 85 yards from the sea margin, and the eastern 33 yards. On the north-eastern side of the latter there is a small 'block beach,' the blocks in which have all the appearance of being yearly tossed about by the waves, while more are added to it, and we may suppose some sucked into the abyss below. Other puffing holes were observed further north-west, but none so large as those just mentioned."

(p. 34.)—"The sands are very considerable, occurring in all the islands. They are ever changing their positions; and in O'Flahertie's 'History' we find mention of various churches, tombs, and fields, now covered or nearly covered by them. During the examination of Inishmaan, tombs were pointed out near its shore that had only a a few months previously been discovered, as up to that time they were covered with sand, which now has been blown away.

"At Trawmore, on the south of Killeany Bay, proofs have been lately discovered (1860–67), not only of the movement of the sand-hills, but also that this part of the land, since the islands were first inhabited, has changed its level, as human structures are found under the strand, and extending out seaward. In the history of the islands, by the then vicar, Rev. W. Kilbride, it is stated: 'This movement of the sands has gradually uncovered the ruins, which consist of two "cloghauns" or stone-cells, with beehive-shaped roofs and structure, in every point similar to those usually called *Leabuidh Diarmaid agus Graine*, or "Dermot and Graine's Bed," and old wall or single stone fences, dividing the ground into regular fields and gardens, evidently under cultivation in former times. These walls extend out seaward, and all the structures, until very lately, were completely covered over by sand from 10 to 20 feet high. They must apparently have been buried a long time ago, for it cannot be less than a thousand years since Eany's church was first erected on part of this sandbank which still remains.' This author also mentions other places to which the sandhills have moved during the historical period, one of the most remarkable being at St. Colman's burying-place on Inisheer, when a 'hillock,' which in O'Flahertie's time (A.D. 1684) was a nice 'green plain,' is now only a mass of sand."

(p. 35.) — "*Inishmaan.*—Seven continuous terraces occur, but whether they are the continuation of the terraces on Inishmore or not, it was impossible to prove.

"*Sea-cliffs.*—On the west coast the sea-cliffs rise in steps, as they followed southward from Trawtagh, until at Aillinera they reach their maximum height (nearly 200 feet), southward of this they gradually fall to nearly the sea-level at Ailyhaloo, the south-west point of the island. Immediately south of Aillinera, at a height of about 170 feet, there is a 'block beach,' which is continuous from this point round the west and south-east sides of the island."

(p. 36.)—"The cliffs below it are always in steps very similar to those described below the 'block beach' on the south-west of Inishmore. In one place steps were observed over high-water mark of spring-tides, on which the following record was made. 'At Taunabruff the limestone is thin bedded, and the winter storms have formed seven low steps between the high-water mark of spring tides and the "block beach."'

"On the west coast some of the blocks are remarkable for their size, and the distance and height to which they have been moved by the force of the waves. The following are the most notable:— 'About one hundred yards southward of Pollnashedaun, "large blocks have been 'quarried' by the sea, the largest measured being 15 by 5 by 4 feet." South of Taunabruff a block 20 by 5 by 1 feet has been raised 20 feet, and moved 31 yards from its natural site.' A little south of this, near Ailyhaloo, a block 19 by 8 by 3 feet was raised 5 feet, and moved 8 yards; and another 27 by 9 by 4 feet was raised 4 feet, and carried 9 yards.

"On the south-coast the 'block beach' is peculiar, being formed of small blocks; also, in other places, the blocks seem to be re-arranged yearly, while here and there they do not seem to have been moved for years, and the impression formed at the time was, that the tidal current cannot hereabout now set as strong in the same direction against the coast as formerly, because samphire, sea-pink, etc., now grow freely on the two terraces below, as well as amongst the blocks forming the beach; moreover the blocks seem not to have been stirred, or added to by the sea, for years." This beach was found extending as far towards the east as Clogharone, the south-east extremity of this island.

(p. 36.)—"*Islands off Errisainhagh*: *Inishtreh.*—This is a small island on the extreme north-west of the Errisainhagh promontory; during low water it is joined to the mainland by a bank of gravelly shingle, which also covers the greater part of the island—the rock is porphyritic granite.

"*Freaghillaun, Rush Island*, and *Inishbigger.*—These islands lie in the entrance to and west of the Moyrus Boat Harbour. The south and south-west shores of Freaghillaun are covered with large rectangular blocks of an even-grained granite, with black mica, similar to the rock about Mall Head.

"*St. Macdara's Island*, or as it was anciently called Croach Mic Dara, *i.e.* '*Macdara's stack or rick*'—The shape of the island may partially be due to ice erosion, as many of the rocks have the appearance of being ice-dressed. However its slopes, more specially those northward and southward, appear in a great measure to be due to the structure of the rock, as it is inclined to split off nearly everywhere in plates a few feet thick. This remarkable weathering can be well examined at the south-west of the island, where the waves of the Atlantic are yearly quarrying largely, and hurling up the blocks above high-water mark, thereby forming a beach of huge blocks, and one of considerable size that was measured, gave 21 by 21 by 2 feet as its dimensions.

"*Mason Island* lies a little east-south-east of St. Macdara's. On the west there are numerous angular blocks and boulders scattered along the shore, while on the east the rock is covered with sand.

"*Wherron, Avery*, and *Ardnacross Islands.*—The two former lie north-west, and the latter east of Mason Island, from which it is separated by a creek, which is fordable during low water, while all are nearly covered by the tide at high water.

"*Mweenish Island, Inishtroghen*, and *Tidal Rocks.*—Mweenish bounds Ards Bay on the south, and is connected with the mainland by a pass, that is fordable at half-tide."

(p. 38.)—"*Duck Island* lies about half a mile south of Mweenish, and its subjacent rocks are similar to those on the south part of that island.

"*Finish Island.*—This island bounds Mweenish Bay, on the south-east, and is connected to the mainland at low water by a strand. A mile south of this island is *Inishmuskerry.*

"*Birmore and Birbeg Islands and Tidal Rocks.*—Birbeg is situated about a mile south-south-west of Ardmore Point, and Birmore south of the latter, the two being connected during low water."

(p. 50.)—"*Inisherk, Dinish, Furnace, Illauncashin*, and *Illaunanarroor.*—These are tidal, being joined during low water."

(p. 56.)—"*Lettermore Island, with Illaunroe*, and *Inchagham.*—Lettermore Island, consists of two hills, one to the east and the other to the west, with a flat bog between them. To the north, at Cashla point, the unweathered veins stand up 2 inches above the surface of the rock. A little east of Cashla Point is a north, 10° east, dyke of quartziferous porphyry; and a little farther east, into which a small bay has been cut by the action of the sea, is a course of rotten granite, running nearly north and south. Hereabouts the unweathered portions stand 3 inches above the mass, while inland south of this and due east of the trigonometrical point, Δ 364, they are only one inch high.

"*Inishlay and Inchmakinna.*—These islands lie south-east of Lettermore in Fearmore Bay. The former is joined by a bank to Gorumna during low water, while the latter lies near the east shore.

"*Annaghvaan, Inishtravin, Illaunakirka, Beaghy, Illaunard, north island*, and the adjacent carrigs (*rocks*) and carrigeens (*small rocks and half tide rocks*). These form a small archipelago at the junction of Fearmore, Camus, and Kilkieran Bays."

(p. 57.)—"Of *Kinnelly Islands*, Mr. Cruise says—these are tidal islands, and are situated about a mile and a quarter due west of Inishtraven."

(p. 71.)—"Here it may be mentioned that a register of the amount of weathering of some of the granites, since the ice disappeared from this country, would seem to be recorded by the veins which traverse these kinds of rocks; as these veins are usually unweathered, retaining their glaciated surfaces, and stand up above the mass of the rock; near the coast being usually from 2 to 3 inches high, while more inland they only average 1·5 inches in height. This weathering would seemingly also suggest that in the neighbourhood of the sea, the atmospheric influences are different to those inland, not only in the amount of work done, as shown by the greater height of the veins near the sea, but also in respect to the colouring matter, in some of the rocks, for, as previously mentioned, the purplish gray or greenish felstones near the sea weather red, while the same rock inland weathers a dull yellowish white."

(p. 71.)—"On the sea-coast, about a quarter of a mile south-east of Foal Island, there is a remarkable kitchen-midden about 50 feet in diameter, 15 feet in height, and forming a flat-topped conical hillock. It seems to be nearly altogether formed of the shells of the *Patella vulgata* and the *Littorina littorea*; no excavations was made into it.

There seems to be added to it yearly a few more shells, by the people who visit the site of a church, and two holy wells dedicated to St. Columbkill, which are in its vicinity."

Memoir Geolog. Survey of Ireland (Sheets 105, and part of 114), 1869. (North of Galway Bay.)

(p. 41.)—"In places along the shore of Galway Bay, peat with the roots of trees is found below high-water mark; this might not prove that the land has sunk, for, at the present day, about two miles west of Galway, between Blackrock and Blake's Hill, is a morass below high-water mark, in which peat and shrubs are growing. This morass is divided from the sea by a barrier of shingle. However, against this theory, we find in a half tide bog west of Blake's Hill, an oak stem, 12 feet long and 2 feet in diameter, immediately above the 'corker' or butt. This tree could scarcely have grown on ground below sea level; moreover on the Aran Islands at the mouth of the bay, there are proofs of the islands having sunk since they were first inhabited." (*See Memoir Sheet* 113.)

Memoir Geolog. Survey of Ireland (Sheets, 114, 122, and 123) (1863). The sheets contain the north-western extremity of the County Clare, lying on the south side of Galway Bay, and the island of Inishere, the smallest and most easterly of the south Isles of Aran. They include the coast line from the southern shore of Liscannor Bay to the Head of Galway Bay.

(p. 5.)—"To the north of Liscannor Bay, in the promontory of Hag's Head, the ground rises to heights of 500 and 600 feet, especially along the coast, which exhibits a line of magnificent precipices nearly three miles long, and rising in one part, quite perpendicularly, to a height of 668 feet; these form the well-known cliffs of Moher (see fig. 1)."

(p. 11.)—"Much of this removal has been caused by the wearing action of the sea, when the land stood at a lower level. The escarpment which runs round the foot of the limestone hills, is as much like an old sea-coast on the east side as on the west where the sea is still beating on it. The action of the sea on the high Coal Measure land may be well observed still going on at Hag's Head and the cliffs of Moher, the waves eating away the lower part of the cliff, and constantly causing fragments of the upper part to fall for want of support. This action is considerably assisted by the great vertical joints, which traversing the rock, divide it into blocks, rendering the work of destruction a far easier matter than it would otherwise be. The best instance of this is at Ailleenasharragh, at the cliffs of Moher. A steep and winding pathway leads the explorer to the foot of this magnificent cliff, and the most casual observer cannot fail of being struck by the immense accumulation of *débris* which forms a *talus* on the beach, huge masses of grit, shale, and flagstone lying piled together in wild confusion. Here the cliffs are constantly decreasing in altitude, inasmuch as the ground slopes inland from the coast; where-ever on the other hand, the slope of the surface is seaward, the height of the cliff is increasing."

(p. 12.)—"There is a tradition among some of the peasantry that at one period Hag's Head was connected with the southern shores of Liscannor Bay by dry land, and that about midway stood the church of *St. Scoitheen*; that by means of an earthquake, land and church suddenly disappeared; and on clear days, when the sea is calm, it is said that the ruins of the church are sometimes visible at the bottom. (Note—I am indebted for this tradition to the late Professor O'Curry. It is alluded to in the 'Annals of the Four Masters,' translated by him.—F. J. F.)."

(p. 19.)—"*The Coast section.*—The almost continuous section along the coast exhibits the structure of the whole district."

Memoir Geological Survey of Ireland (Sheets 115 and 116), 1865. (No available details given.)

Memoir Geological Survey of Ireland (Sheets 131 and 132), 1860. The district described forms part of the western side of the County Clare. (No available details given.)

Memoir Geological Survey of Ireland (Sheets 140 and 141), 1860. The district described includes the south-west part of the County Clare, lying north of the mouth of the Shannon, and a small part of the northern corner of the County Kerry, on the south of that river.

(p. 5.)—"This part of the County Clare is an undulating tract, stretching away westward in a long narrow promontory, the termination of which is Loop Head. The length of the promontory from Poulnasherry Bay to Loop Head is 16 miles in a direction about west 30° south. Its greatest breadth (a little west of Poulnasherry Bay) is five miles, from which point it varies considerably towards the west on account of the irregular form of its southern shore. Thus, at Carrigaholt it is nearly three miles broad, at Kilbaha, $1\frac{1}{2}$, while approaching Loop Head it rapidly contracts, so that half a mile before reaching that point its breadth is little more than $\frac{1}{4}$ mile. It is bounded by precipitous cliffs, which in many places assume fantastic forms, resulting from the action of the sea on the rocks. On the north-west shore these cliffs attain in some places to an elevation of 200 feet perpendicularly above the sea; but along the shore of the Shannon they do not exceed 100 feet."

(p. 6.)—"The shore of the Shannon, south-east of Kilrush, is very varied in form. In some places the ground terminates abruptly in cliffs ranging from 40 to 100 feet in height, while at others it slopes almost imperceptibly towards the river."

"The width of the Shannon between the shores of Clare and Kerry in this map varies from two to three miles."

(p. 13.)—"At the north side of the Loop, the cliffs are 200 feet high. Dermot and Graine's Rock separated from the mainland by a chasm 95 feet in width at the top, forms a striking object. (Fig. 4)."

Memoir Geological Survey of Ireland (Sheet 142), 1860. That part of the Sheet which lies north of the River Shannon belongs to the County Clare. At the south-west corner of the Sheet there is a small portion of the County Kerry. At the south-west corner of the Sheet there is a small portion of the County Kerry, in which is the little town of Tarbert. (No available details given.)

Memoir Geological Survey of Ireland (Sheet 143), 1860. The River Shannon runs with a general bearing east and west through the northern part of the district described. (No available details given.)

Memoir Geological Survey of Ireland (Sheets 150 and 151), 1859. The principal features of the district described are, the promontory of Kerry Head on the west, rising to the height of 700 feet. The promontory of Kerry Head may be described as a regularly formed hill, upwards of twelve miles long, from its western extremity to the point where it sinks eastward into the plain. Its highest points are Trisk and Maulin Mountains, which are upwards of 700 feet above the sea. From these points the ground slopes away very gently towards the sea on all sides except the east, terminating in rugged cliffs, which attain in some places, to a height of 200 feet, but generally vary from 50 to 100 feet.

(p. 10.)—"The action of the water on the north coast of Kerry Head has caused the cliffs to assume various curious forms in many places, such as caves and natural arches. Near Ballingarry Island are some good examples, as also at Illaunamuck. (Fig. 1)."

Memoir Geological Survey of Ireland (Sheets 140, 161, 171, and part of 172), 1863. That promontory of Kerry which stretches on the north side of Dingle Bay, and south-west of the Bay of Tralee, happens to be divided among four of the Sheets, but can obviously be only described as one district. The general form of the ground is that of a broken ridge, traversed by several large valleys and ending westward in the precipitous islets and rocks known as the Blaskets.

(p. 8.)—"This north and south ridge of Mount Brandon rises gradually from the sea near the town of Dingle, till, in the course of 2 or 3 miles, it attains an altitude of about 2000 feet. Still further north it rises to 2764 feet, in Brandon Peak, where it has in some places so narrow a crest that a man may sit down astride of it. A mile further north it reaches with a broader crest, the extreme altitude of 3127 feet, at the point called Brandon Hill or Mount Brandon. From this point it declines towards the north, but still maintains an altitude of 2500 feet to within ⅔rds of a mile of the sea, and terminates in the grand cliffs of Brandon Head. The north and south ridge of Brandon Mountains looks to the west over much low ground, which is indented by Dingle and Ventry Harbours on the south, and by Smerwick Harbour on the north. Between these there runs an undulating ridge, which rises in some points to the height of 900 or 1000 feet high. This is within a mile of the sea-shore, and the promontory terminates in Slea Head, which is 766 feet high, and the lower Dunmore Head, which is the most western point of the mainland. (See fig. 3, p. 10)."

(p. 9.)—"From the cliffs of Brandon Head, a line of similar but lower cliffs is continued along the north coast of the peninsula, broken only by the entrance to Smerwick Harbour. One summit of these cliffs, near the old signal tower of Sybil Point, almost hangs over the sea from a height of 688 feet. Although not so perpendicular, yet the increased height of those near Brandon Head, some of them rising to over 1200 feet as steeply as their jagged and shattered state will allow, makes them perhaps still grander objects. Many of these cliffs consist of a mere heap of ruins, caused by great landslips, huge crags of rock resting discordantly, one on the other, with broken gullies and clefts between them. Standing on some of the highest points of these cliffs, it is curious to mark what a straight line their most striking features preserve along the coast from near Brandon Head to Sybil Point for a distance of 12 miles, and how these features re-appear in the same straight line 5 miles beyond Sybil Point in the island called Inishtooskert, which rises abruptly from the sea into a jagged peak 573 feet high. (Fig. 2.)

"The central ridge of the promontory in like manner shows its submarine continuation in the great Blasket Island, running off from Dunmore Head, and rising to height of 960 feet. There is an almost absolutely perpendicular precipice of that height on the north side, which keeps a height of 900 feet for a distance of about a mile. Still farther out to sea, the Tearaght Island (see fig. 9, p. 47) rises abruptly to 602 feet, the other Blasket Islands being 400 or 50 feet, and finally, the larger of the Foze rocks, 11 miles from the mainland, juts up to 103 feet from water of twice that depth. These islets, and the deep sounds and stormy straits between them, give us, doubtless, a picture of what every part of the mountains of the mainland have been in their turn in the successive stages of their last slow elevation above the sea."

(p. 29.)—"*Brandon Head.*—The wide indentation in the coast, to the east of this point, extends to the western base of Knocknabrestee Mountain (2500 feet high), which terminates at Brandon Head, and here we find the Old Red Sandstone concealed by a mass of rubbish formed from itself, the result of an enormous landslip, which covers the seaface of the cliffs for a width of 750 yards or nearly half a mile."

(p. 45.)—"*The Blasket Islands.*—The Great Blasket Island, which lies at the distance of one mile to the west of Dunmore Head, is three miles and three-quarters in length, with an average width of half a mile."

(p. 49.)—"And here on the shore of Tralee Bay, at the distance of about two miles east of Castlegregory, we find large roots and stems of fir trees standing upright in the sand and shingle of the shore."

Memoir Geological Survey of Ireland (Sheet 162), 1859. The description includes a part of Kerry, round the towns of Tralee and Castleisland. (No available details given.)

Memoir Geological Survey of Ireland (Sheet 173), 1861. The whole of the area described lies in the County of Kerry.

(p. 7.)—"The so-called harbour of Castlemain is choked with mud flats and sand-banks, through which the rivers wind their way at low water."

(p. 24.)—"The local elevation of the land now occupied by the Lower Lake of Killarney, and a large extent of its shores, in very recent geological times, is not a mere supposition; it is clearly demonstrated by the fact, that we find some of the limestone bosses in the pasture land of the southern part of Cahernane Demesne very much water-worn at the base."

Memoir Geolog. Survey of Ireland (Sheets 182, 183, 190, and parts of 172 and 191), 1861. The district described belongs entirely to the County of Kerry, and forms the promontory of Iveragh and Dunkerron, between Dingle Bay and Kenmare Bay.

(p. 5.)—"The most northerly of the other ridges runs along the south shore of Dingle Bay from Rossbehy to Valencia, rising at Drung Hill and Knockadober to heights of over 2000 feet. It makes Doulus Head to the west, at which place it is interrupted by the sea forming the entrance to Valencia Harbour, but afterwards re-appears in the Island of Valencia, terminating at Bray Head, a cliff of 588 feet."

(p. 7.)—"The coast line of this district, in the neighbourhoods of Rosbehy, Cahersiveen, and Aghadda, within the bays of Ballinskelligs and Derrynane, and in some places along the Kenmare river, is low, muddy, and sandy, or edged by a gravelly beach; but in other and more exposed places it is high and rocky, or rises into abrupt precipices, as near Hog's Head, at the seaward side of Scarriff Island, between Bolus Head and Ballynablona, at Puffin Island, and from thence to Portmagee, where there are some cliffs so high as 867 feet, round the western shores of Valencia Island, from Bray Head to Keenadrolaun Point (near the latter of which places, the Fogher cliffs are about 700 feet high), on the west side of Beginish Island, and from Doulus Head to beyond Kells' Bay."

(p. 13.)—" Now if any of the islands near the shore be examined, where faults do not exist, their bedded rocks will be found to resemble, more or less, in dip and direction, those of the adjacent mainland; and even in the distant Skelligs the strike of the beds has the same general direction as that of the rocks, of which the whole promontory is composed. From this it appears that the rocks forming these islands were once in continuation with those of the land, and are even now connected with them by intermediate portions beneath the sea, some of which have projections still above its surface, such as the Lemon Rock, between the Skelligs and the shore, Beginish, with the adjacent islands in Valencia Harbour and those lying between Scariff and Deenish, at the northern entrance to Kenmare River, and not far from Lamb Head, near Derrynane. It was the gradual but ceaseless action of the sea-breakers which cut off the islands from the mainland, and it was a similar action of erosion, exerted upon the rocks now forming this mountainous promontory, as they were gradually rising above the level of the sea, which scooped out its valleys, and, taking advantage of the numerous joints and master-joints found in all stratified rocks, formed all the cliffs and principal features of the ground, which have since that time been modified to some extent by atmospheric influences, and by the glaciers which have left their marks in so many of the glens.

" The supposition that the wearing action of the sea is sufficiently powerful to have produced these results is much strengthened by considering the force with which this coast is assailed by the storm-waves from the Atlantic Ocean. An examination of the shore-line will show that they have produced cliffs of a bolder character, though not of so great a height as some of those which occur inland; while in some instances they have undercut the hard rocks forming these cliffs, and have removed portions of them, so that the rest overhangs the sea; and in other places caves and long fissures have been worn beyond the coast-line far into the land.

" (Note.)—As an illustration of the fury with which the breakers act upon this coast it may be mentioned that during an autumnal gale from the north-west I have seen the sea break clean over Lamb Island, in Valencia Harbour, which has a height of 78 feet above low water, and then runs down its eastern slope in sheets of foam and spray. It is stated, too, that water-tanks, or butts, near the upper light-house, on the Great Skellig Rock, close to which, a height of 380 feet, is marked upon the Ordnance 6-inch map, have been washed from their places in the course of severe gales; and that the Horse Island, at the west side of Ballinskelligs Bay, has not been very long separated from land. A little to the north of this island, the shore of the bay, there composed of 'drift,' has within the historic period been so much worn and carried away by the sea, that the foundation has been washed from under part of the ruined abbey of Ballinskelligs, which was probably built at some distance from the water's-edge, and the skeletons of people buried in the adjoining grave-yard exposed.—A. B. W."

"The Ancient and Present State of the County Kerry." Charles Smith, Dublin, 1756.

(p. 102.)—"The sea towards the bottom of Ballinaskelligs Bay is making great devastations and encroaching on the land every winter. The cliffs are very high, but are unable to resist the fury of the ocean. as they are only formed of different strata of clay."

(p. 103.)—"At Ballinaskelligs are to be seen the ruins of a very ancient abbey or friary of the Order of Augustine Canons: it was formerly removed hither from the island called the Great Skelligs, where there was a monastery, consisting of several cells, dedicated to St. Michael the Archangel, and is mentioned by Giraldus Cambrensis. The time of its foundation is not known, but it must have been of great antiquity, probably as early as the sixth century. The 'Annals of the Abbey of Innisfallen,' in Lough Lane, in this county, say that Flann M'Callach, abbot of *Skellig*, died in the year 885. At what time the monks quitted the island is uncertain, but by the large traces of ruined buildings, which the sea is continually demolishing, it appears that this abbey had been formerly a very large edifice.

"There are some traces of a town still remaining, besides a small castle, built formerly on an isthmus to defend the harbour against pirates, who had done considerable mischief hereabouts."

(p. 187.)—"Between the Harbour of Smerwick and Ferriter's Creek, the land lies low, and hath been much covered with sand by the sea and wind of late years. This isthmus is hardly a mile broad, growing narrower every winter, and will probably become an island.

"The Great Blasket Island, opposite to this place, is said by tradition to have been formerly joined to the continent, and the country people show an old ditch, which they say points to an opposite one at Dunmore. The sound between that island and the mainland is of great depth, and the currents of both ebb and flood set through it with prodigious force and rapidity."

(p. 208.)—"*Fenit Island.*—Towards the north point of Fenit are several sunken rocks, and also one above water called the *Rose.* This island at low water is contiguous to the mainland; but in all former charts and maps is placed at a great distance from the shore.

"*Ballyheigh Bay* and *Strand.*—The land towards the bottom of this bay is very flat, soft, and boggy, and hath no other defence but the above-mentioned sandbanks from the fury of the ocean, which almost every winter breaks through them in many places; and, therefore, a considerable tract of this part of the country will in a few years (from 1756) be probably overflown. The neighbouring inhabitants show rocks visible in this bay only at low water, which they say are the remains of an island that was formerly the burial-place of the family of Cantillon, who were the ancient proprietors of Ballyheigh.

"It is easy to see that if the land were depressed some 2400 feet, the sea would then surround the mountain tops, transforming them in time into islands like the Skelligs, and that if, as the ground arose from the sea, the elevating action occasionally ceased, or went on very slowly, the mountain cliffs and steeper declivities would be formed by an action precisely similar to that which is acting on the present coast."

(p. 18.)—"Purple grits and slates, with a general strike of about east 25° (?) are seen on the mountain slopes on both sides of the road, from Cahersiveen to Coomnahincha and Coonanna Harbour; and the continuation of the ridge from this to Doulus Head exposes along the line of sea-cliffs to the north and round Doulus Head to Laght Point, a series of remarkable contortions in reddish purple girths, amongst which are some slate beds. Some of these contortions are seen in the annexed sketch of Doulus Head from the west. A north and south fissure crosses the headland where the figures 10 to 70 are engraved upon the map between the points marked 355 and 921. At the south end of this, and running inward along it, is the Doulus Lane. Due west of Glanlean (in Valencia Island) is the hill called Geokaun, rising to the height of 888 feet above the sea, and presenting to the north-west the bold sea-cliffs of Fogher, which are some of the finest of the kind in the whole district, being nearly 700 feet in height."

(p. 22).—"In the cliff to the south of Dromgour, which is the highest sea-cliff in this district, being 867 feet above the level of the

the sea, there is a mass of rock that looks like a greenstone dyke. Puffin's Island is chiefly composed of purple slates, which are well exhibited in the cliffs all round it."

(p. 33.)—"The surface of the country round Sneem is stated to have been once a smooth turf bog. Subsequently to the deposition of the drift and accumulation of the bogs, two actions, one of elevation, and the other of depression, seem to have occurred in parts of the district, if not over the whole of it. Owing to the latter action, the sea at Reenagappal, in Valencia Harbour, flows at every tide over part of the bog which so extensively covers the mainland. This could not have been formed in the situation it now occupies beneath the sand at low-water mark, but must have grown above high-water mark, thereby showing a depression of at least 25 feet to have taken place. A portion of the boggy flat at the north-west corner of the map, as has been already stated, is laid under water by the higher tides."

Memoir Geological Survey of Ireland (Sheets 197 and 198 and south-east part of 191). The district described is the termination of the promontory between Bantry and Kenmare Bays, from Kilmakiloge Harbour, and the eastern part of Bear Island to Dursey Head.

The mountainous ridge that separates Bantry Bay from Kenmare Bay (or river, as it is often called), has its loftiest eminences to the east of this district; its crest, however, still retains an altitude of over 1900 feet, south of Kilmakiloge Harbour, forming a rather flat-topped ridge, from which proceed broken lateral spurs and deep valleys, with sides that show many cliffs and precipices of bare rock. About one and a half miles north of Castletown Bearhaven the crest of the ridge sinks rather suddenly down to a level of 300 feet above the sea, forming an open pass between the hills already spoken of and the Mirkish and Knockoura Mountains, which rise to 1272 feet and 1610 feet respectively. The ridge is then continued to the west, gradually sinking down to Dursey Sound, which is another pass (the floor of which is now below the level of the sea), between the mainland and Dursey Island, the summit of which is 825 feet above the sea.

(p. 6.)—"It would be difficult to describe and almost impossible to exaggerate the picturesque beauty of much of this high rocky ground, commanding views over Bantry Bay, on the south, and the still more lovely, Kenmare River, to the north, backed by the Kerry mountains, each bay spreading out into the broad expanse of the Atlantic towards the west.

"Although the cliffs round Dursey Island and Ballydonegan and Coulagh Bays are often lofty, and the land above them mountainous, they are not generally so precipitous as those which stretch eastward from Blackball Head along the north shore of Bantry Bay, or from Kilcatherine point, along the south shore of Kenmare Bay. There are black jagged cliffs, often quite perpendicular for 300 or 400 feet. They, are, however, more broken into than the former by narrow passages, giving admission to sheltered harbours, instead of open bays. The beautiful harbours of Ardgroom and Kilmakiloge, in Kenmare Bay, are intances of this, and a still more striking one is Bearhaven, lying between Bear Island, and the main."

Memoir Geolog. Survey of Ireland (Sheets 200, 203, 204, and 205, and part of 199). The district described belongs wholly to the county Cork. Cape Clear and Mizen Head, the two southern promontories of Ireland, are comprised in it.

(p. 6.)—"As a subordinate feature of the main central ridge may be mentioned the small ridge which runs on each side of Skull Harbour and from thence to Toormore Bay. To the south-west of Toormore Bay it is again met with, and continues out south-west to Mizen Head, where it forms a bold cliff nearly perpendicular and over 300 feet in height.

"The islands that fringe the coast on the south lie in lines parallel to the hills just mentioned, showing that they also are the summits of ridges which are partly submerged, the islands answering to the peaks, and the straits to the longitudinal and transverse valleys. The most northerly of these partially submerged ridges is that forming House Island, Castle Island, Long Island, Goat Island, and the part of mainland that lies to the south of the beautiful land-locked harbour of Crookhaven, and is only prevented from being an island by a sand-flat between the head of Crookhaven and Burley Cove.

"Another forms Inisodriscoll and the Calves; and on the line of the most southerly is Sherkin and Clear Island and the Fastness Rock. The Fastness Rock is remarkable, not only for being the most southerly portion of Ireland, but also for its aspect, as it rises, with nearly perpendicular sides to a height of 97 feet from the water, with not much more than room for the base of the lighthouse that stands on it."

(p. 7.)—"The indentations into the land along the south coast, especially those that form harbours, often lie in the lines of the previously mentioned transverse valleys. Four miles on the east of Mizen Head, however, is the long narrow bay called Crookhaven, which coincides with a longitudinal valley. The bay called Skull Harbour, which lies a few miles further east, is partly sheltered from the swell of the Atlantic by the islands off the coast. Roaringwater Bay, still further eastward, runs for more than two miles up into the land.

"About 3 miles on the east of Baltimore is Lough Hyne, a picturesque salt-water lake, out of and into which the tide ebbs and flows with tremendous force, as the entrance is very narrow compared with the capacity of the Lough. Further north-east are the long narrow harbours called Castlehaven, Glandore, and the Bay of Rosscarbery. This last-named is gradually filling up with sand and slob. (Note.)—When Smith wrote his 'History of the County Cork,' it was a tradition that, 'the harbour of Rosscarbery was formerly navigable for ships.'"

(p. 18.)—"A little on the west of the north harbour (in Clare Island) there is the ruin of a castle called Doonanore, which shows the encroachment of the sea during the historical ages. Smith, in his 'History of Cork,' written in the year 1750, vol. i., p. 286, mentions that 'there is a very narrow passage about a yard broad, and 10 yards in length, leading to the castle.' Now (1860) this passage is nearly all gone, and only half of the castle remains, as the other half was carried away with the rock on which it was built."

(p. 19.)—"There are small *alluvial flats* along some of the rivers. Under the slob on the east of the town of Rosscarbery, Mr. DuNoyer has noted that they dig peat bog for fuel, and also at the head of Tralong Bay, which lies on the coast 2 miles south-west of Rosscarbery. This shows that the land here must have sunk, besides which we have a well-marked record of the encroachment of the sea during the historical period of the old castle of Doneen, which was built on a small island in Castlebay, a mile and a quarter south of Rosscarbery. Half of the castle and the rock on which it was built have been gradually carried away by the sea."

Memoir Geological Survey of Ireland (Sheets 192 and part of Sheet 199), (1864).

(p. 5.)—"The country described comprises the ground round the head of Bantry Bay, and a large part of the mountain ground between Bantry Bay and Kenmare Bay on the north, and the rocky promontory between Bantry Bay and Dunmanus Bay on the south. The ground round Bantry Bay belongs wholly to the County Cork, while that on the Kenmare side lies in the County Kerry.

"The south-west corner of Ireland presents several high rugged promontories running out to the west-south-west, terminating in precipitous headlands with rocky islands and islets, each promontory separated from the other by a picturesque bay, running far into the land.

"Dunmanus, Bantry, and Kenmare Bays are the three which are most regular in general form, while they are at the same time the most beautiful, on account of the loftiness and varied outlines of the ground intervening between them. Dunmanus Bay opens between Three Castle Head and Sheep's Head, and runs in about 13 or 14 miles, with a width never exceeding 2 miles. The opening of Bantry Bay lies between Sheep's Head and Bear Island, from which it runs about 20 miles into the land, with an average width of 3 miles.

"The promontory between Dunmannus Bay and Bantry Bay varies from 2 to 2½ miles in width, and rises in rocky ridges to a height of about 1000 feet above the sea.

"The promontory between Bantry Bay and Kenmare Bay is about 10 miles wide, and is much loftier and more rugged than that to the south of Bantry Bay."

G. Smith, "History of the County Cork," vol i., p. 286 :—

"On the north side (of Cape Clear Island) stands the ruins of a castle (built on a rock in the sea) called Dunanore—('The Golden Fort.') There is a very narrow passage, about 1 yard broad and 10 yards in length to this castle. This path is high and steep on both sides, the sea on either hand being very deep, so that few but persons well used to it will venture to walk it over."

(p. 269.)—"*Rosscarbery.*—The harbour, according to Camden, was formerly navigable for ships, but in his time (1586) it was quite choked up with sand ; and it is now so shallow that no vessel can come up to the town."

(p. 274.)—"On the west of Glendore Bay, not far from the Cape, by the working of the sea, a large portion of the hill fell down, on which grew several trees ; this piece formed an island of about twenty yards in circumference, and the trees continued to grow, but it is now (1750) almost quite washed away."

(p. 111.)—"Near *Ring* several large horns were dug up in this strand (which belonged to the Moose deer) by Mr. Hayman, near Youghal. This strand to the land is terminated by a large extended bay by which was continued, before it was encroached upon by the ocean, a great way beyond the lowest ebb.

" *Clay Castle.*—On this strand is a very bold sudden rising ground or rather small promontory composed of loose, sandy clay, which had also been encroached upon by the sea very considerably within these few years (1745–50). This hill stands about a mile south-west from the town of Youghal."

(p. 256.)—" Near Dunworley to the west the coast is all bold, high shore, abounding with stupendous cliffs, which astonish while they please us.

" On most of this coast are great variety of caves worked by the sea; these caves are generally the habitations of wild pigeons, gulls, and other sea fowl, who live in the upper crevices, while porpoises, seals, and other monsters of the deep have their abode below."

(p. 241.)—" *Old Head.*—Four miles south of Kinsale in the barony of Courcy's is a promontory running far into the sea called '*Old Head.*' A mile from its extremity is an ancient castle of the Lords Kinsale, built from one side of the isthmus to the other, which defended all the land towards the Head. The place was formerly called *Dancearma*, and was an old seat of the Irish kings. The isthmus by the working of the sea is quite penetrated through, so that there is a stupendous arch under which a small boat may pass from one bay to the other."

(p. 254.)—" *Courtmacsherry.*—On both sides are prodigious high cliffs towards the entrance to this bay, where eagles, hawks, and herons build their nests."

Memoir, Geological Survey of Ireland (Sheets 194, 201, 202), (1862). The district described includes the coast line from Galley Head to the Old Head of Kinsale.

(p. 6.)—" Small transverse valleys, at right angles to the general bearing of the ridges, may be noticed in the Clonakilty estuary, in the flat entering Dunworley Bay, in the mouth of Kinsale Harbour, and in the little deep blind cove, that runs for a mile into the high land just to the west of the mouth. It is indeed but a further extension of the same feature which produces the indentations of Clonakilty Bay and Courtmacsherry Bay, separating the once continuous ridge that stretches across these bays into the promontories of Galley Head, the Seven Heads, and the Old Head of Kinsale. The extremity of the Old Head of Kinsale, which rises to 139 feet above the sea, is begun to be cut off from the land by a subterranean sea passage, through which the light can be seen from each of the two indentations of the land, which are hence called 'Holeopen Bays.'

"Galley Head is in like manner nearly cut off from the mainland, and formed into an island; and this is, doubtless, one of the ways in which the rocky islets with vertical cliffs, like those of the neighbouring coasts, have been formed.

"The Sovereign Islands, off the mouth of Oyster Haven, afford examples of these, of one of which the following figure is a sketch taken by Mr. DuNoyer during a gale of wind. (Fig. 1)."

(p. 27).—"On the western side of Courtmacsherry Bay, as on so many parts of the south coast of Ireland, a submerged bog is found at dead low water of spring tides, and is then cut for turf by the neighbouring farmers. How much further it may extend below the sea is, of course, not known. There is a large bog at the back of Dunworley Bay, the surface of which is but little above the level of high water mark, respecting which Mr. J. Good, of Dublin, informs me that a rod was put down for a depth of more than 50 feet without reaching the bottom. These, and other similar facts to be found round all the coasts of Ireland, seem to point to a recent depression of the whole island."

Memoir Geological Survey of Ireland (Sheets 187, 195, 196), (1864). The district described includes the mouth of the River Lee, Cork Harbour and the surrounding district.

(p. 5).—"The two principal longitudinal valleys may be called here, the valley of Cork and the valley of Cloyne. The latter runs across the district of Ballycotton Bay, to Ballinhassig, and beyond that to Bandon and Dunmanway. The principal part of Cork Harbour lies in it."

George Smith, "History of County Cork," vol. ii., p. 11:—

"In the latter end of March 830, Hugh Derndighe being monarch of Ireland in this year, there happened such terrible shocks of thunder and lightning that about 1000 persons were destroyed by it between Corca-Bascoin and the sea-side. At the same time the sea broke through its banks in a violent manner, and overflowed a considerable tract of land. The island on the west coast of this country called Innisfadda (= 'Long Island') was forced asunder and divided into three parts. This island lies contiguous to two others, viz. Hare Island and Castle Island, which, lying in a range, and being low ground, might have been very probably then rent by the ocean."

Memoir, Geological Survey of Ireland (Sheets 188 and 189), (1861). The district described includes some of southern ports of the counties of Cork and Waterford, which lie on each side of Youghal.

Youghal Bay and the mouth of the Blackwater River.

(p. 5.)—"The coast differs in different parts, excepting a line of frequently inaccessible cliffs, where it runs across one of the longitudinal ridges, and low sandy or marshy shores, where the valleys strike out upon it. The cliffs rise to between 150 and 200 feet near Mine Head, while at Ardmore Bay the coast consists of a gravelly sandy beach, backed by low vertical banks of clay. Between Ardmore and Ardrogma Heads it again presents cliffs, some of which are 190 feet high; these are broken at Whiting Bay into low rocky shores, with sandy beaches, but appear again beyond it, and continue as far as the mouth of Youghal Harbour. From Youghal Harbour a gradually widening strand stretches to the south-west for four miles, along low cliffs of marly clay, which in one place at the end nearest to Youghal, rise to a height of 90 feet, but further to the south-west sink down so as to permit the tide to encroach considerably inland. Knockadoon Headland again is edged by vertical cliffs with heights of 130, 170, and 200 feet, but south of Kilcredan, another strand commences where the Cloyne Valley comes out upon the coast."

Charles Smith's "History of Cork" vol. i. (1750):—

(p. 109.)—"The large extended strand of Youghal, as far as the lowest ebbs uncover it, and probably much farther, is no other than a common turf bog, covered over with sand and pebbles, from whence not only good turf is dug every season, but also great quantities of timber, trees, as fir, hazel, &c., are found. Some years ago a skeleton of a monstrous animal was discovered in this strand; I saw one of the shoulder bones in Youghal; it is 3½ feet long, and weighs about 100 lbs. The remainder of the skeleton, and (as I am informed) another of the same kind, lie still buried in the strand. When they were first discovered, it happened to be a very low ebb. These bones lay in a turfy soil not far from the surface. They undoubtedly belonged to some fish of the cetaceous family, which seems the more probable from their being thick, short, and ponderous; and not to an elephant or land animal, as was conjectured by those who discovered them. About eighteen years ago (1750 – 18 = 1732), this strand was entirely divested of all its sand and gravel, and being left quite bare by violent high winds, great quantities of roots of various trees then lay exposed to view. The sea has greatly encroached on this part of the coast, and is likely to gain more ground, as the land within the strand lies low and flat. At the entrance of the harbour of Youghal may be seen the remains of the foundation of a mill standing on a rock, which shows that the ocean has greatly exceeded its limits on this shore."

(p. 343.)—"About a mile east of Doneraile is Castle Saffron, so called from the large quantities of it formerly planted here, being greatly used by the Irish for dyeing their shirts, &c."

Memoir, Geological Survey of Ireland (Sheets 167, 168, 178, and 179) (1865). The surface described includes a portion of the County Wexford, ending in Hook promontory.

(p. 8.)—"The entire coast westward from Credan Head (202 feet), past Brownstown Head (158), is quite precipitous, and it presents the same aspect for the distance of fifteen miles westerly, from Newtown Head (110 feet) to Ballyvoyle Head, where it is 243 feet in elevation. Helvick Head, at the south side of Dungarvan Bay, is 255 feet above the sea, and its shores are also abrupt. Broken ground running easterly from Dunbrody (in the County Wexford) attains a height of 257 feet; further south, the country, though rarely level, attains here and there to elevations of 250 feet, and on the east coast of Waterford estuary to the south of Duncannon, the cliffs reach a height of 128 feet, and at Broomhill Bay 208 feet above the sea. On the east coast of Hook promontory at Houseland the cliffs are, some of them, over 140 feet in height, but to the south of this the promontory becomes lower, with an average height of about 40 feet reaching to 60 feet at the cliffs between the village of Slade and the extremity of Hook Head."

Memoir, Geological Survey of Ireland (Sheets 148 and 149), (1887). The greater portion of the district described is situated in the County Wexford. (No available details given.)

Memoir, Geological Survey of Ireland (Sheets 158 and 159). The area described is a tract lying east and west in the County Wexford. (No available details given.)

Memoir, Geological Survey of Ireland (Sheets 169, 170, 180, and 181), (1879). The area described is a portion of the county Wexford, and forms the south-eastern extremity of Ireland.

(p. 5.)—"Of Bannow there is a tradition that the ancient city was buried in the sand; this, however, cannot be correct, as the sands are only a few feet deep, and could only obliterate the foundations of the houses.

"Off the south coast, are the Saltee and Keragh Islands, with various sea rocks, while south-east of Greenore, on the east coast, is the Tuscar Rock and lighthouse."

From the consideration of the foregoing series of extracts taken from the Memoirs of the Geological Survey of Ireland, it may be recognized, that in one of them alone is the waste of the coast of Ireland specifically alluded to and dealt with, that is, in that of the Counties Wicklow and Wexford, by Mr. George Kinahan. He not only considers the data presented by the coast from that point of view, but also gives measurements and details which would allow of further waste and change being defined and measured as to extent and character.

In his memoir dealing with the Aran Islands he also gives specific details as to the size of the rocks moved by the waves, and enters into interesting details as regards the formation of the block beaches, and their significance. As regards all the other memoirs, the question of the waste or wear of the coast is not specifically considered, although in many of them, the characters of the cliffs, chasms, caves, &c., resulting from the action of the ocean waves on the coast line, are incidentally considered, and more or less fully detailed, but without any attempt at measuring the action of the waves, or of generally defining the outline of the coast by prominent points so as to furnish to some extent points of comparison for future investigations. From the whole of the remarks it can be clearly inferred that considerable and continuous waste of coast line is going on day by day, and that the extent of the area of Ireland is being slowly reduced. It is evident, therefore, that unless a new and special survey of the entire coast of Ireland be undertaken with a view of accurately determining its present outline, and of thus leaving a basis of observation to which future changes of outline and further losses of ground may be referred, and thus become capable of precise measurement, this very important question must remain in a perfectly undetermined state, and in a condition most unsatisfactory, not only from a scientific point of view, but also from the larger and more important one, that of the administration of the country. With the facilities afforded by photography at the present time, it should be possible to so represent pictorially the present outline and state of the coast as to render easy of definite determination the future encroachments of the sea, and thus allow of continuous and accurate observations being systematically carried out all round the island.

It would therefore be worthy of the Royal Irish Academy to promote by its action and influence the undertaking of such a survey, and to bring to bear the services of the Ordnance Survey in conjunction with those of the Geological Survey officers, so as to allow of the attainment of that important object, giving at the same time the fullest importance to all local traditions or personal observations bearing on the subject, as also to all the details to be gathered from the public records now being so carefully examined and published by Government, and by many public bodies and learned societies.

IV.

ON COMPOSITE GNEISSES IN BOYLAGH, WEST DONEGAL.

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(Plates I. to V.)

[Read May 26, 1902.]

I.—Introduction.

The observations on which the present paper is based are in direct continuation of those recorded in 1900,[1] and have been carried on with the assistance of a grant made by the Royal Irish Academy for the study of metamorphic and other rocks in the north-west of Ireland. The barony of Boylagh (Baeighellach) includes the country between the Owentocker and the Gweedore River, with the long sea-inlet of the Gweebarra in the midst of it. New roads have been cut of late years across some of the wilder portions, and the bridge made by the Congested Districts Board over the Gweebarra River has greatly facilitated communications.

The earlier discussions[2] as to the nature of the granite masses which play so important a part in Donegal may now be regarded as set at rest. Dr. Callaway[3] showed, in 1885, that the granitoid gneiss of northern Donegal was an intrusive rock, and his observations were again and again verified throughout the whole county during its detailed examination by the Geological Survey, which resulted in a series of maps and memoirs published between 1887 and 1891. The movements that have undoubtedly left their impress on the granite in many parts of the county of Donegal, as, for example, in the Barnesbeg area, are in all probability of Caledonian age;[4] that is to say, they

[1] "On Metamorphic Rocks in Eastern Tyrone and Southern Donegal." Trans. Royal Irish Acad., vol. xxxi. (part xi.), pp. 431–470.

[2] See references in above paper, pp. 449–450, and the good Bibliography in Geol. Survey of Ireland, Mem. to sheets 3, 4, &c., p. 23.

[3] "On the Granitic and Schistose Rocks of Northern Donegal." Quart. Journ. Geol. Soc. Lond., vol. xli., p. 221.

[4] The recent attempt of some English writers to use the terms "Caledonian," "Hercynian," etc., so clearly defined by Bertrand and Suess to express the trend of folds in general, rather than folds of a particular epoch of mountain-building tends to deprive European geology of a very valuable piece of nomenclature.

are pre-Devonian and post-Silurian; and the trend of the great granite masses across the country implies that these were intruded about the time that the folding was in progress. If, then, in the present paper, we are led to ascribe the foliation of the granite over a wide area to original conditions of flow and intrusion, we must fairly recognise that such flow took place under the influence of the Caledonian processes of mountain-building.[1] At various points the invading granite had doubtless become solid and resisting before the earth-movements came to an end; and here deformations and new structures were set up, and must be attributed to true dynamic metamorphism. In Boylagh, however, it appears that foliated gneisses arose during the ordinary course of igneous intrusion, though their structures were emphasised to some extent by subsequent pressure. The more profound changes that we observe in the contact-zone in the field were not brought about by mineralising emanations from the granite, nor yet by molecular re-arrangements in the heated sedimentary rocks. They were due, rather, to that bodily intermingling and incorporation of two dissimilar masses, which results in the formation of *composite gneiss*. The gneisses of Boylagh retain, then, to a considerable degree the structures both of an igneous and a stratified material. This, at any rate, is the argument of the present paper.

II.—The Dome of Ardara.

Our first observations may be made in the area cited by Mr. J. R. Kilroe[2] as clearly exhibiting the effects of pressure in producing foliation in the granite. Mr. Kilroe, in his memoir, and in the beautiful maps prepared by him in conjunction with his colleagues,[3] shows how the foliation of the schists runs parallel to the curving margin of the granite between Ardara and Clooney, and how similar foliation occurs, also parallel to the margin, at certain points within

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[1] Dr. S. Haughton, forty years ago, came to a very similar conclusion regarding the granite of Donegal, when he stated that in the centre it was probably igneous, "deriving its cleavage-planes and gneissose character from the pressure exercised upon it by the stratified rock, which has been lifted, to the north and south, to a nearly vertical position." ("Experimental Researches on the Granites of Ireland," part iii., Quart. Journ. Geol Soc. London, vol. xviii., 1862, p. 406). The remark is of importance, as showing that this author was not a convinced advocate of a metamorphic origin for the granite as a whole.

[2] Memoir to maps of south-west Donegal (sheets 22, 23, 30, and 31), Geol. Surv. Ireland (1891), pp. 28–30.

[3] Geol. Surv. Ireland, sheets 15 and 23.

the granite mass. But the general trend of this foliation is also that of the strike of the uptilted sedimentary schists. There is no mystery here as to the origin of the schistose series, which admittedly consists of shales, limestones, and sandstones, invaded by basic igneous rocks, and subsequently metamorphosed by pressure. The dynamic action has here and there induced a foliation oblique to the bedding, while thrust-planes have allowed some blocks to move over others; but in most localities the original bedding is traceable, and there has been no general rolling out of the complex mass into mylonitic schist or gneiss.[1] In the promontory, for instance, leading to Loughros Point, west of Ardara, obvious deformations have gone on, with consequent production of garnetiferous mica-schist; but in many places the stratification of shales and limestones is left perfectly clear, with a puckered foliation running obliquely through the shales. Even where great quartz-veins come up along the surfaces of foliation, the original bedding may still be seen, and the character of phyllites, rather than of mica-schists, is preserved by the crumpled shales.

The folded layers, then, of this stratified "Dalradian" series, although inversions and repetitions had already taken place, furnished the important structural surfaces of the district at the time of the upwelling of the granite. West of Glenties, the igneous rock has come up laccolitically along one of these surfaces, forming a low granite dome north of Ardara. On the south side the dip of the Dalradian series is away from the elongated dome; but on the west and north it is towards the granite, and the schists are doubtless there prolonged to some distance beneath the igneous rock. Trusklieve, in Ranny, forming the conspicuous mass north of the Gweebarra, with its bare tabular granite overlying schist, and sending off intrusive veins into this sedimentary substratum, is another example of an igneous boss behaving as a laccolite on its margin. (Compare left-hand end of figure on p. 225).

Along the margin of the granite dome which stretches north from Ardara, foliation appears in patches in the granite. According to an older view, this indicated that the granite had been formed by the progressive metamorphism of stratified schists. On the dynamo-metamorphic view it indicated, on the other hand, a crushing and

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[1] Mr. Kilroe describes the considerable movements and dislocations in this series in the Glenties area (Mem. S. W. Donegal, pp. 19–23). I attribute, however, certain features of the metamorphism described by him to the contact-action and intrusion of the granite, working on a regional scale.

streaking out of the consolidated igneous rock. But it cannot fail to be observed that the clearly foliated masses are formed of dark granite, rich in elongated flakes of biotite. Dr. J. S. Hyland[1] regarded this excess of biotite in the gneissic granite of Donegal as a secondary feature, "as its frequency increases with the intensity of the metamorphism." Mr. Kilroe,[2] however, from his field-observations, holds that shearing was facilitated where the biotite originally was abundant. He elsewhere remarks,[3] "where the mica abounded, as in the more basic portions, the rock has yielded most freely" to the earth-pressures. This presumes a previous process of differentiation in the mass, whereby more basic knots had gathered here and there. In the field, however, inclusions of schist, drawn out along the foliation-planes of the granite, again and again accompany the "metamorphosed" granite. I doubt if they are absent from any of the points where the foliation has been thought of sufficient importance to be recorded on the maps of the Geological Survey. Near Kilgole, immediately north of Ardara, these inclusions are obviously connected with and emphasise the foliation. In Garvegort Glebe, again, nearer to Glenties, a few rugged exposures behind the school-house show a well-developed biotite-gneiss, including similarly elongated fragments of mica-schist, some of which contain tourmaline. The occurrence of this mineral completes the resemblance of the inclusions near Ardara to those caught up in the Caledonian granite near Ballycorus, in County Dublin.

In both the above-mentioned cases of foliated granite between Ardara and Glenties, the undoubted Dalradian series lies only a hundred yards or so away upon the south. At Kilgole the contact-

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[1] Mem. to sheets 3, 4, 15, etc. (1891), p. 135.

[2] *Ibid.*, p. 78.

[3] Mem. S.W. Donegal (1891), p. 29. Dr. Haughton notices that the gneissose granite of Ardara contains black mica "in large quantity" (Quart. Journ. Geol. Soc. London, vol. xviii., 1862, p. 408). Mr. R. H. Scott, discussing the analysis of one of these Ardara masses, which contains only 55·20 per cent. of silica, says that it is, "properly speaking, not a granite at all." (Journ. Geol. Soc. Dublin, vol. ix., 1862, p. 287; see also Dr. J. S. Hyland, Survey Mem. S. W. Donegal, p. 64). The analysis, which was also published in Haughton's paper, shows us a rock allied to Rosenbusch's Minette-Kersantite series, verging on kersantite, but with 4·63 per cent. of soda and only 3·17 per cent. of potash. Since soda is not more abundant than potash in ordinary phyllites and mica-schists, it seems highly probable that this particular darkened and gneissose granite of Ardara became modified by the absorption of an epidiorite or hornblende-schist, as is the case with the gneiss of Carn and Lough Derg in southern Donegal, and the gneissic granite of Derkbeg to be described later.

effect has produced a very fine-grained biotite-gneiss along the junction. There is in the field no question whatever of basic segregations in the granite, such as are so often relied on to explain variations in an intrusive mass. The phenomena are those of intrusion along the pre-existing foliation-planes of a schist; and a good gneissose rock results, set with inclusion-flecks, in which these foliation-planes are still apparent. Subsequent pressure may have intensified the eye-structures, and may have broken up some of the residual and included layers of schist; but this gneissic border to the granite is none the less of composite origin, and its main characters remain due to the circumstances of its original flow.[1]

On the north side of the Ardara dome, towards Gweebarra Bay, the same phenomena are repeated. Uncontaminated granite, like that of Carn in southern Donegal, is seen in the veins that come up through the Dalradian series at Portnoo. The specific gravity of this beautiful white rock is 2·59. It consists almost entirely of quartz, orthoclase, and microcline, with a mere trace of greenish biotite. Muscovite has developed, however, as an alteration-product in the felspars. Another type at Cashelgolan, east of Clooney, is a pale granite with well-developed primary muscovite; here the rock intrudes into a schistose series.

The granite at Portnoo, on the shore on the east side of Dunmore Head, cuts in numerous veins and dykes across a tough diorite, and similarly invades the gray crystalline limestone of the headland. In the former case little absorption takes place, except on the margins of some of the dykes, and the rock remains undarkened; in the latter case the granite has detached small fragments of the limestone, and has even entered along the fissures where the successive beds in a small anticlinal have "sprung" apart. But no appearance of inter-lamination on a large scale has arisen, and the granite remains devoid of foliation. Gray garnet and wollastonite, the latter in microscopic prisms, have arisen in the limestone, some layers of which have become so rich in silicates as to be practically flinty. The variation in the type of alteration in alternate layers is, however, due to original differences in the composition of the strata, and not, as might be supposed in the field, to parallel intrusions of the granitic magma.

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[1] Compare the observations of Lacroix on the granite with elongated inclusions in the valley of Boutadiol, etc., "Le granite des Pyrénées et ses phénomènes de contact," 2me mémoire (1900), Bull. Carte géol. de la France, No. 71, pp. 21 and 25.

Here and there an argillaceous layer occurs, converted almost wholly into mica at its contact with the granite vein.[1]

Opposite Swan Mount, above the Portnoo Hotel, a granite appears amid crumpled mica-schists, and is darkened, toughened, and altogether modified by numerous inclusions of mica-schist and aphanite. There is not the slightest doubt as to the nature and origin of these inclusions, and the rock resembles the similar instance at Castlewellan, Co. Down. A large specimen, with inclusions in various stages of absorption, has the characteristic specific gravity of 2·77.

Higher up, on Cashel Hill, veins of granite, with green mica, penetrate a mica-aphanite; and biotite-granite appears in force near the summit of the hill. All this serves to correlate the Portnoo granite with that of the main mass further east; but it must be borne in mind that pegmatitic veins cut all the rocks of this area, including the foliated granite of the Ardara dome, and that the Portnoo granite may possibly belong to this later series of intrusions. Some faulting has occurred since the intrusion of the granite veins into limestone near the road on the north side of Narin Hill,[2] and these veins may belong to the older granite: but the typical pegmatites occur, cutting across the foliation of dark schists, as near at hand as Clooney, and also freely throughout Ballyiriston. From the point of view of general principles, however, the masses of pure and modified granite at Portnoo are, of course, available, whatever their age, as links in the argument concerning the composite gneisses in the dome of Ardara.

When we come east of Clooney, we are dealing with exposures on the true north flank of the dome. The junction of the Ardara granite and the schists is well displayed in a little quarry by the main road, just east of Cashelgolan Hill. The mica-schist is here delicately penetrated by sheets of muscovite-granite, which have been forced along the almost vertical planes of foliation. This foliation is parallel to that noticeable in the granite itself on the south side of the road. The junction shows very various features. In one place the granite, in which muscovite is the common mica, intrudes in delicate sheets

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[1] Compare Lacroix on the alterations of calcareous strata in the Pyrenees, "Le granite des Pyrénées, etc.," 1er mém. (1898), Bull. Carte géol. de la France, No. 64, p. 15.

[2] This is probably the locality near Narin where Mr. E. H. Blake noted the difficulty of saying "where the slate ends and the granite commences" ("On the primary rocks of Donegal," Journ. Geol. Soc. Dublin, vol. ix. (1862), p. 296). The apparent passage from the one rock into the other was recognised early in Donegal, as elsewhere in Europe.

along the foliation-planes of the mica-schist. The latter rock contains, in addition to the usual pale biaxial mica, a green-brown biotite, probably developed as a product of the igneous contact.[1] A specimen measuring 7 cm. by 8 cm. by 2 cm., from west of the farm of Ardlougher, and formed of clearly defined sheets of muscovite-granite and interlaminated mica-schist, in apparently equal proportions, has a specific gravity of 2·74. Specimens in which far more subtle intermingling has gone on have much the same density, despite the more coarse development of their crystalline constituents. The crystalline associations probably arise at an early stage, and the growth of larger crystals is a process of rearrangement of the groups already formed.

The contact-zone occasionally shows a yellow-brown composite rock, in which brown mica is abundant, but in which granitic characters on the whole predominate. This would be styled by French authors a Leptynolite.[2] The biotite, which is almost uniaxial, and which displays grey-brown to rich yellow-brown face-colours, does not occur in the granite itself, nor is it the same variety as that in the adjacent mica-schist. Muscovite is also present in the leptynolite, and separated out a little before the biotite; the latter certainly does not represent in this case mere patches of residual material derived from the mica-schist. The complete graduation of this rock into the granite, and also into various types of interlaminated composite gneiss, makes it clear that it also is essentially a composite rock, in which absorption of the schist and recrystallisation have occurred. A "leptynolite," or more precisely, a fine-grained "granitite" with oligoclase and two micas, and a specific gravity of 2·70, has resulted from an intermingling that must have amounted in this case to interfusion (Pl. iv., fig. 1). This zone of leptynolite, as observed by myself east of Cashelgolan Hill, is not more than 10 cm. thick; but I see no reason to doubt that similar effects may be produced elsewhere on a far more important scale.

Those who, with Mr. F. D. Adams,[3] have urged that such leptynolites arise from progressive metamorphism of the constituents of a shale,

[1] Salomon, "Geologische Studien am Monte Aviolo," Zeitschr. d. deutsch. geol. Gesell., Bd. xlii. (1890), p. 471, describes the formation of a brown biotite at the expense of chlorite, in phyllites invaded by the tonalite of Monte Adamello.

[2] Compare Lacroix, *op. cit.* (1898), p. 8, and his pl. I, figs. 1-5, and W. Salomon, "Essai de nomenclature des roches métamorphiques de contact," Congrès géol. internat., Comptes rendus, viii[e] session (1901), p. 343.

[3] "The excursion to the Pyrenees in connection with the 8th International Geological Congress," Journal of Geology, vol. ix. (1901), p. 44.

without any addition from the igneous rock, have cited chemical analyses to prove the possibility of such a change; but they seem to me to overlook the evidence of the field itself, and also the intermingling traceable with the microscope on the margin of inclusions and of veins that look sharp enough to the unaided eye. When a passage from an inclusion to the surrounding rock is clearly visible, the inclusion is, as previously remarked, liable to be treated as a "basic segregation."[1] But it is impossible to assert that the contact-schists in such a case as that of CashelgolanHill are "basic segregations" from the granite. The latter rock has none the less intermingled its magma intimately with their crystallizing materials. In such a case, the microscope merely refines and carries further the conclusions forced upon us in the field.

On the rising ground in Ballyiriston, south-east of this junction, there are rapid variations in the constitution of the granite. Very pure types, free from biotite, merge into darkened types with pink felspars and nests of dark green biotite. (Pl. III., fig. 1). The mode of aggregation of this biotite at once suggests its foreign origin; and this is confirmed by the frequency of lumps of schist, streaked out parallel to the east-and-west foliation, even as far south as half a mile from the visible junction on the road. Here, then, on the north side of the dome, the phenomena of Kilgole and Garvegort Glebe are repeated; the foliated granite is clearly of composite origin.

If any evidence were required, in addition to that which is so obvious in the field, to show that the inclusions are not the oft-cited "basic segregations," it would be found in the fact that veins run from the surrounding granite into these inclusions, and take advantage of pre-existing foliation-surfaces in them. A lump of muscovite-biotite-epidote-rock in the granite south of Bonnyglen Lough is thus penetrated by zigzag veins and tongues of biotite-granite. These

[1] W. Salomon, *op. cit.*, Zeitschr. d. deutsch. geol. Gesell., Bd. xlii. (1890), pp. 476 and 493, describes certain large masses, resembling concretions, in the tonalite of Monte Aviolo, as shading off into the igneous rock, but being none the less inclusions from the adjacent schists. Great crystals of biotite and plagioclase, like those of the tonalite, occur within them; their outer portions have been melted, and the tonalite-magma has flowed in along cracks, taking foreign constituents into itself and undergoing thus a chemical modification. Salomon's observations deserve quotation beside those of Lacroix, Sollas, and others, whose conclusions this author to some extent anticipates; and they have more value from the fact that he elsewhere denies that any extensive modification of the tonalite-magma has occurred through absorption of schist upon a large scale ("Ueber Alter etc. der periadriatischen Massen," Tsch. Mittheil., Bd. xvii., 1898, p. 173).

caused a further development of greenish biotite in a thin contact-zone along their junctions with the schist; in fact, this biotite seems to have been deposited as a first product of cooling from the veins themselves, just as the augite in the dolerite veins traversing older dolerite at Portrush has a tendency to gather on their margins. Then the felspar, which is mostly orthoclase, formed a zone on each side, leaving the quartz, which has separated last, to occupy a central band. Some large crystals of biotite occur, set irregularly in the veins. This little block, measuring some 7 cm. by 7 cm. by 6 cm., shows us that many lumps of schist must have been altogether cut to pieces and lost during the invasion by the igneous mass.

The dark microcline-granite in Ballyiriston shows under the microscope the clustered groups and flecks of biotite, associated with epidote, with which one soon becomes familiar along such intermingled contact-zones (Pl. III., fig. 1). A little sphene and green hornblende have developed, indicating the approach to more basic types. The specific gravity of this granite is slightly raised, and is here 2·69, that of the normal granite of Boylagh, as tested from various localities, being close on 2·60. The pure microcline-granite is here, then, modified towards quartz-diorite; at the same time, many of the inclusions in it become so commingled with matter from the granite as to pass at their margins quite insensibly into the igneous mass.

III.—Carbane, near Glenties.

A concrete example of the structure of Boylagh occurs on Carbane, a hill 450 feet in height above the sea, and half a mile east of the little town of Glenties.[1] The Dalradian series in "the Rock," as the rough street at the south end of the town is styled, consists of vertical well-bedded quartzites and black micaceous shales. Along their strike, as they swing round to the north-east, they show crumplings, and the shale-layers pass in a quarter of a mile into foliated and wrinkled mica-schist. The pressure under which this change was brought about is evidenced by the folding of the metamorphosed strata round small eyes of amphibolite (epidiorite); these doubtless represent the characteristic accompanying sheets of dark igneous rock, diorites and aphanites, which have become broken up in the more yielding shales. "The Rock" at Glenties is probably itself an eye on a large scale, a patch of strata that has escaped crumpling and deformation.

[1] This is the area referred to in the Survey Memoir to S.W. Donegal, pp. 29 and 53.

Carbane rises on the south-east of this metamorphosed area, and consists of granite, which penetrates the shale. On the southern slope of the hill the contacts are excellently seen. The granite is a pale pink aplitic rock, consisting almost entirely of pink orthoclase, larger and less decomposed colourless microcline, and quartz. Its specific gravity is 2·59. Near any large inclusions of schist, and near the junction generally, it becomes darkened and gneissose; but even the uncontaminated specimens show a delicate foliation, especially on their weathered surfaces. Specimens intermediate in structure between the darkened granite and those which exhibit distinct veins of aplite penetrating schist are only intelligible when their relations are followed out in the field. The schist, which is here not much more than a dark micaceous shale or phyllite, occurs *in situ*, dipping south-east, about midway between the road from Glenties and the summit of Carbane. The granite not only invades it, but is so worked up in it that crystals of quartz and microcline lie as white oval specks in a dark ground of phyllite, which flows round them. Tongues of granite shade off into mixed rocks of the most diverse character—here into a schist which has become set porphyritically with constituents from the granite; here into a fine-grained composite gneiss, in which the former sediment is represented by delicate waving sheets of biotite, with aplite layers, less than 0·5 mm. thick, between them. Hence the same contact-zone gives us granulitic biotite-gneisses, and rocks that, by themselves, might be regarded as felspathic ash-beds. The more uniformly intermingled masses show the same type of darkened granite as in the dome of Ardara, and occasionally obvious flecks of schist indicate the origin of the darkening. The composite rock, in a handsome specimen specially examined, has a specific gravity of 2·73, and is seen under the microscope to contain bent and streaky groups of biotite and yellow epidote, caught up between the constituents of the normal granite. Sphene, a common accompaniment of such contact-action, occurs freely. Some subsequent pressure-effects are traceable, in the production of mylonitic envelopes about certain felspars, and the alteration of quartz crystals to granular aggregates; but, both in the field and in the section, the actual intermingling is seen to be due to igneous flow. We pass by gradations from this rock to those which resemble felspathic ash, and see under the microscope how an excess of sedimentary material and a deficiency in granite has produced this extreme composite type. (Pl. II., fig. 2). Earth-pressures no doubt assisted the penetration of the granite-magma into the schist; as usually happens, the igneous rock followed, but did not originate, the upheaval, and its consolidation occurred under the very influences that had driven it from its subterranean caldron.[1] But the continuation of these pressures, when consolidation had begun, broke up the tiny sheets of granite, squeezed the yielding layers of biotite-schist between the crystals, and gave us the interesting *porphyroïde* of Carbane as a parallel with the "crush-conglomerates" that occur so often on a larger scale. But, here again, the essential intermixture of materials occurred during the igneous flow. In one specimen, a lump of biotite-epidote-gneiss occurs among the schist-layers, shifted by the dynamo-metamorphic movements from the position it once occupied, but showing that gneissic rocks had arisen in Carbane by intermixture prior to these particular movements.

All the rocks examined from this contact-zone show signs of pressure-alteration subsequent to their having received a foliated structure. Were not the evidence satisfactory in the field, it would be easy to attribute the principal foliation also to dynamic action. This combination of igneous penetration with shearing movements seems a common feature along granite-contacts in the Pyrenees.[2] But again and again, even in hand-specimens, we see that no dynamic movements could have produced such differentiation in successive layers of the rock. This is markedly the case in certain epidiorites of the Dalradian series, which are found on Carbane delicately interfoliated with wavy and fluidal sheets of aplite. The final movements have faulted some of these sheets, and the planes of fracture cut across their foliation (Pl. II., fig. 1); but the original igneous interpenetration, and the consequent production of a hornblende-gneiss with strongly differentiated layers, are as clearly traceable here as in the instance elsewhere cited by me from Cregganconroe, in the county of Tyrone.[3] Sphene and epidote occur in the composite rock; and the latter mineral, occasionally appearing in large patches in the fluidal granite veins, is doubtless there of primary origin, owing to the conditions under which the ultimate consolidation of the rocks took place.[4]

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[1] Compare Weinschenk on the Alps, Congrès géol. internat., Comptes rendus, viii^{e} session, p. 340.

[2] See Lacroix, "Le granite des Pyrénées et ses phénomènes de Contact," 1er mém., pp. 6 and 40, and 2^{me} mém., p. 18.

[3] "Metam. Rocks in E. Tyrone, etc.," Trans. R. Irish Acad., vol. xxxi., p. 440, and pl. xxvi., fig. 1.

[4] See Weinschenk, "Mémoire sur le dynamométamorphisme, etc.," Congrès geol. internat., Comptes rendus, viii^{e} session (1901), p. 340.

The microscopic evidence, in fact, sustains to the full the broader evidence in the field. The handsome red granite of a portion of Carbane, with flakes of mica-schist in it at intervals, passes clearly into darkened gneissic types along its margin. The more we study the relations of the granite and the Dalradian series in Boylagh, the more influence we may ascribe to the structure of the latter, prior to its invasion by the granite. Even where not already foliated by the earth-movements which reared successive mountain-chains, even where it remained as little altered as in "the Rock" at Glenties, the sedimentary series provided surfaces for the penetration of the granite, and the previous structure of the country originated that of the banded gneiss.

Mr. Kilroe[1] has already laid stress on the metamorphosed condition of the strata in Boylagh prior to the intrusion of the granite. I cannot help thinking, in considering the modifications of this igneous mass, that too great importance has been attached to the dynamic action which followed on its consolidation, and too little to the contact-phenomena and interpenetration, of which Carbane serves as so typical an example.

IV.—The Margin of the Granite from Ranny to Derkbeg Hill.

In the southern half of Sheet 15 of the Geological Survey Map, Mr. Kilroe has represented in remarkable detail the intrusive and serrated margin of the granite, where it invades the Dalradian series near the mouth of the Gweebarra. Limestones, diorites, quartzites, and schists are, as it were, dovetailed into the granite across four miles of country. North of the Gweebarra River, their strike is fairly parallel to the granite-margin; but on the south side their outcrops swing round to the north-east, and are crossed at right angles by the igneous rock. The prominent tongues of the granite, however, run out along the strike, and show how potent an influence the lie of the sedimentary rocks exerted on the flow of the invader.

Mr. Kilroe[2] has similarly noted that at Dunlewy, further north, where the granite cuts across the foliation of the Dalradian series, its offshoots invade that series, "usually along the strike." Masses are described as having been detached from the metamorphic series, and remaining as bands within the granite.

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[1] Mem. S.W. Donegal, p. 30 ; also p. 27.

[2] Memoir to Sheets 3, 4, 5, 9, 10, 11, 15, and 16 (1891), p. 71.

In our present area, commencing with the bare white hog's-back of Trusklieve, we find that the granite has included a great eye of schist, a quarter of a mile long, above Ranny Lough, and has caused kyanite to develop throughout it by contact-action. According to the interesting views of Weinschenk,[1] this mineral implies that the intrusion was accompanied by earth-pressures, sufficient to determine the formation of the denser aluminium silicate rather than andalusite. The whole rock thus comes to have a specific gravity as high as 2·86. This schist, viewed under the microscope, is a very handsome quartz-mica-garnet rock, rich in brown biotite, which has a small optic axial angle, and with a little plagioclastic felspar. The longer axes of the kyanite crystals lie in the surfaces of foliation, and tufts of sillimanite have developed extensively in the micaceous patches, and spread throughout the granular quartz. The latter mineral thus comes to resemble cordierite when seen in section; but its granules are, of course, uniaxial.[2]

The main boundary of the granite occurs at Ranny Lough, and the rock becomes darker, showing the usual gneissose bands of biotite as it intrudes among the schists; but another band of granite comes up along the strike of the schists and epidorites at Felmurry Lough, a third of a mile to the south-west, while small veins in the townland of Farragan point to the continued proximity of the igneous masses below. The two great dykes, however, at the old stone fort in Cor, still further south against the Gweebarra, belong in all probability to the later and unfoliated pegmatite series. They have given rise to interesting phenomena of admixture and recrystallization in the massive amphibolite which they traverse.

At the north end of Toome Lough, and the south-east corner of Trusklieve, the marginal granite contains abundant inclusions of the schist, which here dips under the main mass of Trusklieve. A bold banded gneiss has been produced by the intrusion of parallel sheets of pegmatite along the foliation planes of the schist (Pl. i., fig. 1). Its

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[1] "Mémoire sur le dynamométamorphisme et la piézocristallisation," Congrès geol. internat., Comptes rendus, viii^{e} session, Paris (1901), pp. 329 and 341.

[2] Salomon (*op. cit.*, Zeitschr. d. deutsch. geol. Gesell., Bd. xlii., p. 524) similarly indicates the intimate association in his Italian contact-rocks of sillimanite and biotite, the former mineral appearing to replace the latter. The sillimanite also penetrates the quartz in these rocks, both in needles and dense bundles. The connexion between biotite and sillimanite was observed by Lévy, as far back as 1879 ("Formation gneissique du Morvan," Bull. soc. géol. de France, 3^{me} série, t. vii., pp. 861 and 869).

composite origin is, however, almost too obvious; and some authors might, on this ground, exclude it from the category of gneiss.

In the east of Toome the rock-surfaces of the granite show a feeble fluidal foliation, with some inclusions of schist lying at various angles, and not drawn out in the mass. Blocks of schist and diorite are common as inclusions down the east side of Toome Lough; and thence we may proceed to trace the junction on the south side of the Gweebarra.

East of the iron bridge (which is not represented on existing Ordnance maps) a small section in the cliff illustrates how the prominent foliation of the granite may be due to flow, and not to shearing movements affecting it in company with the associated schists. The rocks invaded by the granite are limestones and shales preserving their original bedding; but the granite has become foliated parallel to its junction with the sediments, and across their planes of stratification.

On the picturesque ascent of Cleengort Hill through Kincrum, the granite contains biotite, and is locally foliated; lumps of schist are freely included along this serrated junction. On Cleengort Hill, the schist is more highly altered and more obviously micaceous.[1] In part it contains kyanite and garnet, and these are accompanied by the same handsome brown biotite as occurs in the kyanite-schist of Trusklieve. The kyanite-schists are distinctly felspathic, and probably owe some material to the granite veins associated with them; these are clearly traceable in hand-specimens, but tend to disappear in microscopic sections, owing to the delicate character of the intermingling.

On the crest of Cleengort Hill there is an easily traceable junction of granite and schist; the former rock is foliated parallel to the junction, and is at the same time rich in obvious inclusions from the schist. It would seem unnecessary to multiply such examples had not the later metamorphic stresses been called in to account for the phenomena across so wide a stretch of country. Where fragments of the aphanites or epidiorites from the schist-series have been caught up as inclusions in the granite, they prove to be rich in dark green hornblende, which ophitically includes some of the associated quartz. An older saussuritised felspar is seen in microscopic sections, side by side with recrystallized plagioclase and granular quartz. Seeing that the original pyroxene-dolerites of the Dalradian series were metamorphosed into epidiorites prior to the intrusion of the granite, it is diffi-

[1] Compare J. R. Kilroe, in Mem. to Sheets 3, 4, 15, etc., p. 46.

cult to say, in the ease of such inclusions, what features may be due to the subsequent contact-metamorphism. Sphene and biotite have often been noted as products of contact-alteration and of marginal absorption of amphibolites or hornblende-schists[1]; and thus the epidiorites of Cleengort doubtless yield some material to the adjacent biotite-gneiss. At other times we may expect derived hornblende to remain, and even to revive in the granite magma, as Mr. Kilroe[2] recognised in an example south-west of Ardara. Such instances probably arise where the proportion of derived material is large in comparison with that of the granite magma.

An inclusion of epidiorite from the Cleengort gneiss has a specific gravity of 3·06; iron ores are not prominent, and the amphibole is clearly of high density. It displays dark green and yellower green face-colours, strong axis-pleochroism, and extinction-angles of as much as 20° away from the vertical axis *c*. The study of a mass such as this has an important bearing on the hornblende-granites and hornblende-gneisses farther to the east.

As we cross the bog of Derkmore, and climb to the geat dyke of Cainozoic dolerite on the pass leading over towards Glenties, we see the complex Dalradian series invaded by sheets of graphic granite along the foliation-planes, and also by granite dykes cutting across them. Dr. Hyland[3] has recorded sheared granite from near Meenalargan Hill in this locality, and evidences of the later earth-movements are doubtless traceable here, as at Carbane. But, on rounding the pure granite masses that form the south side of Derkbeg Hill, we come upon patches of foliated granite which have all the characters of fluidal composite gneiss. Included layers of schist are clearly seen, striking north-east, and these are, as usual, surrounded by biotite gneiss, its foliation striking in the same direction.

In places, again, we have a delicately injected schist, which passes at its margins into gneissoid granite. A sample of this granite, in which both light and dark mica occur in strings and layers, shows a few "strain-shadows" under the microscope, but no sign of shearing or mylonitic flow. It is a white aplite, with a few micaceous additions from the schist. In contrast, one of the much darkened portions of the

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[1] See references in "Metam. Rocks in E. Tyrone, etc.," Trans. R. Irish Acad., vol. xxxi., p. 454, and plate xxvi., fig. 5.

[2] Mem. S.W. Donegal, p. 53. Also Mem. Sheets, 3, 4, 15, etc., p. 78. For numerous references to quartz-hornblende-diorites, formed by invasion of granite into basic rocks, see paper in Trans. R.I.A., above referred to, pp. 438 and 439.

[3] Mem. Sheets, 3, 4, 15, etc., p. 134.

granite proves to be almost a "granitised" amphibolite. Deep green hornblende, of the type discussed in connexion with Cleengort, occurs in it in rough foliation-layers; but this mineral forms so much of the rock as to carry the specific gravity up to 2·99—the mean of three closely agreeing determinations. Andesine is present, and, like the hornblende, has probably recrystallized from an epidiorite, which renewed its youth in the granite magma; while quartz and orthoclase, representing the aplitic granite, are more abundant in the joint mass than its specific gravity would suggest (Pl. III., fig. 2). A chain of observations, and especially those made in the field, teach us to regard this rock as composite. It is, then, one of the most extreme modifications met with in the intrusive granite of Boylagh.

It is interesting to observe how hornblende crystals, already formed in andesitic lavas as products of the "first consolidation," become frequently reabsorbed by the magma when it ascends or is poured out upon the surface. They then leave, as von Lasaulx long ago pointed out, a mere skeleton formed of grains of magnetite. But, in our instances of the absorption of amphibolites by a granite magma, the final crystallization takes place under considerable pressures. The conditions are favourable for the crystallization of biotite, or even for the reproduction of the hornblende, and a quartz-diorite with some orthoclase results. Were this mixed rock again melted and thrust out on the surface, a rhyolitic andesite with pyroxene would probably be formed, in which a few corroded hornblendes from the previous consolidation might remain.

Pegmatite veins and masses, belonging to a later granite, and probably of Devonian age, are common throughout Derkbeg and Derryloaghan; but undoubtedly the most striking features are those connected with the foliation of the older granite. The constancy of strike in this foliation becomes, if the foregoing observations are correct, a record of the trend of the folded Dalradian series, which has here left mere traces in the heart of the granite which attacked it.

V.—The Gneissic Structures near Finntown, and their bearing on the Geological History of Gneissic Granite throughout the County of Donegal.

In the eastern part of Galwolie, on the road from the village of Lettermacaward to Doocharry Bridge, a red gneiss, containing muscovite as its predominant mica, reminds one of the crushed and slickensided granite of Barnesbeg in northern Donegal. It similarly owes its present characters to dynamic metamorphism. It is cut, however, by a brown granite, with a specific gravity of 2·60; the foliation in this does not agree with that of the older mass, but is clearly due to igneous flow, running as it does parallel to the margins of the veins. This granite does not show metamorphic deformation under the microscope; its foliation is due to the arrangement of plates of light and dark mica as it flowed. Here we have, in the coarser and earlier rock of Galwolie, the type of foliation that has been accepted as that of the Donegal granite as a whole. But hitherto our observations in Boylagh have shown us the phenomena of the fluidal veins occurring on a large scale, and emphasised by inclusions of schist within the granite. It becomes of considerable interest to inquire to which type the foliated structures belong, which are developed on a still broader scale south of the Gweebarra, between Derryloaghan and Finntown. Our conclusions in regard to them may justly affect our views of similar gneissic districts throughout central Donegal.

On Sheet 15 of the Geological Survey map, the great granite mass west of Finntown has foliation marked on it in some thirty places, and in most cases a dip is assigned to the foliation-planes. South-easterly dips prevail, but north-westerly ones occur near the Gweebarra, and predominate on the other side of the river. The general structure, then, is that of an anticline, measuring some four miles across.

In the strike of this foliation, streaks of epidiorite, limestone, and a little quartzite have long ago been noticed, especially on the south-east flank of the mass in the neighbourhood of Finntown. Mr. E. H. Blake[1] thus recorded vertical layers of limestone and mica-slate within the granite; and Mr. R. H. Scott[2] deduced from those in Glenleheen the metamorphic origin of the granite, in the sense that it was derived from alteration of the ancient sediments in place. Like Dr. Haughton, he favoured this view for the greater part of the granite of Donegal, though he recognised that even the gneissose granite occasionally pierced the other rocks in the form of veins.[3] Mr. Scott, in the first paper quoted, provides a section along Glenleheen, in which the bands of sedimentary rock are shown going vertically down in continuous layers, with the granite cleanly interstratified between them.

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[1] "On the Primary Rocks of Donegal," Journ. Geol. Soc. Dublin, vol. ix (1862), p. 296.

[2] "On the Granitic Rocks of South-West Donegal," *ibid.*, p. 290.

[3] "On the Granitic Rocks of Donegal," 2nd notice, *ibid.*, vol. x (1864; paper read 1862), p. 20.

The papers of Scott and Haughton influenced Mr. W. H. Stacpoole Westropp,[1] who urged that there was an essential difference between the granites of Wicklow and those of Donegal, the former being clearly intrusive and the latter metamorphic. Dr. Haughton[2] had to some extent emphasised the difference by regarding the granite with black mica as typical of County Donegal, which may be true of the surface as now revealed to us; I believe, however, that this apparent mineralogical difference is due to the position of the broad natural sections in regard to the intrusive mass as a whole. The prevalence of black mica, from this point of view, simply indicates our nearness to the schists along the crests and flanks of great arches which are now occupied by the granite (see figure on p. 225).

When, in 1871, the late Professor A. H. Green,[3] in ignorance of the literature already published on the subject, supported the metamorphic view in somewhat exaggerated detail, his paper met with a cold reception. His opponents, however, knew but little of the petrological difficulties of the country which he had visited; and his paper, as finally published in the Geological Magazine, to some extent explained the position he had adopted. He dealt with the Dunlewy district, which may be cited as an illustration of that which we are now discussing; and his error, in face of the frequent interlamination of the granite and the schists, seems excusable when we consider the controversies of more than thirty years ago. He was without microscopic assistance, and seems to have done little to deserve the intemperate and personal onslaught made on him by Prof. David Forbes[4] a few months later.

Dr. C. Callaway[5] recognised that the granite of Barnesbeg had penetrated along the foliation-surfaces of the associated schists; but the apparent sharpness of the included fragments, when viewed with the naked eye, seems to have deceived him, as it has done observers in other countries. He was thus led to deny any process of absorption, and consequent modification of the granite, though the microscope is not needed for its appreciation at Cashel Hill near Portnoo, and at

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[1] Letter on "The Origin of Granite," Geol. Mag., 1867, p. 522.

[2] *Op. cit.*, Quart. Journ. Geol. Soc. London, vol. xviii. (1862), pp.410 and 417.

[3] Abstract of eleven lines in Quart. Journ. Geol. Soc. London, vol. xxvii. (1871), p. 449; and "Notes on the Geology of Part of Co. Donegal," Geol. Mag., 1871, p. 553.

[4] "On the Geology of Donegal," Geol. Mag., 1872, p. 12. On Dunlewy, see J. R. Kilroe, Mem. sheets 3, 4, etc. (1891), p. 71.

[5] *Op. cit.*, Quart. Journ. Geol. Soc. London, vol. xli. (1885), pp. 224 and 229.

various other places in Boylagh, as we have already noted. Dr. Callaway held that the main gneissic structure was due either to igneous flow of molten material, or to flow of some kind under earth-pressures. The latter type of flow might have occurred—(i) during consolidation, or (ii) after consolidation. Dr. Callaway[1] concluded in favour of dynamic metamorphism after the granite had forced its way as an intrusive rock among the schists.

It was in the light of these previous opinions and observations that the officers of the Geological Survey approached the interesting area between Maas and Finntown. Mr. A. M'Henry,[2] in noting the masses of limestone and schist caught up here and enveloped in the granite, explains their parallelism with the foliation in the igneous rock by stating that "both the granite and enclosed masses have been subsequently foliated at the same time by the last great shearing forces that affected this region."

In a previous section of the present paper, on the other hand, certain foliated granites towards the Maas end of the district have been explained as due to imperfect incorporation of the hornblende- and mica-schists in the igneous rock (p. 216). Mr. J. A. Cunningham, B.A., A.R.C.SC.I., who accompanied me throughout these observations, subsequently visited the foliated granite on the road from Glenties to Doocharry Bridge on the south side of the Gweebarra. A photograph taken by him shows how much work remains to be done on the non-homogeneous "banded gneisses" which are boldly developed across this area. At present, however, I propose only to furnish details from personal observation on the historic roadside sections between Glenleghan (Glenleheen) and Finntown. I am willing, however, after experience of similar materials in the Pettigo area, to take these exposures as representative of a much wider district.

On approaching Glenleheen by the highly picturesque road from Doocharry Bridge, the intrusive character of the granite is manifest at the top of the long rise from Adderwal, and just within the townland of Meenmore West. The granite has penetrated the schist along the foliation-planes, and has converted it into a "leptynolite," in which felspars are visible to the naked eye. A band of limestone, marked upon the Survey map, is included in the granite, and has undergone the usual type of metamorphism. Red garnet, diopside

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[1] Quart. Journ. Geol. Soc. London, vol. xli. (1885), pp. 230 and 239.

[2] Mem. sheets 3, 4, 15, etc. (1891), p. 69.

altering to actinolite,[1] quartz, and a lime-scapolite, have arisen in it, together with sphene, which Mr. Scott[2] always associated with altered limestone in Donegal. Labradorite felspar occurs abundantly in parts of this rock, side by side with quartz, but seems to vary in amount in inverse proportion to the scapolite.

This is probably the locality where Mr. Scott[3] discovered scapolite in 1861, in conjunction with sphene, pyroxene, orthoclase, and quartz. After passing Carbal Gap, across the Glenleheen River, a fine section is seen, partly quarried, on the north-east side of the road, in the townland of Loughnambraddan. The structural planes are vertical, and a remarkable variety of rocks can be gathered within a few feet of one another in traversing the strike. After a little scrutiny, two types of rock become sorted out, the one a pink euritic aplite, with the characteristic specific gravity of 2·59, the other a dark hornblende-biotite-schist, with a specific gravity of 2·89.

The former shows under the microscope the structure of a mildly fluidal gneiss, without banding, but in which a few of the felspars assumed ovoid contours, from continued movement after crystallisation had commenced (Pl. v., fig. 1). The quartz settled down in angular interlocking grains, like those of a metamorphic quartzite. Only the merest trace of biotite occurs, and the aplitic character is complete. Iron ores are represented by rounded grains of pyrite.

The dark rock, on the other hand, is an obvious schist, almost slaty in places, though more distinctly crystalline than some of the masses on Carbane (p. 212). Under the microscope it shows a predominance of hornblende over biotite; these minerals are associated with abundant epidote, sphene, and pyrite. The three last-named constituents seem alike to have existed in the rock before its invasion by the granite. The usual basic felspars, and a few granules of interstitial quartz, form a second association of minerals, interwoven, as it were, with the ferriferous ones. So far, the rock is a typical schistose epidiorite (Pl. v., fig. 2).

But other bands in this striking roadside section show a coarse-grained granite with pink orthoclase, intruding up the general vertical planes. In hand-specimens this rock resembles some of the handsome gneisses of the Outer Hebrides; but its most foliated portions are

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[1] The distinct green colour of this paramorphic product indicates the presence of iron also in the diopside.

[2] *Op. cit.*, Journ. Geol. Soc. Dublin, vol. ix., pp. 288 and 289.

[3] *Op. cit.*, *ibid.*, vol. x., p. 21.

marginal, and are due to sheets of schist entangled in it. Mr. Scott[1] aptly compared this type of gneiss near Finntown with the veins at Castle Caldwell on Lough Erne; I have little doubt that in both localities these coarser granitoid rocks belong to the later series of granitic intrusions. They may thus be of Devonian age.

When, however, these coarser rocks associate themselves with the earlier and more fine-grained granites, as they do also at Carn, near Pettigo, the composite rock formed of hornblende- or mica-schist, penetrated along its foliation-planes by coarse and fine parallel veins, presents a remarkable imitation of many Archæan gneisses. Yet it owes its characters to the original flow of granite under pressure up the most easily found planes of parting.

Again and again, the shrinkage of the original uptilted sediments, as metamorphism went forward, a feature on which Mr. Joseph Barrell[2] has laid considerable stress, may have helped the intrusive mass to spread upwards from below. The previous crumpling and compression, however, of the Dalradian series probably drove off a part of its volatile constituents, and so prevented any further marked reduction in bulk under the heating action of the granite.

Short of the local bands of pseudo-Hebridean aspect, we have every variety of intermingling between the granite and the schist. Biotite is developed in these grey gneisses and granites, partly at the expense of hornblende. The epidote of the partially absorbed basic rock remains intact, in association with much biotite, a little green hornblende, and sphene. These minerals are grouped in flakes and patches, which give the rock its gneissic aspect. The sphene is so prominent in some of these mixed rocks that it has probably developed during the epoch of contact-metamorphism. The rock-section selected for illustration (Pl. iv., fig. 2) shows foliated structure on a conveniently small scale; otherwise it represents the more granitoid and less basic type of the composite gneiss of Loughnambraddan. The specimen from which it was cut shows a granite vein penetrating the schist, and losing its identity in so doing, thus affording a complete parallel with some of the specimens from Carbane.

Another of the grey composite rocks examined in detail has a specific gravity of 2·74. It is, when considered apart from its mode of occurrence, a member of the Tonalite series, with zoned orthoclastic and plagioclastic felspars, quartz, biotite, hornblende, epidote, and

[1] *Op. cit.*, Journ. Geol. Soc. Dublin, vol. x., p. 18.

[2] "The Physical Effects of Contact Metamorphism," Am. Journ. Sci., vol xiii., (1902), p. 294.

handsomely developed crystals of sphene. There are signs of deformation in some of the felspars; but the gneissic structure is clearly due to other than dynamic causes. As in previous cases, the epidote is in constant association with the streaks of biotite or hornblende.

It is noteworthy that the rounded granules of pyrite observed in the pure euritic aplite of this locality occur also in the more aplitic layers of the composite rocks.

There is good evidence, then, that the varieties of grey and red gneiss above Finntown are portions of granite masses locally modified by the conditions of their intrusion. The phenomena of Ballyiriston and Derkbeg Hill are here carried out on a still more convincing scale. It seems highly probable that the "Hornblende-Biotite-Granites (Hornblende-Granitites)" described from other parts of Donegal by Dr. Hyland[1] have the same origin as those studied in the present paper.

What, then, is the general conclusion that we may come to in regard to the gneissic patches, often half a mile or so long, which occur with so constant a foliation-strike in the granite mass south of the Gweebarra? Are they not, equally with the strips of epidiorite and limestone, the relics of strata that formerly occurred, in metamorphic wrinklings, in the crown of some great anticlinal arch[2]? It is not necessary to urge that the whole of the space now occupied by granite was formerly filled with folded schists, and that the solution of the latter provided room for the granite in its ascent; the magma of the granite may have at first welled up into the spaces provided for it by the Caledonian folding, and then, under continued earth-pressures, have been forced, with destructive effect, against its bounding roof and walls.

Instead of representing, as Mr. Scott was tempted to do, the foliated and sedimentary strips of rock near Finntown as vertical beds between vertical layers of granite, may we not rather regard the present surface of the mass between Lough Finn and Doocharry Bridge as exhibiting a cross-section of the upper zone of interaction? Some masses from the roof have survived, and give us a profound impression of the material that has been altogether lost within the granite caldron (fig. 1). Had denudation worn away the

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[1] Mem. to Sheets 3, 4, 15, etc., p. 136.

[2] Mr. Kilroe speaks of detached areas and bands of schist, etc., in the granite east of Dungloe, which form a curved series when regarded as a whole, as "obviously fragments of a schist series, which formerly extended from Tor westward" (*Ibid.*, p. 43).

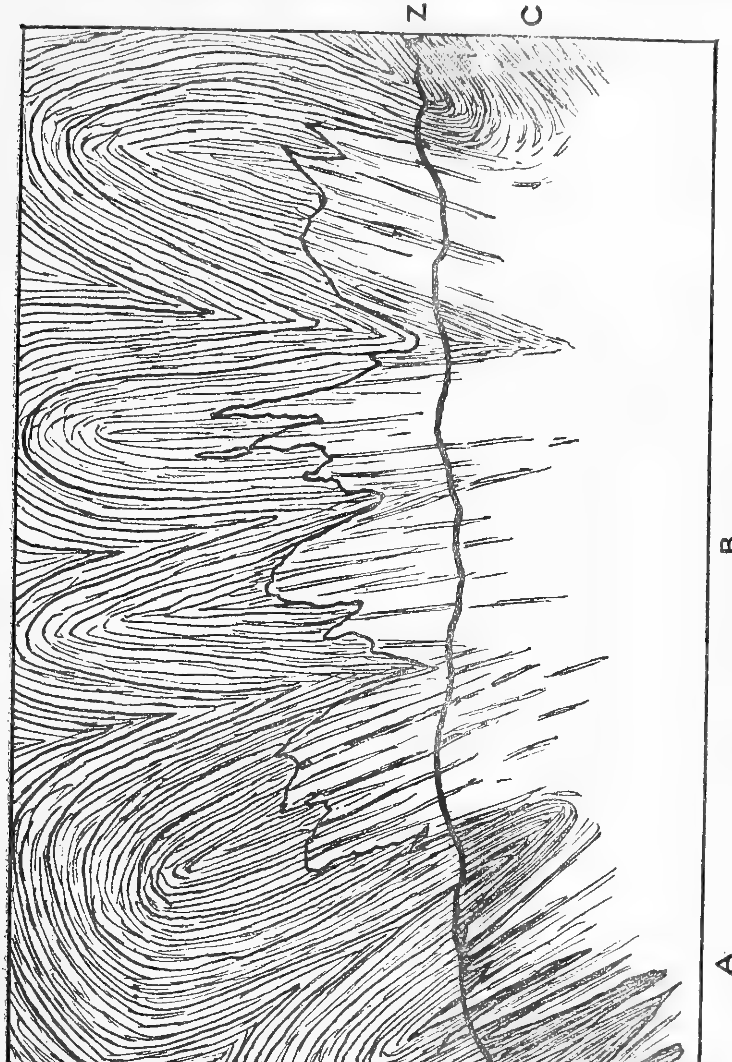

Fig. 1 (for description, see p. 226).

composite mass even down to the present sea-level, our knowledge of the banded gneisses of Boylagh might have been limited to those which arose upon the side-walls of the caldron.[1] As it is, from specimens a few centimetres square up to moorlands that are not to be traversed in a day, we may see throughout Boylagh what attacks are made from below upon the materials of a rising mountain-chain. The final outcome is a consolidation of the anticlinal ridges, by the intimate penetration of igneous material, which crystallizes within their cores; and ribs are added to the Earth's crust, like those of Donegal, which successfully resist later systems of folding, and still hold their own among the rugged highlands of the world.

Fig. 1. Ideal section to illustrate the structure of the granite mass south of the Gweebarra.—A great group of sediments has become folded into a complex anticlinal mass, with production of schistose features in most of the rocks. Granite has intruded during the formation of this compound arch, and especially into the anticlinals, where pressure is relieved; it has found its way most easily along the planes of bedding or foliation, as the case may be, in the overlying mass. Parts of the latter mass are absorbed; but flakes remain, producing a composite rock, and imparting a gneissic structure to the granite. Denudation, acting continuously during these changes, has now worn down the rocks to the surface indicated by the line XZ. Above the point A, the parallel intrusions suggest on this surface that we are on the edge of an uptilted laccolite. At this point it would be very difficult to determine how far the metamorphism of the schists was previous to, and how far due to, the intrusion of the granite. Above B, we have a granite moorland with occasional gneissic structure. As we approach C, the origin of this structure becomes again traceable; and ultimately composite "leptynolites" and "granitised schists" are seen to pass into the ordinary schists on the right-hand side of the complex anticlinal.

VI.—Conclusion.

The references above made to the work of others show that the explanation now put forward for the gneissic structures in Boylagh is one that has raised a certain amount of controversy in the case of other European areas. It is not to be expected that all gneisses

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[1] Compare "Metam. Rocks in E. Tyrone and S. Donegal," Trans. Roy. Irish Acad., vol. xxxi., pp. 468 and 469.

have been formed by the same processes; and even banded gneisses may in certain instances represent stratified materials crystallized and modified in place. This would, at any rate, be the logical deduction from the views of Mr. F. D. Adams,[1] which would bring us back to some of the oldest and half-forgotten theories respecting metamorphic rocks. Fascinating as the dynamometamorphic theory has been, it may be questioned if strongly marked banding can be produced in crystalline rocks by the agencies thereby invoked. Mylonitic destruction, rather than banding, results, as a rule, from earth-pressure combined with movement; and the distinctions between adjacent layers tend to become obliterated. Professor Judd,[2] in 1898, called attention to the slow processes of "statical metamorphism," whereby rocks which are kept stationary underground may be modified, not only in mineral constitution, but even in chemical composition. Crystalline layers, their individual characters dependent on those of the successive original strata, might thus eventually arise, and would even produce a banded gneiss. In Boylagh, however, the phenomena of igneous injection and intimate penetration have played by far the most important part; and there is no particular mystery as to the mechanical or chemical nature of the process, the stages of which are often traceable with the naked eye.

While believing with Lévy and Lacroix that granite does not come into its final position without a considerable absorption of material from the walls of its caldron,[3] I naturally admit, from considerations of geological structure, that the caldron itself most commonly originates in the arch of an anticlinal.[4] As Salomon[5] perceived in the case of the Adamello chain, the position where the igneous rock ultimately manifests itself is determined by the opportunities allowed it during the larger movements of the crust. But are

[1] "Some recent papers on the Influence of Granitic Intrusions upon the Development of Crystalline Schists," Journ. of Geology, vol. v. (1897), pp. 293–302.

[2] "On Statical and Dynamical Metamorphism," Geol. Mag., 1889, p. 243, etc. This subject has been greatly developed by Van Hise, "Metamorphism of Rocks and Rock-flowage," Bull. Geol. Soc. America, vol. ix. (1898), p. 269.

[3] Compare Lacroix, *op. cit.*, Bull. de la Carte Géol. de la France, No. 64 (1898), pp. 1 and 62.

[4] Compare T. A. Jaggar, jr., "The Laccoliths of the Black Hills," 21st Ann. Rep. U.S. Geol. Survey, Pt. iii. (1901), p. 173.

[5] "Ueber Alter, Lagerungsform, und Enstehungsart der periadriatischen granitisch-kornigen Massen," Tscherm. Mittheil., Bd. xvii. (1898), pp. 173–4.

we to believe that such upwellings, implying local relief from pressure, are unaccompanied by incorporation and assimilation on a considerable scale? Even Salomon himself, who shows that the variations in the constitution of the enormous mass of tonalite are not related to the nature of the contact rocks, presents us with a section[1] illustrating "*lit par lit*" injection above the Poglia valley, where the igneous rock assumes a bedded structure, and includes residual and parallel strips of altered Triassic limestone. The resemblance of such structures to those near Finntown is apparently complete; and the author attributes the position of the tonalite between the sedimentary bands to the solution of certain shaly layers, as the tonalite sent off apophyses into them. Salomon still concludes, as in an earlier paper,[2] that the gneissic structure of the tonalite is due to subsequent dynamic action, despite the occurrence of a little true fluidal structure here and there;[3] but his work is nowhere opposed to the views above stated in explanation of the gneiss of Boylagh.

More than twenty years ago, Mr. G. W Hawes[4] called attention to the production of mixed rocks on an important scale at the contact of granite in New Hampshire; and there is little difference between his statements and those made so clearly by Lacroix[5] in 1898 concerning the composite gneisses of the valley of Baxouillade. Considerable stimulus will now be given to such enquiries by the remarks of Mr. Teall[6] in his Presidential Address to the Geological Society of London in 1902; and it is probable that the importance of composite gneisses will be recognised in many areas, where the prevalent structures have hitherto received other interpretations.

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[1] "Ueber Alter, Lagerungsform, und Entstehungsart der periadriatischen granitisch-kornigen Massen," Tscherm. Mittheil., Bd. xvii. (1898), p. 159.

[2] "Neue Beobachtungen aus den Gebieten der Cima d'Asta und des Monte Adamello," Tscherm. Mittheil., Bd. xii. (1891), p. 411.

[3] *Op. cit.*, Tscherm. Mittheil., Bd. xvii., p. 131.

[4] "The Albany Granite and its Contact Phenomena," Amer. Jour. Sci., vol. xxi. (1881), pp. 31 and 32.

[5] *Op. cit.* (1898), p. 49.

[6] Proc. Geol. Soc., pp. lxxiv and lxxviii, in Quart. Journ. Geol Soc. for 1902.

DESCRIPTION OF PLATES.

Plate I.

Fig. 1.—Composite gneiss, produced by intrusion of granite into the schistose series near the base of Trusklieve, on the northern shore of Toome Lough (p. 215).

Fig. 2.—Pegmatitic granite cutting and sending veins into hornblende-schist, which has previously become considerably "granitised." North-east slope of Derkbeg Hill (p. 218, and Pl. iii., fig. 2).

Plate II.

Fig. 1.—Section showing margin of a thin sheet of granite in hornblende-schist, south-west side of Carbane, Glenties (p. 213). × 9.

This microscopic section represents in miniature the structure of the granitic and schistose country in Boylagh. The granite has penetrated the schist, after the latter had become foliated and crumpled. A fluidal structure along the margin has converted the granite locally into gneiss; this is occasionally emphasised by the presence of flakes removed from the schist. Subsequent movements, represented in the section by the faulting, have had some effect upon the joint mass; but the gneissic structure is connected with original conditions of intrusion.

Fig. 2.—Section showing junction of phyllite and gneissic granite, south-east side of Carbane, Glenties (p. 212). × 7.

The coarse granite is seen below, with streaks of biotite, due to inclusion of material from the phyllite. When seen over a wider field, these give a well-marked gneissic structure to the granite. The phyllite contains numerous crystals from the granite, and resembles a "porphyroïde" or a felspathic ash. This intermingling seems due to earth-movements acting after the crystallization of the granite, but in continuation of those under which the igneous rock was intruded.

[Plates III.–V. are from photographs taken with the microscope by Mr. T. Crook, A.R.C.SC.I.]

Plate III.

Fig. 1.—Section of granite containing patches of biotite, hornblende, and epidote, derived from the materials of the schistose series. South of Ardlougher, near Clooney (p. 211). × 10.

Fig. 2.—Section of composite rock (quartz-diorite), produced at junction of granite and epidiorite. North-east slope of Derkbeg Hill (p. 218). × 10. The hornblende has revived and recrystallized under the influence of the intruding granite magma.

Plate IV.

Fig. 1.—Section of composite rock, with brown biotite ("Leptynolite"), produced at junction of granite and mica-schist. Small quarry on road from Clooney to Maas (p. 209). × 10.

Fig. 2.—Section of composite gneiss, inclining towards granite, with delicate streaks of biotite, epidote, sphene, and some hornblende. Quarry in Loughnambraddan, above Finntown (p. 223). × 10.

Plate V.

Fig. 1.—Section of pure euritic aplite, with ovoid forms of constituents. Quarry in Loughnambraddan, above Finntown (p. 222). × 10.

Fig. 2.—Section of schistose diorite (epidiorite), into which the aplite intrudes in the quarry in Loughnambraddan, above Finntown, producing a variety of composite gneisses, one of which is illustrated on Pl. IV., fig. 2 (p. 222). × 10.

V.

A LIST OF IRISH ECHINODERMS. By A. R. NICHOLS, M.A., BEING A REPORT FROM THE FAUNA AND FLORA COMMITTEE.

[Read June 23, 1902.]

The first list of the Irish *Echinoderma* was published by R. Templeton in the ninth volume of the *Magazine of Natural History* in 1836. The next list was contained in the report on the Invertebrate Fauna of Ireland (drawn up by W. Thompson at the request of the British Association), and published in the British Association Report for 1843; a more detailed account of the distribution of Irish Echinoderms and a few additional species were subsequently included in his "Natural History of Ireland," vol. iv., 1856. At the meeting of the British Association in 1858, a Report on the Marine Fauna of the south and west coasts of Ireland was communicated by Prof. E. P. Wright, M.D. and Prof. J. R. Greene, and in this Report is included a tabular list of Irish Echinoderms (excluding Holothurioidea).

Since the publication of this Report in 1859, no attempt seems to have been made to compile a complete list of the Irish species of *Echinoderma*, though a large number of species have been added to the Irish Fauna as a result of the deep-sea explorations that have been carried on off the western coasts of Ireland. These investigations began with the first cruise of H. M. S. "Porcupine" in 1869, and have since been occasionally carried on by various smaller expeditions, during which the richness of the Echinoderm fauna was often commented upon.

In conformity with the British marine area, as defined by the Committee of the British Association in 1888, the Irish marine area may also be regarded as consisting of two portions, viz.: a shallow-water district with a depth ranging from 0 to 100 fms., and a deep-water district whose depth ranges from 100 to 1000 fms.; the boundaries of the shallow-water district are the 56° parallel of latitude on the north, a line half way between Ireland and the opposite shores of Scotland, Wales, and England on the east, the 49° 30′ parallel of latitude on the south and the 100 fms. line on the west. The deep-water district is practically confined to the western coasts and comprises the area contained between the 100 fathoms and the 1000 fathoms lines and the parallels of latitude 56° and 49° 30′. For the convenience of students of geographical distribution the known range of the species round the coast of Ireland has been divided into the same six provinces which I adopted in the paper on the Marine Mollusca of Ireland (Proc. Roy. Ir. Academy (3) vol. v., pp. 477–662, 1900).

These provinces are—

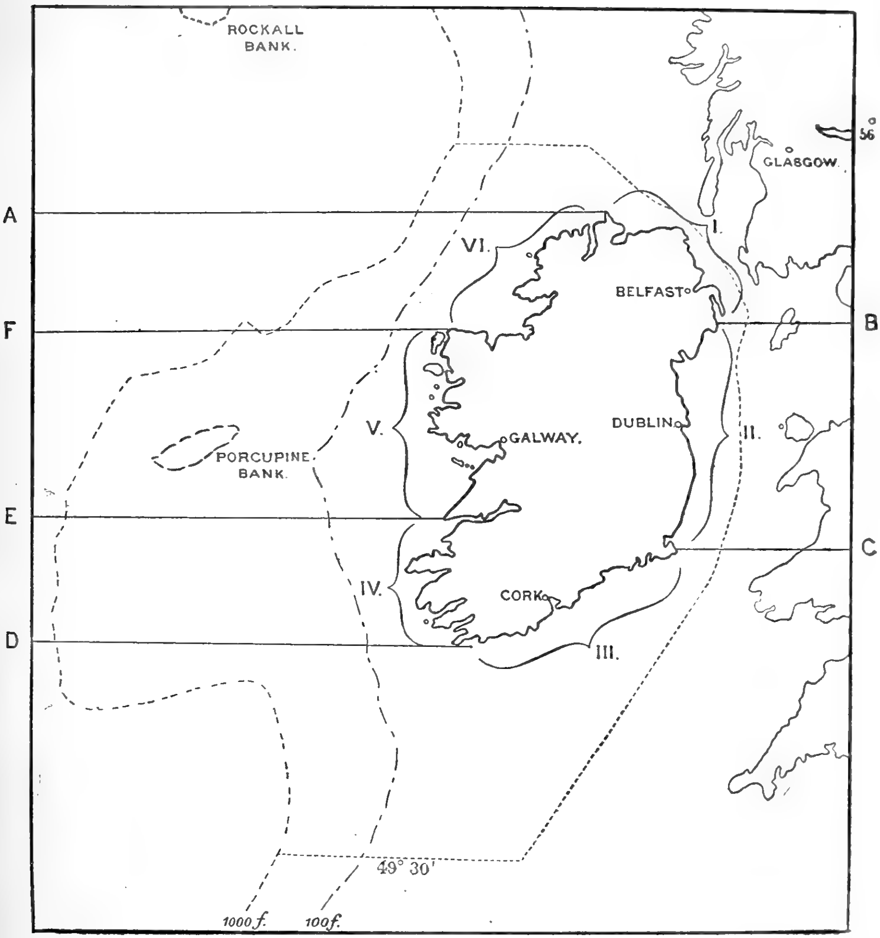
i. North-east. From Malin Head, Co. Donegal to St. John's Point, Co. Down.
ii. East. From St. John's Point to Carnsore Point, Co. Wexford.
iii. South. From Carnsore Point to Cape Clear, Co. Cork.
iv. South-west. From Cape Clear to Loop Head, Co. Clare.
v. West. From Loop Head to Erris Head, Co. Mayo.
vi. North-west. From Erris Head to Malin Head.

The names of the species which have not been found at a less depth than 100 fms. off the Irish coast are placed within *square brackets* and can thus be readily distinguished. Whenever a species is found in shallow-water in some and only in deep-water in other provinces, then the numbers denoting these latter provinces are included in square brackets.

I have followed the classification, and with one or two exceptions, the nomenclature adopted by Bell in the "Catalogue of the British Echinoderms in the British Museum," 1892; but for the convenience of reference I have given the names used by Forbes in his "History of British Starfishes" whenever these names differ from those of the British Museum catalogue.

The general distribution of each species is given very briefly, and has been derived principally from the "Challenger" Reports and the writings of Agassiz, Bell, Carus, Hoyle, Ludwig, Lyman, Norman, Verrill, &c.

The total number of species of Echinoderms found in the seas surrounding the British Islands is 134, and the number in this list is 87, so that the Irish Fauna includes nearly two-thirds. If we exclude from the Irish list the deep-water forms which belong perhaps more strictly to the general Atlantic Fauna, and confine the British list to the species which have been found at less than 100 fms. depth on the coast of the British Isles, then the Irish list contains 60 out of a total of 81 British species or nearly three-fourths; most of the British shallow-water species, that are absent from the Irish list, are northern



Map showing the Shallow- and Deep-water District, and the six Provinces.

A—Malin Head.	C—Carnsore Point.	E—Loop Head.
B—St. John's Point.	D—Cape Clear.	F—Erris Head.

forms, and several of them are recorded as British only from off the north of Scotland.

The only species peculiar to the Irish shallow-water Fauna are two doubtful species of Cucumaria, viz.: *C. andrewsi* and *C. saxicola*; the former species was named by Farran in 1852, from specimens taken at Clonea, Co. Waterford, and the latter by Brady and Robertson in 1871, from specimens taken in Birterbuy Bay and Westport Bay.

Five deep-water species of Echinoderma, viz.: *Holothuria aspera*, *Astropecten sphenoplax*, *Pentagonaster greeni*, *Hymenaster giganteus* and *Cidaris gracilis* have, however, hitherto only been obtained off the western coasts of Ireland; the last two species having been described by Sladen from specimens dredged in 750 fms. in the expedition organized by a committee of the Royal Irish Academy in 1888. *Pteraster personatus*, *Pentagonaster balteatus* and *P. concinnus* were also described by Sladen from specimens obtained at a depth of 750 fms. in this expedition; *P. balteatus* and *P. concinnus* are however regarded by Bell as identical with *P. granularis* Retz., but by Ludwig as possibly identical with *P. hystricis* Marenzeller, and *Pteraster personatus* has since been recorded from the Bay of Biscay.

Strongylocentrotus lividus, the purple sea-urchin, is a very characteristic species of the western coasts of Ireland, from Malin Head to the south coast of Co. Cork; a specimen is stated by Dr. Dickie to have been cast up on the shore at Carrickfergus, but this is the only record for the east of Ireland. It is a southern species ranging from north of Ireland and south-west of England, southwards to the Azores and Canaries. *Holothuria forskahli* (*H. nigra*, auct.), the nigger or cotton-spinner, is another southern species that is generally distributed on the western coasts of Ireland, and there is no record of its occurrence on the eastern coasts.

The two species of Luidia, viz.: *L. ciliaris* and *L. sarsi*, are generally distributed and common off the western coasts of Ireland, and range from Faröe and Norway respectively to Cape Verde but do not appear to have been recorded from the east coast of Ireland.

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HOLOTHURIOIDEA.

Family—SYNAPTIDÆ.

Synapta inhærens (O. F. Müller).

i., ii., . iv., v., vi.

i. Shores of Belfast and Strangford Loughs, in mud banks, at, and a little above, low-water mark, abundant (Wyv. Thomson in Quart. Journ. Microscop. Science ii. (N. S.) 1862): Holywood, Belfast Lough, in considerable numbers in the sand banks (Belfast N. F. C. Guide '74).

ii. Balbriggan, on the beach, a specimen found by Mrs. Hancock after a storm (Thompson '56): Malahide (Jacob and Dixon, f. Haddon '86): Sandycove, Dublin Bay (Kinahan in Nat. Hist. Rev. vii., 1860).

iv. Royal Irish Academy Exp. 1885, Berehaven, 10 fms. (Bell '86): Valentia Harbour, and off Bray Head, 45 fms. (Beaumont 1900).
v. Birterbuy Bay, 12–14 fms., not uncommon, and Clew Bay, 4 fms. (Brady & Robertson '69).
vi. Mulroy Bay, Donegal (Praeger in Irish Naturalist, 1894).
Distribution.—Both sides of the North Atlantic. Mediterranean.

Synapta digitata (Montagu). (*Chirodota digitata* Forbes "British Starfishes.")

i., . . iv., v., vi.

i. A specimen on the sand between tide-marks near Carrickfergus Castle (Hyndman and Thompson, f. Thompson '56): Carrickfergus (Herapath '65 sub *Synapta thomsonii* n. sp.).
iv. Dingle Bay, 36 fms. (Beaumont 1900).
v. Royal Dublin Society Fishing Survey 1890, Roundstone Bay, 5 fms. (Bell '92).
vi. R. D. S. Fish. Survey 1890, Killybegs, shallow water (Bell '92).
Distribution.—British coasts to Mediterranean. N. America.

Family—DENDROCHIROTÆ.

Cucumaria hyndmani (Thompson).

i., ii., . [iv.], v., .

i. Belfast Lough (Hyndman, f. Thompson '40).
ii. Dublin Bay (Kinahan '61).
[iv.] "Porcupine" Exp. 1869, 251 fms. (Bell '92 B): R. I. A. Exp. 1888, off Dursey Head, 345 fms., a single young example (Sladen '91).
v. Roundstone (M'Calla, f. Thompson '56): Killary Bay, numerous (Forbes '41): "Argo" Cruise 1890, west of Ireland (Herdman '91).

Distribution.—Norwegian and British coasts to Spain. Mediterranean.

Cucumaria planci (Brandt).

. . . iv., . .

iv. Valentia Harbour (Beaumont 1900).
Distribution.—British coasts to Mediterranean.

Cucumaria pentactes (? Linné).

i., ii., iii., iv., v., vi.

i. Belfast Lough (Getty, f. Thompson '56): Bangor (Drummond, f. Thompson '56): Donaghadee, 10 fms. (Drummond, f. Thompson '56 sub *Cucumaria fusiformis*): Strangford Lough, 15 fms., very rare (Dickie '58 sub *C. fusiformis*).
ii. Dublin Bay (Kinahan '61 sub *C. fusiformis*): Malahide (Dublin Mus.).
iii. Dungarvan Bay (A. R. N.): R. I. A. Exp. 1885, off Glandore, 40 fms., and off Baltimore, 30 fms. (Bell '86).
iv. Bantry Bay, 15–30 fms. (M'Andrew, f. Thompson '56): R.I.A. Exp. 1885, mouth of Kenmare River, 44–47 fms. (Bell '86): R. D. S. Fish. Survey 1890–91, Kenmare River, 10–21 fms. (Holt '92): Valentia Harbour (Beaumont 1900).
v. Lahinch, co. Clare (Kinahan '63).
vi. R. D. S. Fish. Survey 1890, Inver Bay, 6–10 fms. (Holt '92).
Distribution.—Arctic seas to Mediterranean.

Cucumaria lactea (Forbes & Goodsir). (*Ocnus lacteus* and *O. brunneus* Forbes B. S.)

i., . iii., iv., v., .

i. North-east coast (Thompson '56): Belfast Lough (Drummond, f. Thompson '56 sub *O. brunneus*): Strangford Lough, common (Thompson '56 and Dickie '58, sub *O. brunneus*).
iii. Glandore (Allman, f. Thompson '56).
iv. R. I. A. Exp. 1885, Berehaven, 10 fms. (Bell '86): Valentia (Gamble '96, Beaumont 1900).
v. Lahinch, co. Clare (Thompson '56): "Argo" Cruise 1890, west of Ireland (Herdman '91 sub *O. brunneus*).
Distribution. — Norway. Sweden. British coasts. Brittany. N. America.

[**Cucumaria hispida** (Barrett).]

. . . . v., .

v. "Porcupine" Exp. 1869, 422 fms. (Théel '86 sub *Echinocucumis typica*).
Distribution.—Arctic seas to Bay of Biscay. West Indies.

Cucumaria andrewsi (Farran).

. . iii., . ?v., .

iii. Clonea, Dungarvan, two specimens (Farran '52).
?v. A species closely allied to, if not identical with *Thyone andrewsii*, on north-west coast of co. Clare (Kinahan '63).
Distribution.—Ireland.

Cucumaria saxicola, Brady & Robertson.

. . . . v., .

v. Birterbuy Bay, a specimen dredged in 15 fms., and six specimens in holes of limestone boulders between tide-marks, Westport, co. Mayo (Brady & Robertson '71).
Distribution.—W. Ireland.

Thyone fusus (O. F. Müller). (*Thyone papillosa* Forbes B. S.)

i., ii., . iv., v., .

i. Belfast Lough (Thompson, f. Forbes '41): off Larne, 70–90 fms., two specimens (Hyndman '59): Strangford Lough (Thompson, f. Forbes '41; Hyndman and Thompson, f. Dickie '58; Belfast N. F. C. Guide '74): among Killinchy oysters in Belfast market (Thompson '56).
ii. Dublin Bay (Kinahan '60).
iv. Bantry Bay, 15–30 fms. (M'Andrew, f. Thompson '56): R. I. A. Exp. 1885, Berehaven (Bell '86).
v. Roundstone, numerous (M'Calla, f. Forbes '41): Birterbuy Bay, 12–14 fms., not uncommon (Brady & Robertson '69): Killary (Forbes '41).
Distribution.—Loffoden to British Isles. France. Mediterranean.

Thyone raphanus, Düb. & Kor.

. . . iv., . .

iv. Bantry Bay, 15–30 fms., a specimen (M'Andrew, f. Thompson '56): R. I. A. Exp. 1885, Berehaven, and off Great Skellig, 70 fms. (Bell '86): R. D. S. Fish. Survey 1890, Dingle Bay, 7 fms. (Bell '92): Dingle Bay, 30–40 fms. (Beaumont 1900).
Distribution. — Sweden. Norway. British Isles. Brittany. Mediterranean.

Thyone portlockii, described by Forbes ('41) from a specimen found by Capt. Portlock in Belfast Lough, was regarded by Théel as possibly identical with *Phyllophorus drummondi*, but is believed by Norman ('93 A) to be a synonym of *Cucumaria montagui* (Fleming), which may be a distinct British species (Marenzeller in Ann. and Mag. Nat. Hist. (6) xii., 1893 and Norman '93 A).

Psolus phantapus (Struss.).

i., ...

i. Bangor, co. Down, a single specimen (Thompson '56) : N. E. coast (Belfast N. F. C. Guide '74).

A young specimen of *P. phantapus*, or *P. fabricii*, was dredged in 500 fms., off Black Rock, Blacksod Bay, in R. D. S. Fish. Survey 1891 (Bell '92).

Distribution.—Arctic seas to British Isles and New England.

Phyllophorus pellucidus (Düb. & Kor.). (*Cucumaria hyalina* Forbes B. S.)

i., . . iv., . .

i. Strangford Lough, 15-20fms. (Hyndman and Thompson, f. Dickie '58 sub *C. hyalina*).

iv. R. I. A. Exp. 1888, 50 fms. (Sladen '91).

Distribution.—Arctic seas to British Isles and West Indies.

Phyllophorus drummondi (Thompson). (*Cucumaria drummondii*, &c., Forbes B. S.)

i., . iii., . v., .

i. North of Ireland (Thompson '56 sub *Cucumaria communis*): Belfast Lough (Drummond, f. Thompson '40).

iii. Youghal (Ball, f. Forbes '41 sub *C. communis* ; Humphreys '45 sub *C. communis*).

v. Roundstone (M'Calla, f. Thompson '56 sub *C. communis*).

Distribution.—Loffoden to British Channel.

Thyonidium dubeni Norman, which is stated by M'Intosh in "The Marine Invertebrates and Fishes of St. Andrews," 1875, to have been found by Norman on the coast of Ireland, is probably to be referred to *P. drummondi*.

Family—ASPIDOCHIROTÆ.

[**Holothuria intestinalis**, Asc. & Rathke.]

. . . iv., v., .

iv. R. I. A. Exp. 1888, 750 fms. (Sladen '91).

v. R. D. S. Fish. Survey 1890, off Achill Head, 220 fms., probably (Bell '92).

Distribution.—Finmark to British Isles. Bay of Biscay. Azores. Mediterranean. W. Indies.

Holothuria tremula, Gunnerus.

. . . iv., [v.], [vi.]

iv. R. I. A. Exp. 1886, 110-325 fms. (Haddon '88): R. I. A. Exp. 1888, 345 fms. (Sladen '91): "Flying Fox" Exp. 1889, 100 fms. and 315 fms. (Bell '89): H. M. S. "Research" 1889, 70-400 fms. (Bell '90): R. D. S. Fish. Survey 1891, off Bolus Head, 220 fms. (Holt '92).

[v.] R. D. S. Fish. Survey 1890-91, off Achill Head, 127-220 fms. (Holt '92, Bell '92).

[vi.] R. D. S Fish. Survey 1891, 45 miles off Black Rock, Blacksod Bay, 375-500 fms. (Holt '92, Bell '92).

Distribution.—Norway to Spain.

Holothuria forskahli, Delle Chiaje. (*H. nigra* Bell B. M. Cat.)

. . . iv., v., vi.

iv. Kenmare River (Bell '92 B): Valentia (Haines '53 sub *H. tubulosa*; Norman '93; Gamble '96; Beaumont 1900; Dublin Mus.): R. D. S. Fish. Survey 1890, Dingle Bay, 4 fms. (Bell '92).

v. Miltown Malbay (Foot '60): West coast of Ireland (Todhunter, f. Thompson '56): R. D. S. Fish. Survey 1891, Casheen Bay, 7 fms., Cleggan Bay, 4-9 fms., and Davalaun Sound, 13-16 fms. (Holt '92, Bell '92, '92 B): "Argo" Cruise 1890, Inishbofin, a single specimen, between tide-marks (Herdman '91).

vi. R. D. S. Fish. Survey 1891, Donegal Bay, 30 fms., and Killybegs Harbour, 14-16 fms. (Holt '92): ? Tory Island, a specimen (Hyndman, f. Thompson '56).

Distribution.—W. Ireland and S. W. England to Mediterranean.

[**Holothuria aspera**, Bell.]

. . . iv., . .

iv. "Flying Fox" Exp. 1889, 1000 fms., a single specimen (Bell '89).
Distribution.—S. W. Ireland. Deep water.

[**Stichopus natans** (M. Sars).]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms. (Sladen '91); doubtful if the specimen was an example of *S. natans* (Bell '92 B).
Distribution.—Loffoden. Norway. S. W. Ireland.

Family—Deimatidæ.

[**Lætmogone violacea**, Théel.]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms. (Sladen '91).
Distribution.—Faröe Channel. S. W. Ireland. Off Sydney "Challenger" Exp.

CRINOIDEA.

Family—Antedonidæ.

Antedon bifida (Pennant). (*Comatula rosacea* Forbes B.S.)

i., ii., iii., iv., v., .

i.-v. Generally distributed in these provinces, and probably also in province vi., but there does not appear to be any record of its having been found on the N. W. coast of Ireland. Two specimens dredged at the unusual depth of 250 fms. in "Flying Fox" Exp. 1889 (Bell '89).
Distribution.—Shetland to Mediterranean.

Antedon milleri (J. Müller).

i., ...

i. Belfast (Wyv. Thomson, f. Norman '65).
Distribution.—Arran. Mouth of Mersey. Milford Haven. Belfast.
It is very doubtful if this species can be satisfactorily diagnosed (Bell '92 B).

[**Antedon phalangium** (J. Müller).]

. . . iv., . .

iv. "Flying Fox" Exp. 1889, 250 fms., a single specimen (Bell '89).
Distribution.—Hebrides to Madeira and Mediterranean.

ASTEROIDEA.

Family—ARCHASTERIDÆ.

Pontaster tenuispinus (Düb. & Kor.).

. . . iv., . .

iv. "Porcupine" Exp. 1869, off Valentia, 100–150 fms. (Sladen '89 sub *P. tenuispinus* var. *platynota* and *P. limbatus*): R. I. A. Exp. 1886, 214 fms. and 325 fms. (Haddon '88): "Flying Fox" Exp. 1889, ? 250 fms. and 315 fms. (Bell '89): H.M.S. "Research" 1889, 90–400 fms. (Bell '90): R. I. A. Exp. 1888, 345 fms. (Sladen '91 sub *P. limbatus*).

Distribution.—Both sides of North Atlantic.

[**Plutonaster bifrons** (Wyv. Thomson).]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms. (Sladen '91).

Distribution.—North Atlantic. Mediterranean.

Family—ASTROPECTINIDÆ.

Astropecten irregularis (Pennant). (*Asterias aurantiaca* Forbes B. S.)

i., ii., iii., iv., v., vi.

Generally distributed round the coast from about 10 fms. to 1000 fms.

Distribution.—Scandinavia to Liberia.

[**Astropecten sphenoplax**, Bell.]

. . . . v., vi.

v. R. D. S. Fish. Survey 1890, off Achill Head, 500 fms. (Holt '92).

vi. R. D. S. Fish. Survey 1891, off Black Rock, Blacksod Bay, 500 fms. (Bell '92).

Distribution.—West Ireland. Deep water.

[**Psilaster andromeda** (M. & Tr.).]

. . . iv., . vi.

iv. H. M. S. "Research" 1889, 400 fms. (Bell '90): R. I. A. Exp. 1888 (Sladen '91).

vi. R. D. S. Fish. Survey 1891, off Black Rock, Blacksod Bay, 500 fms. (Bell '92).

Distribution.—Scandinavia to Bay of Biscay. Azores. Cape Verde. N. America.

Luidia ciliaris (Philippi). (*L. fragillissima* Forbes B. S. (pars).)

. . iii., iv., v., vi.

iii. Youghal (Ball, f. Thompson '40 A; Humphreys '45): Glandore, not unfrequent (Allman, f. Thompson '56): south coast of Ireland, not unfrequent (Wright & Greene '59).

iv., v. Generally distributed.

vi. R. D. S. Fish. Survey 1891, Donegal Bay, 32 fms. (Holt '92).

Distribution.—Faröe to Cape Verde. Mediterranean.

A single specimen of *Bipinnaria asterigera* Sars (Larval stage of Luidia) was taken in Valentia Harbour in November 1895 (Browne 1900).

Luidia sarsi, Düb. & Kor. (*L. fragillissima* Forbes B. S. (pars).)

. . . iv., v., vi.

iv., v. Generally distributed.

vi. R. D. S. Fish. Survey 1890–91, Donegal Bay, 33–37 fms. (Bell '92).

Distribution.—Norway to Cape Verde. Mediterranean.

Family—PENTAGONASTERIDÆ.

[**Pentagonaster granularis** (Retz.).]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms. (Sladen '91 sub *P. balteatus* n. sp. and *P. concinnus* n. sp.).

Distribution.—Both sides of North Atlantic.

Ludwig regards *P. balteatus* and *P. concinnus* as possibly identical with *P. hystricis* Marenzeller of the Mediterranean and Bay of Biscay, and not as synonyms of *P. granularis.*

[**Pentagonaster greeni** (Bell).]

. . . iv., . .

iv. "Flying Fox" Exp. 1889, 1000 fms., one specimen (Bell '89).
Distribution.—S.W. Ireland. Deep water.

[**Nymphaster subspinosus** (Perrier).]

. . . iv., . .

iv. R. I. A. Exp. 1888 (Sladen '91 sub *Nymphaster protentus*): "Flying Fox" Exp. 1889, 315 fms., five specimens (Bell '89 sub *N. protentus*): H. M. S. "Research" 1889, 400 fms. (Bourne '90).
Distribution.—S.W. Ireland. Canaries "Challenger." West Indies "Blake."

Family—GYMNASTERIIDÆ.

Porania pulvillus (O. F. Müller). (*Goniaster templetoni* Forbes B. S.)

i., ii., iii., iv., v., vi.

i. Belfast Lough (Grimshaw, f. Templeton '36 sub *Asterias equestris* Sow. ?): Strangford Lough, a specimen (Thompson '56).
ii. East of Ireland (Wright & Greene '59).
iii. Youghal (Wright & Greene '59; Bell '92 B): Nymph Bank (Ball, f. Forbes '41): ? R. D. S. Fish. Survey 1890–91, off Ballycottin (Bell '92).
iv. Off Valentia (Bell '92 B): R. I. A. Exp. 1886, 70–80 fms. (A. R. N.): H. M. S. "Research" 1889, 70 fms. (Bell '90).
v. Coast of Clare (Gabbet, f. Thompson '56; Dublin Mus.): "Porcupine" Exp. 1869, 106 fms. (Sladen '89): R. D. S. Fish. Survey 1891, Davalaun, 30 fms. (Bell '92).
vi. R. D. S. Fish. Survey 1891, Killybegs Harbour, 14–16 fms. (Bell '92): Tory Island (Hyndman, f. Thompson '56).
Distribution.—Scandinavia to British coasts. Bay of Biscay.

Family—ASTERINIDÆ.

Asterina gibbosa (Pennant).

i., ii., iii., iv., v., .

i. Coasts of Antrim and Down (Thompson '56): Strangford Lough (Thompson '56; Bell '92 B): Ardglass (Thompson '56).
ii. Coast of Dublin (Thompson '56): Lambay Island (Thompson '56; Bell '92 B): Dublin Bay (Mackintosh '78): Greytones (Mackintosh '84).

iii. Southern shores (Ball, f. Thompson '56): Youghal (Miss M. Ball, f. Thompson '56): Cork (Humphreys '45): Kinsale and Glandore (Ball, f. Thompson '56): S. W. coast of Cork (Allman, f. Thompson '56).

iv. R. I. A. Exp. 1885, Bantry Harbour, 4–6 fms. (Haddon '86 B): Bantry Bay (Dublin Mus.): Valentia Harbour (Beaumont 1900): R. D. S. Fish. Survey 1890–91, Smerwick Harbour (Bell '92, '92 B).

v. Kilkee (Lord Chancellor Brady, f. Thompson '56): Lahinch (Thompson '56; Bell '92 B): Lahinch and Ballyvaughan, common (Kinahan '63): Clare (Dublin Mus., coll. by Miss O'Brien): Roundstone (M'Calla, f. Thompson '56): Connemara (Alcock '65): "Argo" Cruise 1890, Inishbofin (Herdman '91): R.D.S. Fish. Survey 1890, Killeany Bay (Holt '92).

Distribution.—European and N. African coasts. Mediterranean.

Palmipes placenta (Pennant). (*P. membranaceus* Forbes B. S.)

i., ii., iii., iv., . .

i. Off Larne, 70–90 fms., a very small specimen (Hyndman '59): Belfast Lough (M'Calla in 8th Ann. Rep. Dublin Nat. Hist. Soc., 1845–6; Thompson '56): Ballywalter, co. Down (Bell '92 B): Strangford Lough (a specimen, Templeton '36; Thompson '56; rare, Dickie '58).

ii. Dundrum Bay, numerous (Kinahan '59): a specimen dredged about 7 miles off the Dublin coast (Warren, f. Thompson '56).

iii. Youghal (a specimen, Ball, f. Forbes '41; Humphreys '45).

iv. Kenmare River (Dublin Mus., coll. by Miss Birch; Bell '92 B): R. D. S. Fish. Survey 1890, Kenmare River, 10 fms. (Holt '92): H. M. S. "Research" 1889, 70 fms. (Bell '90).

Distribution.—British and French coasts. Mediterranean.

Family—Stichasteridæ.

Stichaster roseus (O. F. Müller). (*Cribella rosea* Forbes B. S.)

. ii., iii., iv., [v.], .

ii. East of Ireland (Wright & Greene '59): Dublin Bay (Kinahan '61).

iii. Nymph Bank (Ball, f. Thompson '40 A): Youghal (Humphreys '45; Wright & Greene '59).

iv. R. I. A. Exp. 1888, 50–54 fms. (Sladen '91): H. M. S. "Research" 1889, 200 fms. (Bell '90): S. W. coast of Ireland, 55 fms. (Bell '92 B): S. W. Ireland (Grenfell, f. Bell '92 B).

[v.] R. D. S. Fish. Survey 1890, off Achill Head, 144 fms. (Holt '92).

Distribution.—Norwegian and British coasts. Roscoff. Bay of Biscay.

[**Neomorphaster talismani** (Perrier). (*N. eustichus* Bell B. M. Cat.)]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms. (Sladen '91).

Distribution.—S. W. Ireland. Bay of Biscay. Azores. Canaries. Deep water.

[**Zoroaster fulgens**, Wyv. Thomson.]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms. (Sladen '91).

Distribution.—Both sides of the Atlantic. Deep water.

Family—SOLASTERIDÆ.

Solaster papposus (Fabr.).

i., ii., iii., iv., v., vi.

Generally distributed all round the coast and common.

Distribution.—Arctic seas to coast of France and to New England.

Solaster endeca (Linné).

i., ii., iii., . v., .

i. Coasts of Antrim and Down (Thompson, f. Forbes '41): Belfast Lough (M'Calla in 8th Ann. Rep. Dublin Nat. Hist. Soc., 1845–6; Thompson '56; Bell '92 B): Strangford Lough (Dickie '58; Bell '92 B).

ii. Dublin Bay (Ball, f. Forbes '41; Hassall '42; Mackintosh '78).

iii. Youghal (Ball, f. Forbes '41; Humphreys '45).

v. R. D. S. Fish. Survey 1890, Clew Bay, 15 fms. (Holt '92).

Distribution.—Arctic seas to British Isles and to Nova Scotia.

Family—PTERASTERIDÆ.

[**Pteraster personatus**, Sladen.]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms. (Sladen '91).

Distribution.—S. W. Ireland. Bay of Biscay. Deep water.

[**Hymenaster giganteus**, Sladen.]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms. (Sladen '91).
Distribution.—S. W. Ireland. Deep water.

Family—Echinasteridæ.

Henricia sanguinolenta (O. F. Müller). (*Cribella oculata* Forbes B. S.)

i., ii., iii., iv., v., .

i. North of Ireland (Thompson '56): coast of Antrim (Ord. Surv. Coll. in Dublin Mus.): off Larne, 70–90 fms. (Hyndman '59): Strangford Lough (15–20 fms., Hyndman and Thompson, f. Dickie '58; 5 fms., Bell '92 b).
ii. Generally distributed.
iii. Youghal (Ball, f. Forbes '41; Humphreys '45).
iv., v. Generally distributed in these provinces; and probably also on the N. W. coast of Ireland, but I am not aware of any record of its occurrence. Var. *abyssicola*, Norman. R. I. A. Exp. 1888, 750 fms. (Sladen '91).

Distribution.—Arctic seas to British coasts and New England. Bay of Biscay. Azores. ? Mediterranean.

Family—Asteriidæ.

Asterias glacialis, Linné. (*Uraster glacialis* Forbes B. S.)

i., ii., iii., iv., v., vi.

i. N. E. Ireland, a few small specimens (Thompson '56): Belfast Lough (Drummond, f. Forbes '41; Kinahan '59; Bell '92 b): Strangford Lough, occasionally inside and outside (Dickie '58).
ii. Dublin Bay, 12–30 fms., very common (Kinahan '59): Dalkey Sound (Kinahan '53; Corrigan in Nat. Hist. Rev. i., 1854).
iii., iv., v., vi. Generally distributed.
Distribution.—Finmark to Cape Verde. Mediterranean.

Asterias rubens, Linné. (*Uraster rubens* and *U. violacea* Forbes B. S.)

i., ii., iii., iv., v., vi.

Generally distributed all round the coast and common. Dredged by H.M.S. "Research" 1889, at the great depth of 200 fms. (Bell '90).
Distribution.—Finmark to Senegal. ? Mediterranean.

Asterias murrayi, Bell.

. . . . v., .

v. R. D. S. Fish. Survey 1891, west coast of Ireland (Bell '92, '92 B).
Distribution.—West coasts of Scotland and Ireland.

Asterias hispida, Pennant. (*Uraster hispida* Forbes B. S.)

i., ii., iii., iv., v., .

i. Belfast Lough (Portlock, f. Forbes '41): coast of Down (Thompson '56; Bell '92 B): Strangford Lough and Channel, occasionally (Dickie '58).
ii. East of Ireland (Wright & Greene '59): Dublin Bay (Kinahan '59).
iii. Trabulgan, co. Cork, a single young specimen (Greene '58).
iv. South-west Ireland (Wright & Greene '59).
v. North-western coast of co. Clare (Kinahan '63): Roundstone (M'Calla, f. Thompson '56): west of Ireland (Wright & Greene '59).
Distribution.—British coasts. Sweden (Lönnberg).

Family—BRISINGIDÆ.

[**Brisinga endecacmenos,** Asbj.]

. . . iv., . .

iv. Off Valentia and "Porcupine" Exp. 1869, 458 fms. (Thomson '73): R. I. A., Exp. 1886, 325 fms. (Haddon '88).
Distribution.—Norway to Spain.

[**Brisinga coronata,** G. O. Sars.]

. . . iv., . .

iv. "Porcupine" Exp. 1869, 458 fms. (Sladen '89): R. I. A. Exp. 1888, 345 fms. (Sladen '91): "Flying Fox" Exp. 1889, 1000 fms., an injured specimen (Bell '89): H. M. S. "Research" 1889, 200 fms., fragments only (Bell '90, Bourne '90).
Distribution.—Loffoden to Azores. Mediterranean.

OPHIUROIDEA.

Family—OPHIOLEPIDIDÆ.

Ophiura ciliaris (Linné). (*O. texturata* Forbes B. S.)

i., ii., iii., iv., v., vi.

Generally distributed and common; very large specimens are often obtained off the S. W. coast of Ireland.

Distribution.—Eastern side of North Atlantic. Mediterranean.

Ophiura albida, Forbes.

i., ii., iii., iv., v., vi.

Generally distributed and common.

Distribution.—North European seas. Mediterranean.

Ophiura sarsi, Lütken.

. . . ? iv., . .

? iv. "Porcupine," Exp. 1869, 75 fms., a young specimen (Hoyle '84).

Distribution.—Both sides of North Atlantic.

[**Ophiura signata** (Verrill).]

. . . ? iv., . .

? iv. R. I. A. Exp. 1888, 345 fms. (Sladen '91, but rather doubtful of the determination).

Distribution.—N. E. America. Faröe Channel. ? S. W. Ireland.

Ophiura affinis, Lütken.

. . . iv., . .

iv. R. I. A. Exp. 1885, Berehaven, mouth of Bantry Bay, 40 fms., and off Great Skellig, 110–120 fms. (Haddon '86 B) : R. I. A. Exp. 1886, mouth of Bantry Bay, 37½ fms. (Haddon '88).

Distribution.—Both sides of North Atlantic. Mediterranean.

[**Ophiocten sericeum** (Forbes).]

. . . iv., . .

iv. H. M. S. "Research" 1889, 400 fms. (Bell '90).

Distribution.—Eastern side of N. Atlantic. Arctic seas. Off Massachusetts (Lyman). ? Marion I. "Challenger."

Family—Amphiuridæ.

[**Ophiomusium lymani**, Wyv. Thomson.]

. . . iv., . .

iv. "Porcupine" Exp. 1869, 180 fms. (Thomson '73).

Distribution.—Atlantic and Pacific Oceans. Deep water.

Ophiocnida brachiata (Montagu). (*Ophiocoma brachiata* Forbes B. S.)

i., ii., . iv., . .

i. Belfast Lough, a young specimen (Thompson, f. Forbes '41): Strangford Lough, in rock-pools (Thompson, f. Forbes '41).
ii. Off Dundrum, co. Down, two specimens (Hyndman and Thompson, f. Thompson '56): several specimens from stomachs of haddock taken off Newcastle (Thompson '56).
iv. Kenmare River (Sir P. Egerton, f. Bell '92 B).
Distribution.—North European seas. Mediterranean.

Amphiura chiajii, Forbes.

i., . . iv., v., .

i. Bangor, co. Down (Bell '92 B).
iv. "Porcupine," Exp. 1869, 75 fms. (Hoyle '84): R. I. A. Exp. 1885, Berehaven, 5-12 fms., common (Haddon '86 B).
v. Killary Sound, very abundant (Norman, f. Hoyle '85).
Distribution.—North European seas. Mediterranean.

Amphiura filiformis (O. F. Müller). (*Ophiocoma filiformis* Forbes B. S.)

i., ii., iii., iv., v., vi.

i. This species was apparently dredged from 50 fms. off South Rock, co. Down (Thompson '56): off Strangford, rare (Dickie '58): in quantity from haddock off Killough (Thompson '56).
ii. From stomachs of haddock taken off Newcastle, co. Down (Thompson '56): Dublin Bay, a single specimen (Hassall '42): Kingstown Harbour (Ball, f. Thompson '56).
iii. R. I. A. Exp. 1886, off Ballycottin, 39 fms. (A. R. N.): Courtmacsherry Harbour (Allman, f. Thompson '56): R. I. A. Exp. 1885, off Glandore, 40 fms. (Haddon '86 B).
iv., v. Generally distributed.
vi. North-west Ireland (Wright & Greene '59).
Distribution.—North European seas. Mediterranean.

Amphiura elegans (Leach). (*Ophiocoma neglecta* Forbes B. S.)

i., ii., iii., iv., v., vi.

i. Coasts of Antrim and Down (Templeton '36 sub *Ophiura minuta*; Hyndman and Thompson, f. Forbes '41): Belfast Lough and Bangor (Thompson '56): Strangford Lough, abundant (Hyndman and Thompson, f. Forbes '41): Strangford Channel, 25 fms., rare (Dickie '58): common between tide-marks at Ardglass (Thompson '56).

ii. Common between tide-marks at Annalong (Thompson '56): Rush (Duerden in Irish Naturalist, 1894): Lambay (Thompson '56): Dublin Bay (Kinahan '59; Mackintosh '78): Greystones (Mackintosh '84).

iii. Ardmore (Kinahan '59): Trabulgan, co. Cork (Greene '58 sub *Amphiura leachii* n. sp.).

iv. R. I. A. Exp. 1885, Berehaven (Haddon '86 B): Valentia (Kinahan '59; Beaumont 1900): R. I. A. Exp. 1886, 108 fms. (A. R. N.): S. W. coast, 70 fms. (Bourne, f. Bell '92 B).

v. Common on the west coast (Forbes '41): Lahinch (Thompson '56): north-west coast of co. Clare (Kinahan '63): Roundstone (Dublin Mus.): Killary Bay, 3–12 fms., and Clew Bay, 3–10 fms. (Thompson '56).

vi. Tory Island (Hyndman, f. Thompson '56).

Distribution.—North Atlantic. Mediterranean. Cape of Good Hope and Australia "Challenger."

Ophiactis balli (Thompson). (*Ophiocoma ballii* and *O. goodsiri* Forbes B. S.)

i., ii., iii., iv., . .

i. Giant's Causeway, adherent to *Pinna* (Bell '92 B).

ii. Dublin Bay (Kinahan '61): Dalkey Sound (Ball, f. Thompson '40; Bell '92 B).

iii. Nymph Bank (Thompson '56): R. I. A. Exp. 1886, off Ballycottin, 39 fms. (A. R. N.).

iv. R. I. A. Exp. 1885, 80 fms. (Haddon '86 B): Dingle Bay, 30–40 fms. (Beaumont 1900).

Distribution.—Scandinavian and British coasts. Bay of Biscay (Koehler).

Ophiopholis aculeata (Linné). (*Ophiocoma bellis* Forbes B. S.)

i., ii., iii., iv., v., .

i.–v. Generally distributed, but does not seem to have been recorded from province vi.

Distribution.—Both sides of N. Atlantic from Arctic Ocean to British Isles and New England.

Family—OPHIOCOMIDÆ.

Ophiocoma nigra (Abilg.). (*O. granulata* Forbes B. S.)

i., ii., . iv., v., vi.

i. Belfast (Kinahan '59): coast of Down (Thompson '56): Strangford Lough (Thompson, f. Forbes '41; Dickie '58; Bell '92 B).
ii. Dublin Bay, common: Greystones (Mackintosh '84).
iv. Berehaven (Dublin Mus.): R. I. A. Exp. 1885, Berehaven, 5–12 fms., common (Haddon '86 B): R. I. A. Exp. 1886, 70–80 fms. (Haddon '88): Valentia (Kinahan '59; Beaumont 1900).
v. R. D. S. Fish. Survey 1890–91, Kilkieran Bay, 4–8 fms., and Birterbuy Bay, 7–13 fms. (Holt '92).
vi. R. D. S. Fish. Survey 1891, off Malin Head, 22–23 fms. (Bell '92).

Distribution.—North European seas.

Ophiopsila annulosa (Sars).

. . . iv., v., .

iv. Kenmare Bay (More, f. Norman in Hoyle '85).
v. Birterbuy Bay, a single fragment of a ray (Brady & Robertson '69).

Distribution.—W. Ireland. Mediterranean.

Family—OPHIOTHRICIDÆ.

Ophiothrix fragilis (Abilg.). (*Ophiocoma rosula* and *O. minuta* Forbes B. S.)

i., ii., iii., iv., v., vi.

Generally distributed all round the coast and very common, often on oyster- and other shell-banks.

Distribution.—Finmark to Mediterranean. Azores "Hirondelle."

Ophiothrix lütkeni, Wyv. Thomson.

. . . iv., . .

iv. "Porcupine" Exp. 1869, 180 fms. (Thomson '73): R. I. A. Exp. 1885, 80 fms., two specimens (Haddon '86B): R. I. A. Exp. 1886, 93–160 fms. (Haddon '88): "Flying Fox" Exp. 1889, 200–315 fms. (Bell '89, '92B): H. M. S. "Research" 1889, 200 fms. (Bell '90 sub *O. pentaphyllum*, '92 B): R. D. S. Fish. Survey 1891, off Bolus Head, 115 fms. and 220 fms. (Bell '92).

Distribution.—S. W. Ireland. Azores "Challenger."

STREPTOPHIURÆ.

[**Ophiobyrsa hystricis**, Lyman.]

. . . iv., v., .

iv. H. M. S. "Research" 1889, 400 fms., one specimen (Bell '90): ? R. I. A. Exp. 1888, 345 fms., fragments of rays only (Sladen '91): "Flying Fox" Exp. 1889, one specimen, 315 fms. (Bell '92A).

v. R. D. S. Fish. Survey 1890, off Achill Head, 220 fms., a young form, which may, perhaps, be referred to this species (Bell '92).

Distribution.—Faröe Channel and off western coasts of Ireland. Deep water.

ECHINOIDEA.

Family—CIDARIDÆ.

Cidaris papillata, Leske.

. ii., . iv., [v.], [vi.]

ii. "Porcupine" Exp., off Wexford, 30–40 fms. (Bell '92B).

iv., [v.], [vi.] Generally distributed in the deep-water marine area off the western coasts of Ireland, and in some places very abundant. Dredged in 93 fms. in R. I. A. Exp. 1886 (Haddon '88).

Distribution.—Atlantic and Pacific Oceans.

[**Cidaris gracilis** (Sladen).]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms., a single specimen, probably immature (Sladen '91); perhaps when a mature specimen is found, it will be seen to be only *C. purpurata* Wyv. Thomson (Bell '92B).

Distribution.—S. W. Ireland. Deep water.

Family—ECHINOTHURIIDÆ.

[**Asthenosoma hystrix** (Wyv. Thomson).]

. . . . v., vi.

v. "Porcupine" Exp. 1869, off west coast of Ireland (Thomson '74).

vi. R. D. S. Fish. Survey 1891, 45 miles off Black Rock, Blacksod Bay, 500 fms. (Bell '92, '92B).

Distribution.—Hebrides to Portugal and Azores. W. Indies.

[**Phormosoma placenta**, Wyv. Thomson.]

. . . iv., v., vi.

iv. "Flying Fox" Exp. 1889, 1000 fms., six specimens (Bell '89): R. I. A. Exp. 1888, 750 fms. (Sladen '91).

v. "Porcupine" Exp. 1869, off west of Ireland, fragments and spines (Thomson '74): R. D. S. Fish. Survey 1890, 54 miles off Achill Head, 500 fms. (Bell '92).

vi. R. D. S. Fish. Survey 1891, 45 miles off Black Rock, Blacksod Bay, 375–500 fms. (Holt '92).

Distribution.—Both sides of Atlantic. Deep water.

[**Phormosoma uranus**, Wyv. Thomson.]

. . . iv., . .

iv. R. I. A. Exp. 1888, 750 fms., a single fine example (Sladen '91).

Distribution.—Both sides of Atlantic. Deep water.

Family—ECHINIDÆ.

, **Echinus acutus**, Lamarck. (*E. flemingii* Forbes B. S.)

. . iii., iv., v., .

iii. Off Youghal (in very deep water, Ball, f. Forbes '41 ; Humphreys '45): "Porcupine" Exp., south of Ireland, 100 fms. (Agassiz '72'–74).

iv. "Flying Fox" Exp. 1889, 55 fms., 110 fms., and 500 fms. (Bell '89): H. M. S. "Research" 1889, 70 fms. (Bell '90): Dingle Bay, 30 fms. (Dublin Mus.).

v. R. D. S. Fish. Survey 1890, Galway Bay, and off Achill Head, 126 fms. (Bell '92).

Distribution.—Both sides of Atlantic. Mediterranean. Kermadec I. "Challenger."

Echinus norvegicus, Düb. & Kor.

. . . iv., . .

iv. "Porcupine" Exp. 1869, off Valentia, 808 fms. (Hoyle '91): "Porcupine" Exp. 1869, 80–110 fms. (Bell '92B): R. I. A. Exp. 1888, 345 fms. and 750 fms. (Sladen '91): H. M. S. "Research" 1889, 400 fms. (Bell '90). Var. *rarispina*, Sars. Off Valentia, 110 fms. (Thomson '73; Norman Coll., f. Hoyle '91).

Distribution.—Both sides of N. Atlantic. Off Japan and off Patagonia "Challenger."

Echinus microstoma, Wyv. Thomson.

. . . iv., [v.], [vi.]

iv. "Porcupine" Exp. 1869, off Valentia (Norman Coll., f. Hoyle '91): R. I. A. Exp. 1885, 80–120 fms., common (Haddon '86B): R. I. A. Exp. 1886, 93–214 fms. (Haddon '88): R. I. A. Exp. 1888, 345 fms. (Sladen '91): "Flying Fox" Exp. 1889, 110–500 fms. (Bell '92B).

[v.] "Porcupine" Exp. 1869, off west coast of Ireland, 150–400 fms., very abundant (Thomson '74).

[vi.] R. D. S. Fish. Survey 1891, off Black Rock, Blacksod Bay, 250 fms. and 500 fms. (Bell '92, '92B).

Distribution.—West coasts of Scotland and Ireland. Bay of Biscay.

Echinus miliaris, Gmel.

i., ii., iii., iv., v., vi.

Generally distributed on all the Irish coasts.

Distribution.—Iceland and Norway to Mediterranean.

Echinus esculentus, Linné.

i., ii., iii., iv., v., vi.

Generally distributed round the coast in the shallow-water marine area, and common. "Flying Fox" Exp. 1889, 110 fms. (Bell '89).

Distribution.—Spitzbergen and Iceland to Mediterranean.

[**Echinus elegans**, Düb. & Kor.]

. . . iv., v., vi.

iv. "Porcupine" Exp. 1869, off Valentia, 110 fms. (Thomson '73; Norman Coll., f. Hoyle '91): "Flying Fox" Exp. 1889, 250 fms., four specimens (Bell '89).

v. R. D. S. Fish. Survey 1890, 54 miles off Achill Head, 500 fms., eight specimens (Bell '92).

vi. R. D. S. Fish. Survey 1891, off Black Rock, Blacksod Bay, 250 fms. and 500 fms. (Bell '92, '92B).

Distribution.—Both sides of Atlantic. Mediterranean. Off Admiralty I. "Challenger."

Strongylocentrotus lividus (Lamarck). (*Echinus lividus* Forbes B. S.)

i., . iii., iv., v., vi.

i. A specimen cast up at Carrickfergus (Dickie '53).

iii. Cork (J. Humphrey, f. Bell '92 B): Lough Hyne (Kinahan '59; Haddon '88): south-west coast of Cork (Allman in 9th Ann. Rep. Dublin Nat. Hist. Soc., 1849).

iv., v. Generally distributed.

vi. Bundoran, Donegal Bay (Hyndman, f. Forbes '41; &c.): Tory Island (Hyndman, f. Dickie '53): Bay of Dunfanaghy (Rev. Mr. Gallaher, f. Dickie '53): Malin Head (Dickie '53).

Distribution.—North of Ireland to Canaries. Mediterranean. Brazil

Family—Clypeastridæ.

Echinocyamus pusillus (O. F. Müller).

i., ii., iii., iv., v., .

i. North of Ireland (Portlock, f. Forbes '41): off Maidens, 70–90 fms. (Hyndman '58, '59): Belfast Lough (Hyndman and Thompson, f. Thompson '56; Hurst in Irish Naturalist, 1896): Castle Chichester, 6–10 fms. (Bell '92 B): Strangford Lough and outside in 15–25 fms., rather rare (Dickie '58).

ii. Portmarnock (Thompson, f. Forbes '41; Bell '92 B): Dublin Bay (Hassall '42; &c.): off Bray Head, 23 fms. (Haddon '86).

iii. Cork (Humphreys '45): west coast of Cork (Allman, f. Thompson '56): Baltimore (A. R. N.).

iv. Bantry Bay (Thompson, f. Forbes '41): R. I. A. Exp. 1885, Bantry Bay, abundant (Haddon '86 B): Berehaven (Dublin Mus.): "Argo" Cruise 1890, off Dursey Head (Herdman '91): Dingle Bay, 54 fms. (Adams, f. More '70): Kerry (More '70): Valentia Harbour (Beaumont 1900).

v. North-west coast of co. Clare (Kinahan '63): Roundstone (M'Calla, f. Thompson '56): Connemara (Alcock '65): off Achill I. (Dublin Mus.).

Distribution.—Norway to Azores. Mediterranean. West Indies. Brazil "Challenger."

Family—Spatangidæ.

Spatangus purpureus, O. F. Müller.

i., ii., iii., iv., [v.], .

i. Off Maidens, 90 fms., small (Hyndman '58): Carrickfergus (Dublin Mus.): entrance of Belfast Lough, dredged alive (Hyndman, f. Thompson '56): Belfast Lough (20–23 fms., Thompson '56; Hurst in Irish Naturalist, 1896): Strangford Lough (Hyndman, f. Thompson '56; Dickie '58): outside Strangford Lough, rare (Dickie '58).

ii. Newcastle, co. Down, from the stomach of a haddock (Thompson '56): Portmarnock Strand (Baily '65): Dublin Bay (Templeton '36; &c.): off Bray (Ball, f. Thompson '56): coast of Wicklow (Dublin Mus.).

iii. Cork (Humphreys '45): R. I. A. Exp. 1886, off Cork, 52 fms. (A. R. N.).

iv. R. I. A. Exp. 1885, mouth of Bantry Bay, 35–40 fms. (Haddon '86 B): R. I. A. Exp. 1888, 54 fms. (Sladen '91): "Flying Fox" Exp. 1889, 50–60 fms. (Bell '89): H M.S. "Research" 1889, 70-400 fms. (Bell '90): R. D. S. Fish. Survey 1891, Kenmare River, 21 fms. (Holt '92): off Blasquets (More '70): Valentia (Dublin Mus., pres. by Mrs. E. Waller): off Valentia Harbour, 20–45 fms. (Beaumont 1900).

[v.] R. D. S. Fish. Survey 1890, off Achill Head, 220 fms. (Bell '92).

Distribution.—Norway and Iceland to Azores. Mediterranean. Bermuda.

Spatangus raschi, Lovén.

. . . iv., [v.], [vi.]

iv. "Porcupine" Exp. 1869, off Valentia, 110 fms. (Thomson '73; Norman Coll., f. Hoyle '91): R. I. A. Exp. 1885, 30–120 fms. (Haddon '86 B): R. I. A. Exp. 1886, 93–214 fms. (Haddon '88): R. I. A. Exp. 1888, 345 fms. (Sladen '91): "Flying Fox" Exp. 1889, 100–180 fms. (Bell '89): R. D. S. Fish. Survey 1891, off Bolus Head, 115–220 fms. (Holt '92): off Valentia (Dublin Mus., pres. by Mrs. E. Waller).

[v.] R. D. S. Fish. Survey 1890–91, off Achill Head, 127–500 fms. (Holt '92).

[vi.] R. D. S. Fish. Survey 1891, off Black Rock, Blacksod Bay, 375-500 fms. (Holt '92).

Distribution.—Norway to Azores. Cape of Good Hope "Challenger."

Echinocardium cordatum (Pennant). (*Amphidotus cordatus* Forbes B. S.)

i., ii., iii., iv., v., vi.

Generally distributed, and very common on sandy shores after storms.

Distribution.—Both sides of Atlantic, from Norway to Spain, and Carolina to Brazil. Mediterranean.

Echinocardium pennatifidum, Norman.

. . . iv., . .

iv. Off Valentia Harbour, 20–45 fms. (Beaumont 1900).

Distribution.—British Isles. Bay of Biscay, Mediterranean (Koehler). W. Indies and Florida (Agassiz).

Echinocardium flavescens (O. F. Müller). (*Amphidotus roseus* Forbes B. S.)

i., ii., iii., iv., v., .

i. Off Maidens, 70–90 fms. (Hyndman '58, '59): near Belfast (Forbes '41): off Strangford Bar, 20 fms., rare (Dickie '58).
ii. Dublin (Ball, f. Forbes '41).
iii. Youghal (Ball, f. Forbes '41; Humphreys '45): south of Ireland (Wright & Greene '59; "Porcupine" Exp., f. Agassiz '72–'74).
iv. Bantry Bay (Wright & Greene '59): off Blasquets (More '70): R. I. A. Exp. 1885, 5–79 fms. (Haddon '86 B): R. I. A. Exp. 1886, 37 fms. (A. R. N.): R. D. S. Fish. Survey 1890, off the Skelligs, 80 fms. (Holt '92).
v. West of Ireland (Thompson '44; Wright & Greene '59).

Distribution.—Norway to Cape of Good Hope. Mediterranean. Florida.

Brissopsis lyrifera (Forbes). (*Brissus lyrifer* Forbes B. S.)

i., . iii., iv., . .

i. Outside Strangford Bar, 25 fms., a single specimen in mud (Dickie '58).
iii. Off Cork, 40 fms. (M'Andrew, f. Thompson '56).
iv. Off Cape Clear, and from 30 fms. in Bantry Bay (M'Andrew, f. Thompson '56): Bantry Bay (Dublin Mus.): "Porcupine" Exp., off Valentia (Agassiz '72–'74): R. I. A. Exp. 1885, Berehaven, 10 fms., and off Great Skellig, 70–79 fms. (Haddon '86 B): R. I. A. Exp. 1886, 70–80 fms. (Haddon '88): R. I. A. Exp. 1888, 5 fms. and 54 fms. (Sladen '91): "Flying Fox" Exp. 1889, 5 fms. (Bell '89).

Distribution.—Both sides of N. Atlantic, from Greenland to Azores and W. Indies. Mediterranean. Cape of Good Hope "Challenger."

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[*The figures refer to the pages.*]

VI.

SOME REMARKS ON THE ATLANTIS PROBLEM.

By R. F. SCHARFF, B.Sc., Ph.D.

[Read November 10, 1902.]

The problem of the former existence of a land beyond the pillars of Hercules has occupied the mind of man since the early dawn of history. Plato was the first to record the story of this mysterious land, to which the name of "Atlantis" was given. According to his narrative, Solon is said to have visited the city of Sais in Egypt, and there to have heard, from priests, of the ancient Empire of Atlantis and of its final overthrow by a convulsion of nature. From the account given by Plato, this Atlantis was a continent lying in the Atlantic ocean beyond the Strait of Gibraltar.

Quite a flood of literature has appeared on this subject since it was first handed down to us by Plato. By some it was scouted as a vague and inconsistent tradition; while others believed in the story, and republished the account with many fanciful amplifications of their own. Others again, in their zeal for speculation, enlarged the Atlantis so as to make it join the New World and the Old across the Atlantic, and argued that the early races of man must have migrated on this land-bridge from Europe to America, and have peopled the latter continent in this manner.

Although the original narrative has thus led to extravagant theories, thoughtful men have, from time to time, expressed their conviction either that it rests on some actual historic basis or that the legend was a vestige of a widely-spread tradition. I need only mention in this connection the names of Humboldt and Sir Daniel Wilson.

The Atlantis problem, however, was only raised to scientific importance when modern research revealed the fact that the living, as well as the extinct, floras of Europe have quite a number of types in common with North America.

The first naturalist who attempted the solution of the Atlantis problem from a botanical point of view was Prof. Unger, an Austrian botanist. The Swiss naturalist, Prof. Heer, elaborated Unger's theories, and argued (p. 183)[1] that the prominent European character of the Atlantic Islands, as shown by their plants and insects, proved that they were formerly connected by land with the continent of Europe. But besides these forms, he noticed that certain American types occurred in all the islands, and that the flora of the latter, in some respects, resembled the tertiary flora of Europe, which, again, was allied to that of America. These remarkable features were explained by Heer by the supposition that, during the tertiary era, the continents of Europe and America were joined across the Atlantic, and that the plants travelled on this old land-connection from the one to the other. The plants of the Atlantic Islands, he thought, were more European in character than American, because the islands had been united with the Old World much longer than with the New (p. 185).

Oliver denied altogether the necessity for what he called "the Atlantis hypothesis," and insisted that the American element in the flora of the Atlantic Islands played only a subordinate part, whereas mediterranean, with a proportion of peculiar or macaronesian types, greatly predominated (p. 163). He explained the relationship between the flora of Europe and that of the New World—as has been done more recently by Prof. Engler (p. 82) and Dr. v. Ihering (A. p, 43)—by the supposition that the plants wandered across a land-bridge which formerly joined Eastern Asia to North America. Christ, on the other hand, attributes the American element in the flora of the Canary Islands to the action of the Gulf stream (p. 515); and Trelease, in his careful account on the Botany of the Azores, remarks that, so far as the peculiar species were concerned, their ancestors seemed to have all been introduced by such accidental means as drift or migratory birds (p. 87).

Edward Forbes maintained that, at the close of the Miocene Epoch, a vast continent extended far into the Atlantic from the coast of Portugal, past the Azores, and bounded on the north by Ireland (p. 14). While adopting Forbes's hypothesis, Murray enlarged the area of this Atlantic continent as far as Newfoundland, Greenland, and Spitsbergen (A, p. 37).

Imbued with the belief in the permanence of the great ocean basins, Dr. A. R. Wallace vigorously attacked Heer, Forbes, Murray, and others in his Presidential Address to the Entomological Society of London, delivered in January, 1871. Neither Murray nor later

[1] A list of the works and papers referred to in this Essay will be found in the Appendix.

writers, he contended, had really grappled with the facts as a whole. In 1900, he republished his address, stating, in a foot-note (A p, 250), that it may serve as a reply, not only to the arguments advanced by the late Andrew Murray, but also to similar views still occasionally put forward.

As many writers have expressed themselves against Dr. Wallace's views since the first publication of his address, I venture again to give the salient points advanced by him, and to bring forward a few arguments which appear to me to favour the older doctrines of Murray and others. I have also paid special attention to the fauna of the Atlantic Islands as a whole, with the view to reinvestigating the "Atlantis problem."

Dr. Wallace's address deals only with the beetles of Madeira, one of the Atlantic islands; but he maintains that the opinion he enunciates, and which is founded on a study of these insects, explains the origin of the Madeiran and of other insular faunas.

One of the most striking characters of the coleopterous fauna of Madeira is the unexampled preponderance of wingless species on the island. Darwin's ingenious explanation of this remarkable phenomenon is that the act of flying would expose the insects to being blown out to sea, and thus destroyed. Those insects which flew least would therefore remain behind in increasing numbers; and by a continuous process of natural selection, a race of wingless forms would thus, in the course of ages, become established on the island.

If Madeira, asks Dr. Wallace, were the remains of a continent, once continuous with the south of Europe, and deriving its fauna from such continuity, how are we to explain the absence of extensive genera very abundant in southern Europe, and, from their being wingless, specially adapted to the peculiarities of Madeira? Such, he continues, are *Carabus*, *Lampyris*, *Pimelia*, *Akis*, and many others. The genus *Carabus*—a prominent member of the large family of running-beetles—possesses, according to Dr. Wallace, 80 species in southern Europe and northern Africa, while not a single species has crossed to Madeira. Many other similar facts are set forth by the same author; and these seem to him quite inconsistent with the theory of the distribution of insects having been effected by a former land-connection with Europe. Their transmission appears to him to have been brought about, not by means of drift-wood or ocean currents, but by a passage through the air when assisted by gales and hurricanes.

Now it is evident that if Madeira had ever been connected by land with Europe, the part of the Continent with which it would have been joined must have been either southern Spain or Portugal. I venture to think, therefore, that Dr. Wallace should have drawn his comparisons of the Madeiran coleopterous fauna with that portion of our Continent and not with southern Europe and northern Africa generally. It is perfectly correct, as Dr. Wallace affirms, that not a single species of *Carabus* has ever been discovered in Madeira; whereas a large number of species of that wingless genus occur in the Mediterranean region. But when we subject the known range of the genus *Carabus* in Europe to a little further scrutiny, the unexpected circumstance reveals itself to us, that the number of species decreases rapidly as we proceed westward from the east. Out of about 153 European species, seventeen species are now known from the Spanish Peninsula, and only eight have so far been detected in Portugal.[1] In the extreme south of Spain, in Gibraltar and vicinity, three species have been found by Mr. Champion, and only two in Marocco. To judge from the geographical distribution of *Carabus*, it would seem as if the genus had originated somewhere in the east, and had only invaded western Europe in comparatively recent times.

Let us now examine the range of the second genus mentioned by Dr. Wallace—viz., *Lampyris*. Of nineteen European species, two occur in the Spanish Peninsula, and only one in Portugal.

Pimelia, the next genus, is more largely represented in the Spanish Peninsula; for, out of forty-one European species, no less than eighteen have been traced in Spain, though not a single one seems to be known from Portugal.

Even a larger percentage of species of the genus *Akis* occurs in Spain; for, out of eleven European species, seven have been taken there, of which one has penetrated into Portugal.

These facts tend to show that, even if Madeira had formed part of the Spanish Peninsula, not one of the species belonging to the above-mentioned genera would probably have reached that island. The absence of those genera of beetles from Madeira certainly cannot be adduced as a proof that the island has never been connected with Europe.

However, Dr. Wallace founded his views upon three other important statements, which require to be dealt with. He pointed out, in the first instance, that the Atlantic Islands were entirely composed of

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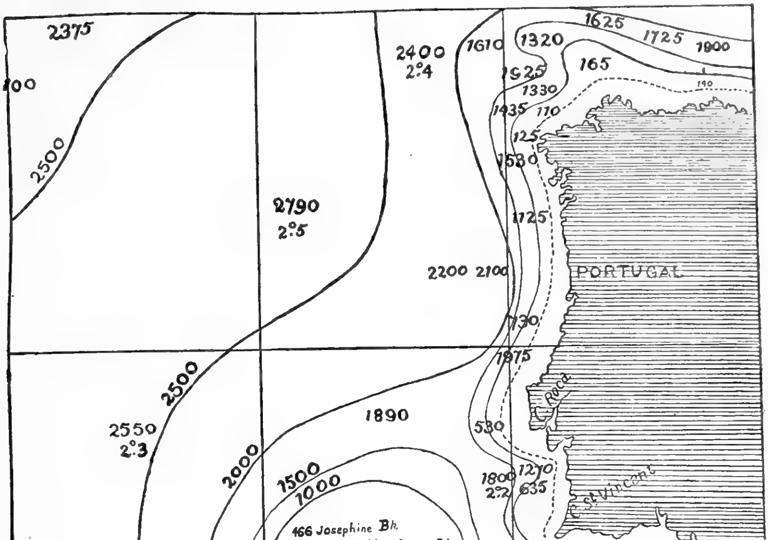
[1] These and other results have been obtained from the "Catalogus Coleopterorum Europæ (1891)" by Heyden, Reitter, and Weise.

volcanic rocks; secondly, that they were surrounded by great depths of water; and, lastly, that they possessed no indigenous land-mammalia.

As regards the fact that the Atlantic Islands are composed of volcanic rocks, it does not necessarily imply that they could not, therefore, have formed part of the continent of Europe in former times; for even Hartung, who made a special study of the Geology of Madeira, looked upon the Atlantic Islands as the summits of submerged mountain-chains (p. 175); while two other geologists—viz., Guppy (p. 496) and Neumayr (p. 547)—maintain that these islands are the remnants of a great continent which united the Old World with the New. Lyell, on the other hand, arguing from the supposed great depth separating the Atlantic Islands from the Continent, does not consider it possible that they could have been connected with Europe (p. 411). However, as Dr. Blanford reminds us, in his interesting address to the Geological Society of London (p. 34): "The occurrence of volcanic islands does not prove that the area in which they occur is not a sunken continent." "If," he continues, "Africa south of the Atlas subsided 2000 fathoms, what would remain above water? So far as our present knowledge goes, the remaining islands would consist of four volcanic peaks—the Camaroons, Mount Kenia, Kilimanjaro, and Stanley's last discovery, Ruwenzori, together with an island, or more than one, containing part of the Abyssinian table-land, which, like the others, would be entirely composed of volcanic rocks."

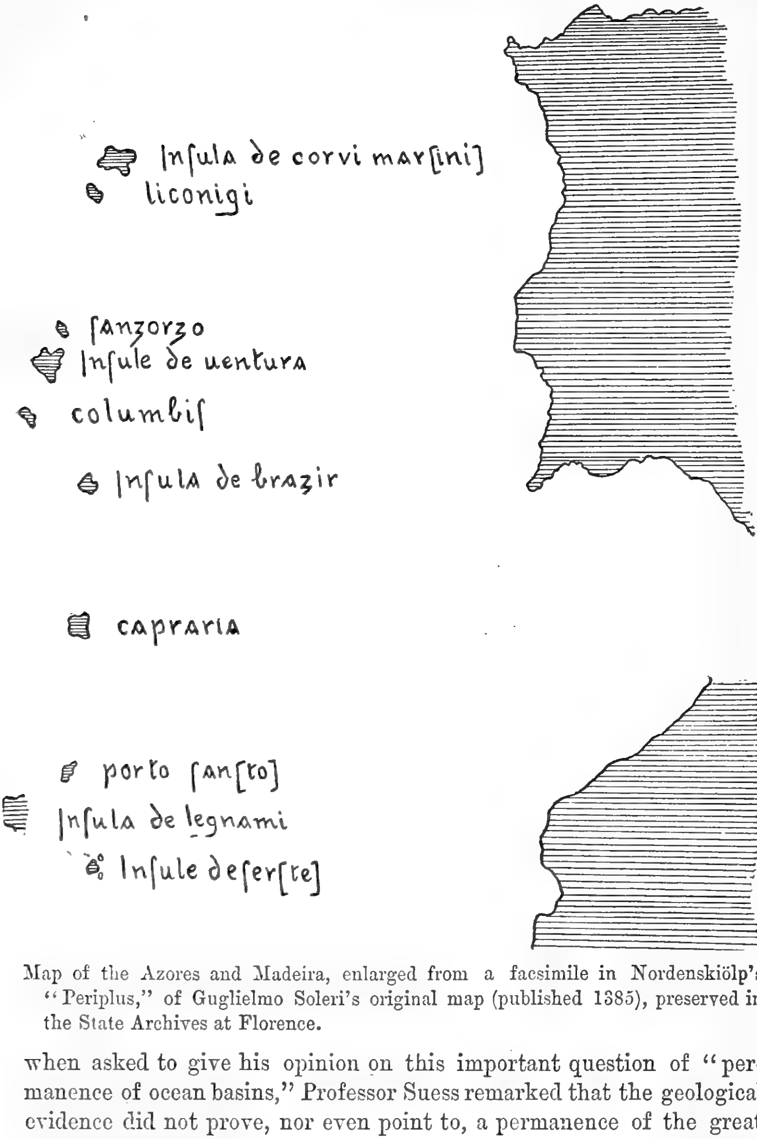
Dr. Wallace's second statement, that the Atlantic Islands were surrounded by great depths, is only partially correct. On the little map he published in 1900 (A, p 253), Dr. Wallace indicates a depth of 12,000 feet between Madeira and Europe, though it is now twenty-five years since Commander Gorringe, of the United States' Navy, discovered the Gettysburg Bank, and demonstrated the undoubted fact that there are shallow banks only a couple of hundred feet below the surface of the sea in that area. He also suggested that a submarine ridge probably connected the island of Madeira with the coast of Portugal (*cf.* J. J. Wild, p. 377).

The Azores seem to be separated by much greater depths from the Continent; and Dr. Wallace is so convinced of the permanence of the great ocean basins that he will not allow that any very great changes of level have taken place in former times. But that Dr. Wallace's views are not generally accepted may be gathered from the remark made by Dr. Blanford that "not only is there clear proof that some land-areas lying within continental limits have at a comparatively recent date been submerged over 1000 fathoms, whilst sea-bottoms now over



Contour-chart (after Wild), showing the submarine ridge between Madeira and Portugal. The data were furnished from the soundings obtained by the "Challenger," "Gazelle," and "Gettysburg."

1000 fathoms deep must have been land in part of the Tertiary Era; but there are a mass of facts, both geological and biological, in favour of land-connexion having formerly existed in certain cases across what are now broad and deep oceans" (p. 77). Moreover,



Map of the Azores and Madeira, enlarged from a facsimile in Nordenskiölp's "Periplus," of Guglielmo Soleri's original map (published 1385), preserved in the State Archives at Florence.

when asked to give his opinion on this important question of "permanence of ocean basins," Professor Suess remarked that the geological evidence did not prove, nor even point to, a permanence of the great depths—at least, in oceans of the Atlantic type—and that he believed some kind of a coast-line stretched across the present Atlantic ocean during part of Tertiary times (pp. 185–186).

It now remains for me to deal with Dr. Wallace's third statement—that the Atlantic Islands possess no indigenous land-mammalia. "It is true," he remarks, "that rabbits, weasels, rats, and mice, and a small lizard peculiar to Madeira and Teneriffe, are now found wild in the Azores; but there is good reason to believe that these have all been introduced by human agency" (A, p 248). Dr. Wallace does not inform us what are his grounds for believing in the artificial introduction of the species referred to. I can find no records of such introductions having taken place, and the results of my endeavours to trace the history of their origin on the islands point rather to some of them, at any rate, having reached the latter in the normal way, which is by a former land-connexion with Europe.

Take the rabbit, for example. We are naturally led to assume that this destructive rodent was brought over by the Portuguese when they first colonized the islands. But when the Azorean archipelago was discovered by a Flemish merchant sailing from Lisbon, in 1439, the most striking feature of the islands was the abundance of hawks, from which fact the name "Açores" (meaning hawks) was given to them. Now these hawks, which still frequent the islands, are really buzzards (*Buteo vulgaris*); and these birds usually live upon small mammals, such as mice, rats, and young rabbits. It seems probable, therefore, that such animals already inhabited the Azores when the Portuguese first set foot on the islands. But this supposition receives confirmation from a still earlier record of the history of the islands. Though uninhabited by man, the existence of the Azores had already been known to earlier navigators, and had since fallen into oblivion.

In a book (*libro del conocimiento*) published in 1345, by a Spanish mendicant friar, the Azores were already referred to, and the names of the individual islands given. In fact, the islands even make their appearance in an atlas issued about that time. The atlas is of unknown authorship, but was probably drawn by a Genoese. Towards the end of the same century in 1385, another atlas was published at Venice[1]—

[1] Mr. Lyster kindly drew my attention to the splendid series of reproductions of ancient maps in Nordenskiöld's "Periplus" contained in our National Library of Ireland. Though the position and size of the Azores in these old maps is incorrectly marked, there can be no doubt that the early Italian navigators had discovered them, and had roughly sketched their bearings as indicated.

that is to say, more than fifty years before the discovery of the Azores by the Portuguese—in which seven of the islands of the Azorean archipelago are indicated by name. Some of these names are of very particular zoological interest, as they are evidently derived from the names of animals which the early Genoese navigators discovered on the islands. They are as follows:—

Capraria = goat island (now San Miguel).
Columbis = pigeon island (now Pico).
Li Conigi = rabbit island (now Flores).
Corvi marini = island of sea-crows (now Corvo).

Drouet has already directed attention to the peculiarities of the goat of Saint Michael island with its antelope-like horns; while Godman states (p. 15) that the island of Pico, with its dense growth of evergreen brushwood, is the home of the wood-pigeon (*Columba palumbus*, L.). I do not know whether the rabbit still inhabits Flores, though it is known to occur in the uncultivated districts of St. Michael; but it seems evident that the name "*rabbit island*" was given by the early discoverers of the island, because these animals were abundant there. As regards the expression "corvi marini," the term may possibly refer to the great shearwater (*Puffinus major*), which, according to Godman, may be seen throughout the archipelago, and which formerly may have been particularly common on the island of Corvo.

The result of these historical inquiries seems therefore to justify the supposition that mammals, such as the wild goat and the rabbit, are truly indigenous species on the Azores, and that these islands have received their land fauna from Europe by a direct land-connection When we examine the general fauna of the Atlantic Islands more closely, the validity of such a supposition becomes more and more strengthened; and it must be apparent that their colonization cannot have been due to influences of atmospheric propulsion, even when assisted by hurricanes.

Even if the Azores possessed no indigenous Mammalia, their invertebrate fauna alone seems to me to favour the view that the islands had recently formed part of our Continent. Are not the Seychelles destitute of mammals? Yet even Dr. Wallace admits (B, p 243) that they cannot be classed among the oceanic islands. New-Caledonia has neither mammals nor amphibians; nevertheless its general fauna is such that it must have formed part of larger land-areas within Tertiary times (*cf.* Hedley's interesting observations on Placostylus).

After a few remarks on the geological aspects of the "Atlantis" problem, I propose, in the following pages, to deal shortly with the geographical distribution of the principal groups of vertebrates and invertebrates, in so far as it affects the questions of the existence of a former land-connection between the Old World and the Atlantic Islands, and of a land-bridge across the mid-Atlantic.

Geology of the Atlantic Islands.

Teneriffe, the principal island in the archipelago of the Canary Islands, has always been a centre of attraction for the naturalist, on account of the beauty of its scenery, and from the fact that it possesses a volcano rising to an elevation of 12,000 feet. Not only its Zoology and Botany have been carefully studied, but competent geologists have from time to time visited it, and have given us many valuable observations on the nature of the rocks found upon the island.

Being entirely covered by immense masses of recent lava, no fossiliferous deposits, if such do exist, have as yet been encountered, the only indication of the presence of older crystalline rocks having been obtained by blocks ejected from the Old Peak and other volcanic vents.

On the islands of Palma, Fuerteventura, and Gomera, an older mountain-chain, consisting of diabase—an eruptive rock generally found in older geological formations—has been shown to exist. Fritsch and Reiss are of opinion that rocks of a similar nature also form the foundation of the more recent volcanic deposits on Teneriffe (p. 315).

On Grand Canary and Palma, two islands belonging to the Canary group, an upheaval of from 600–1000 feet can be demonstrated; and in Madeira, one up to nearly 1400 feet, while it is surmised that there was probably a similar rise in Teneriffe.

The Azores and the Canaries, as well as Madeira, are believed by Fritsch and Reiss to be contemporaneous; and these authors maintain that, at the commencement of Middle Miocene times, a considerable part of the mountain masses of the islands must already have been formed (p. 220).

Madeira differs from Teneriffe in so far as volcanic activity has ceased for a considerable time past; so that even the most recent lavas exhibit signs of long erosion. Marine deposits occur here at a considerable elevation as well as on the Azores, and on the islands of Porto Santo and Gran Canaria; and geologists seem to agree as to these deposits having been laid down towards the middle of the Miocene Period.

Hartung, who specially studied the geology of Madeira, looked upon the whole Atlantic Islands as summits of submerged mountain-chains; while Neumayr (p. 547) and Guppy (p. 496), as I have already had occasion to mention, saw in them the remnants of a great continent.

Sir Charles Lyell maintained that Madeira originated in Upper Miocene times, and that it was separated from the Continent by a great depth. He did not consider it possible, therefore, that the two could have been ever connected (p. 411). However, I have already shown that Lyell's supposition was not borne out by later researches, and that Suess believed in some kind of coast-line having stretched right across the Atlantic during part of Tertiary times. Prof. de Lapparent expresses himself even more decisively on this subject. He favours the view of the existence of a coast-line, or at least that of an island-chain, during the Miocene Period, connecting the West Indies with southern Europe. The end of the Pliocene and the whole of the Pleistocene Period, he believes, were distinguished by a series of subsidences which resulted in finally opening up the northern depression of the Atlantic Ocean (p. 1392).

From a careful study of the structure and distribution of the geosynclines, Mr. Haug has recently come to the conclusion that the convex arch formed by the Antilles, and the one found along the western border of the Mediterranean, were connected, in the Tertiary Era, by tangential chains of land. According to his view, a coast-line stretched across the Atlantic from Venezuela to Marocco, and another between the Lesser Antilles and Portugal, the intervening space being covered by the sea (p. 635).

The hypothesis of a North Atlantic continent and of an Africano-Brazilian one, to some extent meets the views expressed by Murray on zoological grounds. As already mentioned, Dr. Gregory urged that the intimate affinity between the Miocene marine species of the West Indies and those of the Mediterranean Region could only be explained by the assumption of the existence of a shallow-water connection across the Central Atlantic in—at latest—Miocene times (p. 306).

Fauna of Atlantic Islands.

Mammals.

The historic reasons for the belief that the rabbit (*Oryctolagus cuniculus*) might be indigenous in some of the Atlantic Islands have already been alluded to. If we supposed these islands to be the last remnants of a former land-connection between Europe and America, the rabbit might be regarded as a relic form which reached us originally from the New World. That our European hares and the rabbit have come to us from America is suggested by Prof. Osborn (p. 58), though he does not indicate the route they are likely to have taken in their migrations.

I am not advocating a direct land-connection between southern Europe and America by way of the Atlantic Islands. I think there was only one land-bridge in southern latitudes, between the Old World and the New, which joined Africa and South America. This must have lain further south than the Atlantic Islands. But from North Africa, there was frequent intercourse with southern Europe—with which the Atlantic Islands, I believe, were connected; and South American species would then have been able to reach Madeira and the Azores indirectly.

To resume the discussion on the rabbit. The zoological position of the Leporidæ was recently subjected to a thorough and most careful revision by Dr. Forsyth Major, according to whom the rabbit belongs to a different group altogether from that of the European hares. He places it along with the South African *Lepus crassicaudatus* into the genus *Oryctolagus*, the two species being characterized by a very discontinuous distribution, which we are assured by Dr. Wallace is a sign of antiquity. The nearest relative of *Oryctolagus* is *Sylvilagus*, a genus containing five species which range from south-eastern North America southward to Paraguay. It does not seem unnatural, therefore, that America should have been selected by Prof. Osborn as the original home of the group. The first branch (*Capreolagus*) was probably sent off eastward to southern Europe and Asia. Of this, three species are known, two of which are now extinct, while a third still survives in India. This genus may subsequently have given rise to the allied form *Nesolagus Netscheri* of Sumatra.

We have therefore evidence of migrations, not only between Europe and America, but also between Africa and America.

It has already been urged by Mr. Lydekker that the hystricomorphous Rodents of the South American Region are so closely related to those of Africa that a connection between the two areas must have existed (p. 127); and another instance of a still more startling character was quite recently referred to in Prof. Howes' admirable address to the British Association at Belfast—viz., that a fossil mole had just been discovered in the celebrated Argentine deposits of South America which agreed with the golden mole (*Chrysochloris*) of South Africa (p. 7).

We must also remember the affinity of the West Indian Selenodons to the Tenrecs of Madagascar, in which island probably many of the older forms are still preserved which have become extinct on the neighbouring Continent. Thus the faunal approximation between Madagascar and South America is frequently more apparent than that between the latter and the continent of Africa.

The intimate affinity which existed in early Tertiary times between the mammalian fauna of Western Europe and that of the New World is especially marked among the Carnivores. The genus *Hyænodon*, for instance, which is confined to North America and Western Europe, lived in both continents from Eocene to Miocene times. *Stenogale*, one of the Mustelidæ, represented by five species in the Eocene and Miocene deposits of France and Germany, turns up again in the Miocene strata of North America. Among the Canidæ, *Galecynus* is found in the Miocene of North America and Switzerland; while *Thous*, which is still living in South America at present and has never been met with in North America, inhabited France in Pliocene times. Some Felidæ also exhibit a similar range. Thus *Eusmilus* occurs in the Miocene of France and North America; and the sabre-toothed tiger, *Machærodus*, which roamed over central and southern Europe from Eocene until Pliocene times, spread eastward into India, and also right across to North and South America (Smilodon).

Some of these cases, no doubt, can be accounted for by the supposition that the mammals migrated from or to Europe across Asia, where they may have found a land-connection joining that continent to America across Bering Strait; but others seem to me to have used a more direct route between our continent and the New World.

Messrs. Sclater recognize a distinct division of the marine area of the globe as consisting of the middle portion of the Atlantic which they call "*Mesatlantis*" (p. 208). Two genera of mammals are assigned as characteristic of this region—viz., *Monachus*, the Monk Seal, and the Sirenian *Manatus*. Now neither of these animals frequent the open ocean, being bound to the proximity of land. *Monachus albiventer* inhabits the Mediterranean, and the closely allied *M. tropicalis* the West Indies, separated by the enormous expanse of the Atlantic Ocean, where no Monachus is known to exist. Manatus is still more permanently attached to the coast. One species, *Manatus inunguis*, has even forsaken the sea, and now lives only in fresh water. Of the two other species, *Manatus senegalensis* inhabits the coasts and estuaries of West Africa, *M. americanus* being found along the South American coast and among the West Indian islands.

The range of these marine mammals appears to Messrs. Sclater to imply that their ancestors have spread along some coast-line which probably united the Old World and the New at no very distant period (p. 217).

Birds.

The birds of the Atlantic Islands, and the relationship of the birds of the Old World to those of the New, deserve a more careful study than I was able to extend to them. A list of the birds inhabiting the Azores is given in Godman's work already referred to; and he informs us that 91 per cent. are also found in Europe, *Pyrrhula murina* being peculiar to the islands.

Dr. A. König has paid special attention to the birds of the Canary Islands, and discovered in the island of Teneriffe an owl (*Glaucidium siju*) which had hitherto only been known from Cuba. He also noticed that the Teneriffe wren differs considerably from both the European species, and that it approaches more nearly the American *Regulus satrapa* (p. 8).

Doubts are thrown upon the correctness of the author's conclusions as to the existence of an American element in the Canarian avi-fauna by Dr. Hartert. He believes that the Canarian avi-fauna is exclusively composed of European and North African species. He also records the fact that the avi-fauna of the Eastern and Western groups of islands are strikingly different from one another as is the fauna of Madeira from that of the Canary Islands generally (p. 114).

South American affinities with Europe or Africa are perhaps less noticeable in birds than in any other group; though there are a few instances denoting that such exist.

Comparatively few fossil species of birds are known; but there is one which is of exceptional interest, as pointing to a former more intimate connection between Europe and South America—viz., *Trogon gallicus*, discovered in the Miocene deposits of France. The genus Trogon, including some of the most gorgeous birds known, is now entirely confined to Central and South America, where twenty-five species are still found living.

Reptiles.

Many of the existing species of Reptiles are very ancient. The distribution of the class, as a whole, elucidates therefore, in a striking manner, some obscure points in the ancient geographical condition of the part of the world with which we are dealing at present.

The reptilian fauna of the Atlantic Islands is almost altogether European in its character, and shows scarcely any trace of an American relationship.

The Lacertidæ, of which family a few species occur on the islands, are not found at all in America; and the only genus of the Scincidæ which inhabits the Atlantic Islands is also unrepresented in the New World. It is only among the Geckonidæ that we find a link across the ocean. Two species of *Tarentola* inhabit the Canary Islands; while an allied form has been met with in the West Indies. To judge from the general range of the genus, the migration has taken place from North Africa to America.

Among this same family of Geckonidæ, we meet with some interesting instances of discontinuous distribution: thus *Gymnodactylus mauriticanus* lives in northern Africa, while the closely allied *G. D' Orbignyi* inhabits Chili. Only a single species of *Phyllodactylus* occurs in Europe, the remainder of the genus being confined to South America, South Africa, Madagascar, Socotra, and Australia. *Hemidactylus*, another genus of the same family, seems to be an exceedingly ancient one, to judge from its distribution. One species inhabits the borders of the Mediterranean, while a closely related one is found not only in South America, but also in Madagascar and South Africa—viz., *H. mabouia*. The other species of the genus are distributed over the Cape Verde Islands, Socotra, St. Helena, South India, Mauritius, the islands of the western Pacific, West Africa, Ceylon, Persia, South America, and East Africa.

The Anguidæ, which are frequently limbless or only provided with rudimentary limbs, are almost entirely confined to America. The genus *Ophisaurus*, however, which has a species in Mexico, and another in eastern North America, is represented by one species in southern Europe, and by another in the Himalayan mountains.

Of much interest, from a geographical point of view, are the burrowing Amphisbaenidæ, which, generally limbless, often spend their entire existence underground in ants' nests. That such species are not likely to be conveyed across an ocean by accidental causes, in the manner described by Wallace and others, is evident. Now this large family of sixty-five species is quite confined to America, Africa, and the Mediterranean region. As very few species range into North America, while not a single one has been discovered in Asia, the hypothesis of a land-connection across the Atlantic explains the geographical distribution of this family better than any other theory. Take, for example, such a case as the genus *Anops*. There are two species, *A.*

Kingi being known from Southern Brazil, Uruguay, and Argentina, while the allied *A. africanus* is only met with in West Africa.

Among the snakes, we find similar cases of distribution. Thus the Boinæ are mostly South American, but one genus Eryx inhabits North Africa, Greece, and south-western Asia. The genus *Boa* is confined to Central and South America, with the exception of the two species *B. Dumerili*, and *B. madagascariensis*, which turn up far away in Madagascar. This curious relationship between Madagascar and South America, which occurs among many groups of animals, has already been alluded to.

There are naturalists who attribute such cases to "convergence," in order to obviate the difficulties of land-connections across deep oceans; but I cannot see how the two species of Boa, agreeing in every anatomical detail with the characters peculiar to the American genus, could have arisen independently in Madagascar. The Boidæ, too, must be looked upon as a comparatively ancient family; though the Ophidia, as a whole, are no doubt a relatively young branch of Reptiles, and, according to Dr. Gadow, essentially of Tertiary date (p. 586).

This theory of convergence, so much discussed at present, appears to me even less applicable to fresh-water than to land forms. Yet among the Pelomedusidæ, a family of fresh-water tortoises, a species of *Podocnemis* occurs in Madagascar; while several allied species of the same genus are commonly met with in South America.

Amphibians.

Whether *Rana esculenta*, the common edible frog of the Canary Islands and the Azores, is indigenous or not will probably never be known, as we cannot altogether rely on the reports of its supposed introduction. To the latter islands, it is said to have been brought in the beginning of the last century; while the introduction to the Canary Islands dates, according to Steindachner, from the sixteenth century.

Besides the common frog, the tree frog (*Hyla arborea*) inhabits most of the islands of the Canarian archipelago, and also Madeira and the Salvages.

The distribution of the genus *Hyla* is very instructive, as it is almost entirely confined to America and Australia. It is absent from the Ethiopian Region, and only represented by a few species in Europe and Asia. It has probably come to us from the East, spreading chiefly along the Mediterranean, where it has formed several distinct varieties. In the Canary Islands, I found it commonly at Laguna and even higher in the island of Teneriffe; and it has every appearance of being indigenous there.

No relationship between the amphibian fauna of the Atlantic Islands and America is traceable; but, among the European Bufonidæ, *Bufo calamita* is closely allied to *B. variegatus* of Chili.

As regards the connections between the New World and Africa, the family Dendrobatidæ is entirely confined to Madagascar and Tropical America; while the tongueless toads occur only on the continent of Africa and in Tropical America.

Fishes.

The River-eel (*Anguilla fluviatilis*) is the only species of fish which has been observed in the fresh-waters of the Atlantic Islands; so that no comparison of their fish-fauna with those of America or Europe is possible. A few facts however might be stated concerning the relationship of the American and African fish-faunas.

According to Dr. Günther (p. 232), two of the most natural families of fishes, the Chromides and Characinidæ, are peculiar and (with the exception of *Etrophes*) restricted to South America and Africa. The Dipnoi inhabiting the same two continents are also very nearly related to one another; and the Pimelodina, so characteristic of tropical America, have three representatives in Africa. Yet, though Dr. Günther believes in the former union of Africa and South America, he is of opinion that the separation is geologically of old standing.

Molluscs.

The land and fresh-water Molluscs of the Atlantic Islands have been studied by a number of careful observers, particularly by Lowe and Wollaston. The latter published a most valuable work entitled "Testacea atlantica," on the distribution of the Molluscs in the various islands, which, for a long time to come, will remain the standard treatise on the subject.

After dwelling on the marked individuality of the island fauna, he refers to the marvellous segregation of species in most of the archipelagos, an overwhelming proportion of them being confined to single islands, and not having colonized even their respective groups. He also draws attention to the fact that the Mediterranean element is much more traceable in the Canaries than in the other groups of islands. Altogether, he believes that the Atlantic Islands have originated from the breaking up of a land which was once more or less continuous, and which had been intercolonized along ridges and tracts (now lost between the ocean), thus bringing into comparatively intimate connection many of its parts; whilst others were separated by channels which served practically to keep them very decidedly asunder (B, p. 564).

It is of importance to note that a good many species of land-mollusca from the Tertiary deposits of western Europe have their nearest living relations on the Atlantic Islands. Thus the operculate genus *Craspedopoma* is quite peculiar to these islands at the present time; but, on the Continent, it first turns up in the Lower Eocene of the Paris basin, then again in the Oligocene of the Isle of Wight, and in the Lower Miocene of Hochheim, and finally disappears in the French Pliocene strata.

The peculiar Clausiliæ of the Atlantic Islands grouped in the sub-genus *Boettgeria* have many features in common with the Miocene group *Laminifera*, which has still a solitary living continental representative in the Pyrenees. Many other Atlantic Island Mollusca, especially among the Helicidæ, have their nearest representatives in the European Miocene.

One of the most remarkable species of animals in these islands is *Plutonia* (*Viquesnelia*) *atlantica*, a subterranean slug-like Mollusc, which, like Testacella, devours earthworms. It occurs on the islands of Fayal and San Miguel under sphagnum and liverworts, and is quite peculiar to the Azores. Professor Simroth, who first made known to us its anatomical structure, is of opinion that it has originated on these islands (B, p. 223). From a similarity of the slug fauna of southern Portugal, southern Spain, North Africa, and the Canaries, the same author concludes that there was probably a broad land-connection between these four countries, and that it must have persisted until comparatively recent times (B, p. 402).

The influence of Wallace's views are clearly traceable in Dr. Kobelt's earlier writings, in which he ridicules the idea of an Atlantis and of a former union between the Atlantic Islands and the Continent (A, p. 8). After having independently worked out the same problem more recently, however, he came to precisely the opposite conclusion. Comparing the European with the West Indian and Central American faunas, he points out that the land-shells on the two opposite sides of the Atlantic certainly imply an ancient connection having subsisted between the Old World and the New, which only became ruptured towards the close of the Miocene Epoch.

And he contended that the West Indian terrestrial molluscan fauna had been partly derived from the Miocene fauna of Europe (B, p. 147–148). He is now convinced that the Atlantic Islands must have been joined to the mainland in Miocene times (D, p. 53); though he does not comment upon the question whether the islands have had a continental connection since. He still leaves it to be explained how the strong Mediterranean element reached the islands. Dr. von Ihering solves this problem in a peremptory manner by saying that no malacologist nowadays could explain the presence of these continental Molluscs on the islands in any other way but by their progression on land (A, p. 51).

The molluscan fauna of the Atlantic Islands does not apparently lend any support to the theory that they formed part of an ancient land-bridge joining our Continent to the West Indies or North America. But a study of the Mediterranean fauna reveals a certain relationship with that of the West Indies in the genera *Glandina*, *Tudora*, and *Leonia*. This resemblance of the two faunas, however, becomes much more marked when we compare the extinct land Molluscs of Europe with those at present living on the other side of the Atlantic. A migration from our Continent across Asia and Bering Strait to America, in explanation of these facts, is inadmissible, as the species in question have never been found fossil in either of the last two continents. A direct land-connection between Europe and America must therefore have existed across the Atlantic in Miocene times, the Molluscs migrating from the former to the latter. Dr. Kobelt places this land-bridge much further north than the Atlantic Islands (B, p. 147). I should, on the contrary, be inclined to locate it to the south of these islands, as it seems evident that *Glandina*, *Tudora*, and *Leonia* have only spread from the West Indies into North America proper in comparatively recent times. The fact that these species, which have representatives in the West Indies, are more or less confined to the Mediterranean region in Europe, also points to a southern connection rather than a northern one; and it is quite possible that the migration took place along the northern coasts of the land, which is supposed to have united Africa and South America, and in favour of which Mr. Murray, Dr. Blanford, and Dr. von Ihering especially have brought forward many important distributional evidences.

Dr. von Ihering produces evidence of a strong resemblance between the Brazilian and the West African invertebrate coast fauna. He also draws attention to the fact that the fresh-water mussels of South

America are very closely related to those of Africa, while they differ enormously from the North-American ones. A similar resemblance in the fish-fauna of Africa and South America has already been alluded to; and the author concludes that there can be no other interpretation of these phenomena but that of a former land-connection between Brazil and Africa. He assumes this connection to have been mainly a Mesozoic one; though he admits that it may have persisted until Oligocene times (B, p. 135).

This large continental mass, which partly filled the southern Atlantic, must have covered vast areas of the ocean, including islands like St. Helena and Fernando de Noronha. These may therefore represent remnants of the Atlantic continent. Their fauna and flora would naturally be of extreme interest in throwing light upon this subject. But although the animals and plants of these islands have been investigated by competent naturalists, who have declared them to possess either African or South American affinities, Wallace's decided views in favour of the accidental transmission of species greatly influenced opinion regarding their origin. Even Wollaston expressed himself against the theory that St. Helena had ever formed part of a continent (B, p. 530). However, a large number of species inhabiting that island are peculiar to it; and Wallace himself recognizes that the insect fauna is suggestive of a very great antiquity (B, p. 300).

Mr. E. Smith—one of the more recent writers on the molluscan fauna of St. Helena—detects a greater resemblance to the South-American fauna than was suspected by either Forbes or Wollaston. All the same, arguing from the isolated position of the island and the depth of the surrounding ocean, he does not believe in its having been formerly joined to South America. Still more recently, Dr. Kobelt discusses the problem again from a study of the molluscan fauna of the island, and comes to the conclusion that St. Helena is a last relic of a Mesozoic continent (E, p. 202).

In the very interesting account of the fauna of "Fernando de Noronha" by Mr. Ridley, the writer does not enlarge upon the possibility of this group of little islands having formed part of a continent, though the occurrence of a subterranean amphisbæna (*A. Ridleyi*) and of a peculiar fresh-water snail (*Planorbis norhonensis*) might have suggested to him a different explanation of their origin than that of accidental importation. At any rate, Dr. von Ihering is confident that Fernando de Noronha has had an ancient land-communication with South America on the west, and with Africa on the east.

Insects.

The insects of the Atlantic Islands agree perfectly with all the other classes of animals, in so far as they exhibit mostly South-European or North-African affinities. Taking the various orders separately, the *Hymenoptera*—or at any rate that group of Hymenoptera to which the ants belong, have been fairly well investigated and are of particular interest from a distributional point of view.

A very minute ant (*Monomorium minutum carbonarium*) inhabits Madeira and also the West Indies and Central America; but there is a possibility of its having been introduced into the former locality by man. The genus, as a whole, has a very wide range in the Tropics. There is no other feature which might indicate a direct land-union between Madeira or the Azores and America; but Teneriffe is inhabited by an ant (*Leptothorax gracilicornis*) which is peculiar to it, and has some allied species in America, though most members of the genus are Palæarctic.

In the Mediterranean region, we find a minute ant in decaying wood (*Epitritus argiolus*). No other species of the genus has hitherto been detected in the Holarctic region; in the West Indies, however (Island of St. Thomas), another species has been met with (*E. emmæ*).

Special attention is directed by Dr. von Ihering to the family Dorylidæ, which are principally African, a few species penetrating into the Oriental and southern Palæarctic regions. A single genus (*Eciton*) of this family is altogether confined to South America; and being closely allied to the African genus *Anomma*, its distribution contributes additional evidence, according to von Ihering, in favour of the theory that these two continents have formerly been connected with one another (D, p. 418).

Our knowledge of the distribution of flies is still very incomplete. Dr. Dahl, who has collected them in the Azores, maintains that they are there thoroughly European in character (p. 333): and there is apparently nothing else which calls for special notice.

The lepidopterous fauna of the Atlantic Islands has been carefully studied by quite a number of competent observers. Rebel and Rogenhofer give us an excellent account of the species inhabiting the Canary Islands; and they inform us that the whole lepidopterous fauna of the archipelago has probably undergone profound modification, owing to the almost complete destruction of the native forests during the last few centuries. Still there are 183 species left. Of these, sixty-one occur also in Madeira. The Canaries possess 70 per cent. of their butterflies and moths in common with the Mediterranean region; while about 20 per cent. occur also in America. The authors, however, do not place any signification upon this high percentage of American forms, as only seven species belong exclusively to the Canarian district, all of which they look upon as having been imported in commerce. One of the most remarkable forms is the small moth *Setomorpha discipunctella*, which, though peculiar to the Canary Islands, belongs to a genus represented in America and Africa, and is closely allied to the South American genus *Lindera*.

There are many cases of distribution proving the existence of Africano-American relationship. The following may serve as familiar examples:—The nymphalid genus *Hypanartia* is confined to South America, Africa, and Madagascar. Amongst the Hesperidæ, there are three genera which are found in South America as well as in Africa—viz., *Oxynetra*, *Leucochitonea*, and *Pardaleodes*. A particularly suggestive case of distribution is that of the remarkable and most beautiful type *Urania*. Though this genus has now been separated into the two genera *Uranidia* and *Chrysicidia*, their close relationship is well seen by their general structure and brilliant colouration. The former inhabits Brazil, Central America, and the West Indies; the other, Madagascar and Zanzibar.

The Coleoptera, like the Lepidoptera, are a popular group of insects; and it need not be wondered at that the beetles of the Atlantic Islands have received a good deal of attention. Indeed, Dr. Wallace, in his paper on the beetles of Madeira, already quoted, bases his belief of the 'oceanic' nature of that island chiefly on the absence on it of certain coleopterous continental forms. The arguments which I brought forward in the introduction against those advanced by Dr. Wallace need not be repeated here.

Andrew Murray (C) was the first to advance the theory, from a study of the beetles, that West Africa and Brazil had been once united by land—namely, at a period subsequent to the appearance of the present forms of Coleoptera. The presence of the South-American genus *Lia* in Old Calabar, of *Goniotropis*, *Hypolithus*, *Galerita*, and *Alindria* in West Africa, seem to him to clearly indicate the existence of a former land-communication between the latter country and South America.

Since the time that Murray first announced these views, he found many other genera of beetles exhibiting a similar relationship. And he reiterated the same theories which he had expressed before in a later paper, reinforced by additional facts and arguments. At the same time, it may also be interesting to quote his opinion on the fauna of the Atlantic Islands. "How the European character," he says, "of this general fauna is to be accounted for, except on the supposition of a former connection of them all with Europe, and how the presence of these special forms of the same sub-fauna in all the islands and nowhere else, is to be accounted for except on the supposition that, after they were disunited from Europe, they were still united among themselves, it is for those who advocate the theory of dispersal by chance introductions to say" (A, p. 14).

Having made a careful study of the Coeloptera of the Atlantic Islands, Wollaston states that his own views are more in accordance with those propounded by Murray than with the theory of exceptional atmospheric dissemination so ably advocated by Dr. Wallace (A, p. 209). He aptly remarks (A, p. 210) that storms and hurricanes, so much relied upon by the latter for the aërial transmissal of European species to the Atlantic Islands, are not only rare in these latitudes, but blow almost invariably from the south; and that the apterous, rather unwieldy forms, so largely represented on those islands, are the least suitable for atmospheric propulsion.

In their European and North African character, the Neuroptera of the Atlantic Islands agree perfectly with the above-mentioned orders of insects. M'Lachlan says of the Madeiran species: "That some of the purely terrestrial forms may have been introduced from Europe is very possible; on the other hand, I see no reason to doubt that some of the European forms mentioned may be considered true natives of the islands also. It is worthy of remark that (with one possible exception) the whole of the species of Trichoptera are peculiar to the islands, although belonging to familiar European genera, and that they all inhabit running water in the larval stage."

The Hemiptera of the Atlantic Islands likewise follow the preceding orders in their general relationship; but a few cases of distribution are deserving of notice, in so far as they throw light on the question of a former Atlantic continent. The genus *Noualhieria* is confined to the Canary Islands, with two species. Its nearest allies, *Marmothania*, *Sisammes*, and *Erlacda*, occur in Algeria, Guatemala, and Chili, respectively. *Velia maderensis*, of Madeira, belongs to a genus confined to Africa, southern Europe, and South America. Brachysteles has two species in Madeira, two in Europe, and one in the West Indies. We can trace the relationship between European or Atlantic Island and American forms in many other cases; but the genera, as a rule, are widespread, and are found on other continents as well.

We do not expect to obtain much information from the distribution of the Orthoptera, as they are such an ancient order, *Progonoblattina* from the Carboniferous rocks of Switzerland being much like a modern cockroach, except for the difference in the neuration of the wings. The group containing the earwigs is now often separated from the Orthoptera, and placed into the distinct order Dermaptera. Some attention has been devoted to these orders in the Canary Islands by Krauss, who found that the affinity between the fauna of those islands and that of the Mediterranean region was a most characteristic feature. Of the sixty-four species referred to by the author, thirty-three are common to both districts; and fifteen species peculiar to the islands are allied to Mediterranean forms. He thinks that the relationship with the American fauna is not so distinctly traceable in these as in other insect orders. The two species of Orthoptera belonging to the cockroach section certainly have originated in the South-American region—perhaps also *Periplaneta americana*, *P. truncata*, and *Leucophæa surinamensis*. Among those having near relations in the Ethiopian and Neotropical regions might be mentioned two species of *Holocampsa*; while the origin of the locust *Orophila nubigena* in the Canary Islands cannot, according to Krauss, be at present determined (p. 164).

The range of some of the European species of Orthoptera is of special interest, though the *Forficulidæ*, owing to their enormously wide distribution, are of comparatively little use in helping us to unravel the history of former geographical revolutions. The species of *Chelidura* are, with us, mountain forms. Two are found on the Spanish mountains; two others high up in the Pyrenees; two on the Alps; one on the Italian mountains; and one in Central Europe. It is therefore remarkable, and particularly suggestive, that the two remaining species known to science inhabit lower altitudes—one of them Madeira, and the other Mexico. There are three other genera whose range will be of interest in connection with these inquiries—viz., *Turpelia*, *Isophya*, and *Odontura*. The former is confined to the West Indies, Mexico, Brazil, and Madagascar; while *Isophya*, of which a number of species are known from the Mediterranean region, reappears again on the opposite side of the Atlantic in Brazil. Finally, *Odontura*, a South European genus, is represented by a single species in Patagonia.

Spiders and their allies.

The Azorean spiders, remarks Mr. Simon, are mostly of European origin; there are a few examples, however, which appear worthy of note. *Theridion pulchellum*, common on the Azores and also on Madeira and the Canary Islands, is likewise known from southern Europe, North Africa, St. Helena, and South America. *Segestria florentina* occurs in the Azores, the Canaries, the Mediterranean region, and St. Helena; while *Dysdera crocata* has a similar range, except that it has not yet been discovered in the Canary Islands.

The distribution of the minute white Pedipalp *Kœnenia mirabilis* is most instructive. It lives under stones in southern Italy, Sicily, and Tunis, and reappears again on the other side of the Atlantic, in Chili and Texas.

There is an exceedingly peculiar Phalangid, *Cryptostemma*, evidently an ancient type, of which only a single species is known to science—viz., *C. Westermanni*, which has been taken on the shores of the Amazons in South America, and also on the banks of the Kribi river in West Africa.

Such instances need no comment. But it may be mentioned that, from a study of the distribution of the Scorpions and their allies, Mr. Pocock has come to the conclusion (p. 230), which I have again and again supported in the preceding pages, that a Tertiary land-connection must have existed between South America and Africa.

The Acarids of Central America and those of Central Europe appear to be closely related, according to Professor Stoll. In some instances even the same species are represented in the two countries (p. 19).

Centipedes and their allies.

The Myriopod fauna of the Azores, described by Latzel, also very closely resembles the European; and there is, as in other groups, a distinct indigenous element. Professor Stoll draws attention to an important case of distribution—viz., that of the genus *Polyxenus*, which includes very minute and delicate Millipedes living in secluded localities, and being characterised by a nocturnal *habitat* and lack of mobility. Three species are found in Europe and North Africa; while others occur in Guatemala, the West Indies, and the southern States of America. A single species has been discovered in Ceylon (p. 25).

Crustaceans.

The terrestrial Isopod Crustaceans, or "woodlice," are of much value in zoogeographical research, as many of them pass their existence entirely underground, and are therefore not liable to accidental dispersal. Some others, frequenting the crevices or bark of trees, may occasionally be swept into the sea on floating timber, and on rare occasions be stranded on a foreign shore. A few woodlice, no doubt, are introduced by man with plants and in packing-cases. They not only form the exception among woodlice, but they rarely spread far beyond human habitations, and are easily recognisable as intruders.

From the researches of Dollfus and Norman, who have given us valuable reports on the woodlice of the Azores and Madeira, we notice that they are mostly identical with those of Europe and North Africa, and that there is likewise an endemic element. Some characters in the fauna of these islands seem to support the view that they have not long ago formed part of the continent of Europe. *Philoxia Couchi*—a species which occurs on the shores of the Mediterranean under sea-weed, and extends along the Atlantic coasts of Europe as far north as the south of England—also inhabits the Azores and the Canaries. Among the rocky coasts of the Atlantic, we find another species, much more common than the last—viz., *Ligia oceanica*, which is replaced in the Mediterranean by *L. italica*; but the latter form turns up again on the coasts of the Canary Islands, the Azores, and Madeira.

In the Canary Islands, a species of the peculiar blind woodlouse, *Platyarthrus*, has been discovered, which inhabits the subterranean burrows of ants. One cannot conceive of any accidental means of transport to an island of such a creature, and the occurrence of *Platyarthrus Schöbli*—a Mediterranean form—in Teneriffe is a very convincing argument in favour of a land-conneetion with North Africa in late Tertiary times. Nineteen species of terrestrial Isopods are known from the Canary Islands, sixteen from the Azores, and twelve from Madeira.

There is little in the crustacean fauna of either Madeira or the Azores which might lead us to believe that they were once connected by land with America; but it is different with the Canary Islands, which probably formed part of a land stretching, as was suggested before, from North Africa to South America.

The genus *Platyarthrus*, including several small blind subterranean species, is represented by three species in Western Europe and North Africa, one of which, as we have seen, reached the Canary Islands. The only other species of the genus *P. Simoni* has been discovered in Venezuela, in South America.

Take again, *Porcellio*, an almost essentially European and North African genus. We find one species peculiar to Venezuela. Metoponorthus, evidently an ancient genus, is also mostly European; but one species has spread eastward to Sumatra, another is found in North

America, a third in Mexico, while still another has found means to reach Madagascar. Similarly, *Philoscia*, of which there are a number of European species, has two in North America, ten species in South America, one in Madagascar, one in Zanzibar, and another in Borneo.

There is, however, another group of Crustacea which yields such decisive indications of the former land-connection between Africa and South America that scarcely anything else is needed to put that theory on a firm basis. The group referred to is that of the fresh-water Decapods (cf. Ortmann, A), the species on both sides of the Atlantic showing a most remarkable affinity.

There are, in the first place, to be mentioned two species of *Atya*, *A. scabra*, occurring in Central America, the West Indies, and also on the Cape Verde Islands, off the west coast of Africa; while *A. gabonensis* inhabits the Orinoco river in South America, and the Gabun river in West Africa. Next we have two species of fresh-water Palæmon—viz., *P. jamaicensis* and *P. olfersi*, the former being known from South and Central America, southern California, and the West Indies, and also from Liberia, the Niger river, and the Congo, in West Africa. *Palæmon olfersi* has been recorded from the West Indies, from Brazil, and from the island of St. Thomas on the east coast of Africa.

Dr. Ortmann points out that the crustacean fauna of the East-American litoral region exhibits a very marked relationship to that of western Africa—such species as *Remipes cubensis*, *Calappa marmorata*, and *Callinectes diacanthus* occurring on both sides of the Atlantic. This fact appears to me to be suggestive of a former coast-line having existed across the Atlantic, along which these shallow-water forms migrated from one country to the other. Dr. Ortmann, however, is of opinion (B, p. 84) that the larvæ of these species had been able to cross the Atlantic by means of ocean currents.

Worms.

There is one more group of invertebrates to be considered, which is of importance in deciding questions of former geographical revolutions—viz., that of the earthworms. Land-planarians, no doubt, might be most useful in aiding us to unravel problems of zoogeography; but their distribution is as yet very little known, and their relationship has not been sufficiently studied for this purpose.

The ocean, according to Mr. Beddard, is an insuperable barrier to most of the earthworms, and more effective than any other. The latter are therefore, as that author remarks, exceptionally qualified for careful consideration in relation to the theories of past changes of land (p. 57).

As regards the earthworms of the Atlantic Islands, most of them are identical with European or North African forms. Whenever peculiar species occur,—such as *Helodrilus Möbii* of Madeira—they are closely allied to continental ones. The particular species mentioned has its nearest relation (*H. Molleri*) in Portugal. Several of the rarer forms,—such as *Dendrobæna madeirensis* of Madeira and *Bimastus Eiseni* of the Azores,—occur also on the part of the Continent nearest to them—viz., in Portugal.

As for any indications of an American relationship among the Atlantic Island earthworms, there are some species—such as *Pheretima californica* of Madeira and *P. barbadensis* of Teneriffe—which may be of American origin; but they probably owe their existence on the islands to artificial introduction.

The problem of the former land-connection between America and Africa also receives some support from the distribution of earthworms. The family Geoscolicidæ is almost entirely confined to South America and Africa; only a few species reach the Palæarctic and Oriental regions.

Among the genera which indicate the former union between the two continents might be mentioned *Gordiodrilus*—which is confined to the West Indies, the Gold Coast, and Zanzibar—and *Nematogenia*, which is only found at Lagos in West Africa, and at Panama in Central America (cf. Michaelsen).

Very little is, as yet, known of the leech-fauna of the Atlantic Islands, but our common European horse-leech (*Hæmopis sanguisuga*) has been met with in the Azores; while *Dina Blaisei*, a common Mediterranean species, occurs on several islands of the Azorean archipelago, and also on Madeira.

Conclusions.

The conclusions based upon this general survey of the fauna of the Atlantic Islands are of more value than if only a single group of animals had been taken into consideration. It will also be conceded that, from the facts and examples I have collected, we are entitled to form a very definite judgment on the subject, though my interpretation of these may not appeal to all.

The great importance of such data of distribution, as factors in solving problems of former geographical changes, is now generally recognized. Dr. Wallace was the first to appreciate the bearing of a study of zoogeography in the determination of past changes in the surface of the globe. "It is certainly a wonderful and unexpected fact," he says (C, p. 14), "that an accurate knowledge of the distribution of birds and insects should enable us to map out lands and continents which disappeared beneath the ocean long before the earliest traditions of the human race."

That certain species are occasionally liable to be accidentally carried away from their homes towards distant lands, has been noted and referred to by Lyell, by Darwin, by Wallace, and many others. Yet, owing to a variety of circumstances, and especially the great difficulty such species have in maintaining a foothold in their newly acquired quarters, such species do not persist as a rule in large numbers in any country. Altogether I am convinced that their influence in the permanent colonization of a country has been exaggerated. Actual observations of accidental introductions, moreover, have only been made in exceedingly few instances; while there are numerous records to show that such occasional intruders rarely become established. In order to find out whether animals could traverse oceans and thus populate islands, Darwin and others have attempted to determine experimentally how long certain snails could stand immersion in sea-water. For one of their experiments *Cyclostoma elegans* was taken, a snail provided with a lid or operculum which can be closed over the mouth of the shell. This provision of nature enabled the creature to withstand a fortnight's immersion in sea-water; and one would imagine such a species to be easily transported by sea to distant islands in that time. *Cyclostoma elegans* is common on the western border of France and England; but though dead shells of the species have been cast upon the shores of Ireland repeatedly, and probably living ones as well, it has never become established on this island. If a species so particularly favoured by nature to resist the deleterious influences of sea-water is unable to establish itself in a neighbouring island, what chances are there for less suitably endowed forms to cross the ocean?

But in studying zoogeographical problems such as the one I have endeavoured to solve, it is not at all necessary to base a theory on species which can be accidentally transported by hurricanes or marine currents. We can confine ourselves to those whose habitats preclude the possibility of occasional dispersal. As such I consider *Plutonia atlantica*—a slug-like creature living altogether underground in the Azores; the fresh-water crayfish, confined to South America and West Africa; the blind woodlouse Platyarthrus, inhabiting ants' nests in

Western Europe and Venezuela; the burrowing Amphisbaenidæ, whose range is restricted to America, Africa, and the Mediterranean Region; and many others alluded to in the preceding pages.

From the facts quoted, I conclude that Madeira and the Azores, up to Miocene times, were connected with Portugal; and that from Marocco to the Canary Islands, and from them to South America, stretched a vast land which extended southward certainly as far as St. Helena. This great Continent may have existed already in Secondary times, as Dr. Ihering suggested; and it probably began to subside in early Tertiary times. But I think its northern portions persisted until the Miocene Epoch, when the southern and northern Atlantic became joined, and the Azores and Madeira became isolated from Europe.

This, however, does not explain the whole history of the Atlantic Islands. To account for the extraordinary predominance of the Mediterranean element in their fauna, they must have again united with the Old World in more recent times. This took place, no doubt, in precisely a similar manner as before; and I believe they were still connected, in early Pleistocene times, with the continents of Europe and Africa, at a time when man had already made his appearance in western Europe, and was able to reach the islands by land.

APPENDIX.

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VII.

ABSTRACT OF A PHYSIOLOGICAL HYPOTHESIS TO EXPLAIN THE WINTER WHITENING OF MAMMALS AND BIRDS INHABITING SNOWY COUNTRIES, AND THE MORE STRIKING POINTS IN THE DISTRIBUTION OF WHITE IN VERTEBRATES GENERALLY.

BY CAPTAIN G. E. H. BARRETT-HAMILTON, B.A., F.Z.S., M.R.I.A.

Read MAY 11, 1903.

ALTHOUGH so much attention has been attracted to the subject of the winter whitening of mammals and birds, no theory has, so far as I know, been advanced to explain the physiological meaning of this phenomenon. On the other hand, Naturalists seem to be perfectly agreed as to the advantages in a protective sense which the animals of snowy countries derive from their seasonal change, it being regarded as one of the most perfect of known instances of adaptation to environment. I venture to believe that scientific investigations have now brought together facts sufficient to shed a glimmering of light upon the physiological or primary meaning of the white seasonal colour changes. I therefore put forward the following hypothesis, which is based upon an intimate connexion between fat and animal pigmentation.

I. *The connexion between Fat and Vertebrate Pigmentation.*

While I was in South Africa I was greatly surprised at the number of species of birds in which the fat is more or less deeply coloured, rich yellow, orange, or even reddish. I further found a correspondence, often quite remarkable, between the colour of such fat and the pigmentation of the feathers. Thus in birds in which yellow appears in the plumage the fat is usually of a correspondingly yellow or orange tint. Instances of this may be found in the Great-tailed Widow Bird, the Cape Long-Claw, the Masked Weaver Bird, and the Red and Taha Bishop Birds.

In other birds, although more rarely—to include some other than South African species—as the Chough, Stork, and Flamingo, the fat is red, in conjunction with a corresponding external colouration of the legs and bill. It has been shown that for the Flamingo intensity of the red colour is proportional to the amount of fat or oil present in the feathers.

Again, fat saturated with pigment may be found in birds whose feathers are deeply pigmented, yet whose colours are not necessarily red or yellow. Such are the Coot and Blackbird, the latter of which, as Dr. Gadow informs me, may be distinguished in this very particular from the closely allied but less darkly coloured Song-thrush. In the Sacred Ibis, a white bird with the bill, bare head and neck, and the legs of the deepest black, the fat is intensely red.

I further observed that the feather-tracts are amongst the parts of the body where fat especially tends to accumulate.

But deeply coloured fat is not confined to birds. It occurs also in mammals, as is well known in the case of domestic cattle. I found it also in wild forms, such as the South African Hedgehog and the Aard Wolf. It is present in abundance in reptiles, such as the African Monitor, and in the Lizard *Agama distanti*. In the Monitor and many other reptiles, in which the fat is deeply pigmented, there is a strong accumulation of black pigment in the body cavity. Lastly, the common Salmon is an instance of the same thing amongst fish.

In all these creatures fat is frequently deposited in the ovaries, testes, or other glands, which, as a result, are often yellow, sometimes black, and to a similar cause the yolks of the eggs of birds owe their colour. The yellow pigment of the yolks of fowl's eggs, called by Krukenberg coriosulferin, is said to be, like zoomelanin, a coloured fatty oil.

The yellow or red fat pigments belong to the same class, that of the lipochromes, as the reds and yellows of external pigmentation. They are also found in certain vegetable substances, such as maize. If an animal be fed on maize, the colour of its fat is greatly heightened. A third important pigment, but a little less intimately connected with fat, is black. The constituents of the two are very similar, zoomelanin being, according to Bogdanow, composed of carbon, hydrogen, nitrogen, and oxygen, as found in the black feathers of *Pica*, *Corvus*, and *Ciconia*.

When we regard mammals and birds, we find, with few exceptions, great uniformity of pigment-colours. Black, red, and yellow, with their inter-mixtures, are almost the only three pigmentary colours with which we have to deal. In the lower vertebrates the effect of white is due also to a pigment, guanin, a purely waste product of nitrogen. Almost all other vertebrate colours are structural. The basis of these structural colours is, however, always a strong deposit of pigment.

Finally, we have evidence of the direct part played by fat in animal colouration in the marked change which may be brought about in the plumage of birds, such as the Bullfinch, by the ingestion of a fatty food such as hempseed.

It has been pointed out to me[1] that the pigmentation of the skin which accompanies the peripheral distribution of fat in human pregnancy is a fact which supports my views. Again, in the morbid symptoms of Addison's disease abnormal pigmentation is remarkably associated with abundance of fat, especially distributed subcutaneously on the abdomen. Most striking of all, perhaps, is the removal of fat, and with it pigment, from certain organs of the breeding Salmon (muscles, intestines, and liver) for deposition in the ovaries and the skin. The result is that these organs become pigmented, to use Miss Newbiggin's expression, "as it were incidentally in the life-history of the individual under circumstances which render the question as to the inheritance of acquired characters absolutely unimportant."[2]

It seems, then, hardly possible to avoid connecting this pigmented fat of animals with their external colouration. The suggestion is not, I think, a new one.

II. *The connexion between Fat and Winter Whitening.*

Let us now apply these facts to the Arctic mammalia and birds, first briefly recapitulating the known phenomena of winter whitening. The phenomena are not nearly so isolated as seems to be generally believed. From the always pure white (or rather yellowish) Polar Bear and the Snowy Owl, through the seasonably white Polar and Alpine Hares and Ptarmigans, there are many intermediate degrees of winter whitening, until the commencement of the process is just visible in the numerous instances where northern animals wear a winter coat or plumage lighter than that of summer (Squirrels, Auks, Guillemots, &c.).

The manner of this change of colour has been deeply discussed, and has caused much disagreement. The Polar Hare, in particular,

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[1] By Dr. Gadow and Mr. Anderson, of Cambridge, who have been so kind as to read my paper.

[2] See Report of Fishery Board for Scotland for 1898.

has formed the subject of many contradictory assertions. Whatever may be true of other species, Mr. J. Barcroft could find no trace of an autumn moult in the case of a Scotch Variable Hare, kept at my request at Cambridge under constant observation in the Physiological Laboratory during the autumn of 1899, and which had turned almost completely white by January of 1900. In the very same winter a wild Variable Hare which lived close to this house turned from half to almost completely white within the space of a few days in late December. The first half of the change had been accomplished earlier in the season. It is, therefore, very hard to believe that the positive statements made in regard to the change of colour of *Lepus americanus* by moult alone can apply to the Variable Hares of Europe as regards the autumn change. The spring change, on the other hand, appears to be due in all cases which have been studied to a change of coat.

Summarised from a physiological aspect, it would appear that there are two conditions of the animal's body, in one of which white, in the other pigmented, hairs are produced.

That this is so cannot indeed be doubted in view of the experiments of Professor Halliburton and Drs. Brodie and Pickering.[1] These investigators have shown that the condition of the intravascular blood varies in animals which, like the Arctic Hare, are sometimes white, and at other times in a pigmented state. Further, that the composition of the blood of an animal which has undergone winter whitening is similar to that of a permanent albino. The presence or absence of pigment is then but the external evidence of changes occurring internally in an animal possessing a varying metabolism. So the white hairs of Arctic animals must be regarded as due to a cause similar to that which brings about absence of pigment in albinos, and, almost certainly also, in aged animals.

And, since it has been shown that Arctic animals possess a varying metabolism, it seems most reasonable to suppose that the vital changes reach their lowest point at the same season as in the human race, for which physicians accept a metabolism at its lowest in autumn. That is to say, metabolism is lowest just at about the very time of the change from brown to white (Dr. J. Netton Radcliffe in Quain's Medical Dictionary, p. 114).

It is at this very season that there comes the shock to the system of the onset of the cold of the Arctic winter, and, as is well known,

[1] Journal of Physiology, xvi., p. 135, 1894; xviii., p. 285, 1895; xx., pp. 310 to 315, 1896.

heat and cold exert very serious influences on animal organisms. In the human body, for instance, "continued exposure to such degrees of cold as is yet not incompatible with the maintenance of life, nevertheless keeps at low ebb activity of nutrition and function alike" (Dr. A. E. Durham in Quain's Medical Dictionary, p. 270). The action of the skin is sluggish, that of the kidneys more active. Under an increase of temperature, on the contrary, the exhalation of carbonic acid and of water is lessened; the urine diminishes in quantity and contains less urea and chlorides. But the skin acts much more freely, its secretion being increased by about 24 per cent.

One of the concomitants of a sluggish metabolism is diminished oxydisation and consequent storage of fat. For instance, fat is readily accumulated by castrated animals in contrast to those which are in full sexual activity. Many animals accumulate fat during one season of the year, and utilize it during the breeding season. In particular, this has been shown in considerable detail by Dr. Noel Paton and his colleagues of the Fishery Board for Scotland to be true of the Salmon, while the African Mud-Fish (*Protopterus*) is another well-known example.

I have already shown the connexion between fat and animal pigmentation. It seems then not an unreasonable suggestion that the temporary cessation of metabolism of fat and the absence of pigment are part of the same process. In the autumnal season the metabolism grows more and more sluggish, particularly in the periphery of the body, until there comes a time when a maximum of fat remains idle internally.

There is, as it were, to use a graphic expression, at one time a centrifugal, at another a centripetal, condition of fat. And, since the pigment accompanies the fat, any hairs or feathers which grow during the prevalence of the centripetal condition are white to an extent which is evident more or less according to the intensity of the physiological influences at work. Hence results a condition of things wherein exists great opportunity for the play of such diverse factors as heredity, individual temperament, and the influence of external conditions. This exactly corresponds to the observed facts, always so puzzling, often at first sight so contradictory.

But not only are new hairs white. Eventually there comes a time when, with a constantly lowering metabolism, not only is peripheral activity sluggish, but, as shown by Mr. Barcroft, material is actually recalled from the hairs, no doubt for the internal uses of the body. The working of this process has been observed by Professor

Metchnikoff,[1] who in the case of old men and dogs saw the phagocytes passing from the medullary to the cortical layers of whitening hairs. These phagocytes ingest the pigment granules, and remove them into the body—a process which, as Professor Metchnikoff believes, "can be classed under the general law of atrophy of solid parts of the organism." And that the organism is at this time economical of its resources, and unwilling to waste them peripherally, is probably indicated by the fact that the silkiness of the winter hairs of animals inhabiting cold countries indicates a fineness of texture, that is to say, less material is appropriated for their manufacture in proportion to their length than for the summer hairs. Since the animal organism has power to recall pigment from its hair, it matters not whether or no the physiological causes of winter whitening culminate at the time of a moult. Once the required condition prevails, new hairs will grow, and already existing hairs will rapidly become white.

As to the reverse process, the recolouration of the coat, years of study have failed to supply me with an instance of its occurrence without a moult: so that the conclusion seems hardly avoidable that the hairs, once whitened, are dead to further changes of colour. Thus is explained the curious fact that in the mild climate of the district where I write, such winter whitening as occurs in the Hares (and it is sometimes considerable in extent) remains in force, no matter what the weather may be, until the spring moult. As this moult does not take place until the spring has well advanced, those Hares which have undergone the most complete winter change are for some little time incongruously conspicuous in the flowery meadows of the south of Ireland, while the April and May sunshine lights up their Arctic livery. At the time of the spring moult, the physiological causes which led to the whitening of the previous autumn having now passed away, vital change being now at its high-water mark, and fat, and with it pigment, available for constructive purposes throughout the body, the new coat (or, in the case of birds, the plumage) comes up of the pigmented summer tint.

But it is not fair to regard as typical of its kind the cycle of winter whitening as observed in England or Ireland. Here at the southern limit of the conditions which have called it into existence, the process is complicated by numbers of contradictory factors, the resultant of which is a considerable modification and obscuring of the typical phenomena. In the Arctic regions these are nearly uniform.

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[1] Proc. Roy. Soc., London, vol. lxix., p. 156, 1901.

We have then in winter whitening an instance of peripheral atrophy of the hair or feathers—an atrophy which manifests itself more or less in all the members of the Fauna of cold countries, and which may be partial or complete, seasonal or permanent.

Not the least remarkable feature of this atrophy of winter whitening is the fact that the order of the parts affected by it is to all intents and purposes the same in all mammals, even in those so widely separated as the Stoat and Hare. Excluding, for purposes of this paper, the head, the change begins from the base of the tail at the posterior margin of the back, and on the flanks, just where the dorsal colour meets the white of the underside. It then creeps up the back. In many animals, as in British specimens of the Common Hare (*Lepus europæus* Pallas), which frequently whitens to a slight extent, it rarely climbs higher than the rump. In spring the moult, and with it the brown colour, progresses in exactly the opposite order, creeping down the back, and extending to the sides until it reaches the permanent barrier of the white belly. It is, in fact, as if the internal physiological condition represented by the white belly annually overpowers more than its ordinary share of the animal in autumn, and in its ascent reaches a height dependent upon its energy, to remain in possession until driven out in spring by the way it came.

I look upon this fact as a confirmation of my hypothesis that winter whitening is connected with the fat of the body and its distribution. For it seems more than a mere coincidence that the upward march of this winter whitening and the order of the parts affected by it is almost exactly indicative of the order in which fat is accumulated internally in an ox, sheep, or fowl—an order which is probably applicable to other mammals and birds also. In oxen, sheep, and fowls, as in man and most vertebrates, the favourite region for fat storage is the belly, where, besides being deposited on the deeper organs, such as the kidneys, it forms a layer known as the *panniculus adiposus,* lying near the surface, between the skin and the abdominal walls. Next in order, as regards the accumulation of fat, comes the rump, and thirdly, portions of the neck region and of the back and ribs.

And since we know that the presence of fat is indicative of deficient oxydation, it is not altogether surprising to find external atrophy its accompaniment.

For the success of my theory two crucial tests have been suggested, either of which might be performed by experiment. If my supposition be true, there should (it has been thought) be more fat in hair in summer than in winter; and, further, the fat of an animal should be more deeply coloured in winter than in summer. It is obvious that these experimental proofs of my theory cannot be performed all at once. But I do not care to delay publication until I can myself institute the necessary investigations, since some other worker may possibly be in a position to do so. As regards the second point, I am not at all sure that it is actually necessary that the winter fat be more deeply pigmented than that of the summer. The point is rather that there should be more unoxygenated fat peripherally at the time of the autumn than of the spring change; and that this is so I can myself answer in the affirmative. It is full of significance, also, that the muscle of the breeding Salmon becomes pale on transference of the fat and pigment to the genitalia or for combustion as a source of energy.

III. *The meaning of white in Domestic Animals and Vertebrates generally.*

If my conclusions be accepted, it seems that we may be hovering somewhere near the explanation of the primary or physiological meaning of many puzzles of animal colouration. The widespread existence of white undersides in vertebrates—a fact only as yet explained on purely secondary grounds (as by the ingenious suggestion of Mr. Abott H. Thayer)—is now seen to have a direct connexion with the main peripheral fat-tract of the body. The white rumps of birds and mammals, the familiar "recognition marks" of Mr. Alfred Russel Wallace, correspond to one of the next most important fat-tracts, light neck- and ring-marks to yet another.

I am inclined to push my theory even further, since I see in it the explanation, often vainly sought for, of the marked extent to which the white colour makes its appearance in domestic animals. Since nearly all these animals derive their commercial value from their power of accumulating fat, it is natural that, if my suppositions be true, the pigmentation of the hair (or feathers) should be affected. I am aware that in many breeds the appearance of the white patches is believed to be quite irregular, and not to follow any definite order of frequency as regards the regions affected. I feel sure, however, that further investigations will show that this is not really the case. Thus my own studies, unfortunately as yet incomplete, indicate that even in such, at first sight, irregularly-marked animals as cattle, the markings, although undoubtedly subject to very great latitude, tend to arrange themselves in accordance with one or two definite patterns. The latitude is no doubt due to the fact that, although following the general order described above, the *panniculus adiposus* of domestic animals is almost universally distributed over the body, and varies only with each animal's individual idiosyncrasy of constitution. It is noticeable, moreover, that the Hereford breed of cattle, in which the arrangement of the fat differs from that of other breeds, it being mainly distributed peripherally, is distinguished by regularity of pattern, having the principal peripheral fat-tracts clearly mapped out in white.

The accumulation of fat in a fattening ox is, however, marked, not by loss of pigment, but of the hair, the skin becoming bare, particularly on the rump and neck, as the animal ripens. This, then, is only another aspect of the atrophy which may accompany deposits of fat under the skin. Here again I find more than a mere coincidence in the fact that the bare buttocks of monkeys correspond to the light rump-patches of many other vertebrates; further, that the accumulation of subcutaneous fat in marine mammals is correlated with deficiency of hair, in a graduating series, from the amphibian warmly furred Fur-seals to the completely aquatic hairless Cetacea and Sirenia.

A great difficulty for some time lay in the way of my theory, namely, the occasional reversal of the ordinary arrangement of vertebrate colouration, whereby the ventral is usually the lighter, the dorsal the darker surface. For instance, in the Skunks, Polecats, and the Eider Duck, the upper surface is conspicuously lighter than the under. These facts were not at all explained by Mr. Thayer's hypothesis, and each case is usually argued on its own merits, the Skunk's white back being regarded as a warning of its bearer's malodorous nature, the Eider Duck's as protective to the sitting-bird, and so on; they certainly proved a stumbling-block to me. I hardly felt bold enough to predict that the unusual arrangement would be found to correspond with a like internal disposition of the *panniculus adiposus*; and no other supposition, unless, as it were, some *deus ex machina*, in the shape of an ingenious secondary explanation, seemed likely to be able to pull me round the difficulty.

A second difficulty lay in the fact that the heads of vertebrates are very frequently the centre of conspicuous light marks or bars, which, while not apparently related to any internal fat-tracts, are yet so similar in many widely-distinct forms (such as mammals and birds) as to be without doubt due to some similar cause in all.

Most fortunately both these difficulties were simultaneously and, as I think, most remarkably, removed by the accidental trapping of a Badger. In this animal, as is well known, although the case is not nearly so conspicuous as are many others, the deepest tints occur on the under side. In the particular specimen (a male) the upper surface of the body, with the whole tail, and the inguinal region, was contrasted by its light colouration with the remaining portions of the under side. On examining the carcase, I found that the lightest external parts, viz., the rump, tail, and inguinal region, lay over the thickest accumulation of fat. A thinner layer of fat extended over the whole back, whereas the upper belly and breast were almost free from fat. Thus external colouration was here directly correlated with the distribution of the *panniculus adiposus*. In view of this fact, it seems probable that certain of the colour-differences which help to distinguish some of the foreign species of Badgers from our own are due to further developments of the *panniculus adiposus*, for they frequently follow the line which would be taken by winter whitening on a Hare or that in which fat is deposited on an ox. That is to say, when a Badger differs from our own species in regard to the lightness of its upper surface, we may almost predict that the lightest part will be the rump, while in another species the white will have undergone further extension up the back. Thus a series of skins of the various species of Badgers may be almost made to match (in regard to the whiteness of the upper side), one consisting of the skins of Hares in process of whitening.

The second difficulty was upset in a most unexpected manner when I came to examine the animal's head. There I found that the three white bands lay over three regions of the skull where no flesh intervenes between the bone and the skin: the three white external bands were, in fact, clearly marked out by three similar cranial bands of ligament and bone. Here, then, was the most unexpected fact that not only may deficiency of pigment be associated with the presence of underlying subcutaneous fat, but also with that of bone or ligament. So that we may almost lay down the law that there is a tendency to pigmentary aberrations at those parts of the body where nutrition of the skin is interfered with by contact with underlying fat, bone, or ligament, or better, that adjoining regions of uneven nutrition tend to originate unevenness of external pigmentation—a result which Mr. Alfred Tylor missed by very little in 1886.[1]

It is obvious that this conclusion, if further borne out, may exercise

[1] "Colouration in Animals and Plants;" London, 1886.

a profound influence upon current views of animal colouration. For instance, it at once dawned upon me that therein lies the explanation of the white "blaze" of so many domestic animals, and in particular of horses. This is usually situated over the frontal or nasal bones where they lie directly under the skin. Again, the fact that in man baldness occurs first in corresponding regions is almost certainly but another instance of the working of the same law.

Although thus pushing my theory to lengths which have, I believe, been untouched by any other view, I must be the first to point out its own restrictions. I have at present, at all events (although I confess I begin to see light here also), no desire to connect it with such complicated colour schemes as the spots of the Leopard or the stripes of the Tiger and Zebra. It is further evident that puzzles like the curious arrangement of the white areas on the tails of birds, or the restriction of pigment to the upper side of a flat-fish, are phenomena which, although probably connected in their origin with subcutaneous fat, seem to require some further factor for their full explanation.

In birds, for instance, without entering into detailed descriptions of what is perfectly well known to naturalists, the light patterns on the rectrices are frequently the sum of a series of complicated markings, different as to each individual feather, but fitting into their place like the pieces of a mosaic. Now, although the deficiency of pigment in this case is, on my showing, certainly connected in a general manner with the fat-tract of the region whence these feathers spring, it is hard to see how all the complicated details of the pattern can be thereby explained. But in view of Dr. Finsen's discoveries, it does not seem too great a stretch of imagination to suppose that the exact distribution of the pigment may be not unaffected by the varying amount of light to which the different parts of the feathers are subjected, or again that the pigmentary differences between the two surfaces of a flat-fish may have in a like manner been due, although exactly how we do not understand, to unequal stimulations of the light which they receive.

Thus, then, I have no wish to extend my arguments universally to white colouration in nature, since there may undoubtedly be causes other than atrophy which result in absence of pigment. It is obvious also that many animals are not subject to the hair-atrophy which in others follows the peripheral accumulation of fat. On the other hand, it may well behove Zoologists to consider not only the external advantages accruing from but the deep-seated physiological processes involved in seasonal colour changes. Even those connected with sex may but represent the external symptoms of a varying metabolism. They may be, as I have elsewhere suggested, primarily but the symptoms of a pathological or quasi-pathological condition, the importance of which to the organism must quite overshadow any external applications for ornament or protection.

In conclusion, I submit that my hypothesis, although it may not explain the minutiæ of each individual case, throws a distinct light on the phenomena of winter whitening, and through it of animal colouration as a whole. It also illustrates the possibility in nature that characters having a definite physiological or primary meaning may be found useful for some quite secondary external purpose.

VIII.

AN ADDITION TO THE LIST OF BRITISH BOREAL[1] MAMMALS.

By CAPTAIN G. E. H. BARRETT-HAMILTON, B.A., F.Z.S., M.R.I.A.

Read May 11, 1903.

In the present Paper I wish to describe a remarkable Bank Vole or Red-backed Mouse (*Evotomys*) inhabiting the small island of Skomer, off the coast of Pembrokeshire, Wales.

Skomer Island[2] is said to owe its Danish name, which, according to some writers, signifies "the rocky," to its rough character. It is the haunt of immense numbers of Puffins, *Fratercula arctica*, and of Manx Shearwaters, *Puffinus anglorum*. It has an area of about 700 acres, and, forming the southern horn of the crescent of St. Bride's Bay, is parted from the mainland by a narrow sound some two miles wide. There is but one house upon the island; in connexion with this there are about 250 acres of cultivation. The island is without bush or tree, and is said to be very wind-swept.

I first heard rumours of the existence of a peculiar Vole on Skomer Island in or about the year 1898. In October of that year Mr. H. W. Marsden, of Clifton, was so kind as to send me a pair. They had been caught by Dr. Y. H. Mills, of Haverford-West. Dr. Mills has since obtained for me several excellent specimens, so that I now possess a dozen in all.

I believe, however, that Mr. R. Drane, of Cardiff, deserves the credit of having been the first to collect and recognise the interesting character of the Skomer Voles. Mr. Drane sent specimens for exhibition to the Linnean Society of London, but they were regarded by the members present as "the Common Bank Vole, *Microtus glareolus*."[3] Mr. Drane's own opinion, however, as expressed to me in a letter, is both different and decided. He wrote: "They are, I contend, a local

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[1] These details are taken mainly from the Rev. Murray A. Mathew's "The Birds of Pembrokeshire and its Islands," 1894, pp. xxx to xxxi.

[2] Proc. Linn. Soc. Lond., June, 1899, p. 63.

[3] I use the term throughout in the sense given to it in the works of American writers on geographical distribution.

variety of this Vole (i.e. *Evotomys glareolus*). They certainly are not either of the other two British Voles; they are the common Bank Vole, a local variety of it or a new species to this country."

Mr. Drane "always took these Voles about farm buildings or within them, where one would not expect to find Voles." When traps were set a few hundred yards away, he never took the Voles but only Wood Mice, *Mus sylvaticus*.

The predilection of the Skomer Voles for the neighbourhood of houses is corroborated by Dr. Mills, who wrote that he usually caught them in the heaps of turnips stored up for winter, and that the turnips are their food.

The following is a description of the "Skomer Vole," which I propose to name

Evotomys skomerensis, sp. nov.[1]:—

General Characters.—Size large; skull of adults, about 25 mm. in greatest length; total length, averaging about 165 mm.; hindfoot, averaging 18 mm.; ratio of tail vertebræ to total length, 33; skulls strong, (for *Evotomys*) angular and ridged for muscular attachment; the zygomata rather heavy. Colour deep and moderately bright. *Skull* of the same type as that of *E. nageri* (I have no skulls of either *E. norvegicus* or *E. vasconiae* for comparison) with which it agrees in size, angular appearance, and general massiveness, but is, on the average, slightly smaller.

The skull of an adult male presents the following dimensions (in mm.):—Greatest length, 25; basilar length, 22·5; palatal length, 12; length of palatal foramina, 4·5; zygomatic breadth, 14; breadth of brain-case above zygomata, 11·75; length of molar series (both upper and lower), 6; length of nasals along middle line, 8.

Colour.—Above between bright "cinnamon-rufous" and "madder-brown,"[2] the general appearance being due to the subterminal bands of the hairs, about 2 mm. in breadth. The hidden (and major) portions of these hairs are "slate-black" and the tips black. Face, sides of head, and flanks becoming gradually deficient in rufous, and running through light "hazel" or "vinaceous-cinnamon" to a dull greyish-buff. Rump and upper side of the sharply bi-coloured tail, "mummy-brown." Under side of body and tail, with the legs and feet, white (the hidden portion of the hairs again near "slate-black"),

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[1] I thus accord this form full specific rank in order to secure uniformity with Mr. Miller's treatment. (See footnote No. 2, p. 318.)

[2] Names of colours in inverted commas are taken from Mr. Robert Ridgeway's "Nomenclature of Colours," 1886.

usually with a very perceptible yellowish wash. The line of demarcation between the colours of the upper and under surfaces moderately defined. Ears nearly naked externally; internally covered with light "cinnamon-rufous" hairs.

The rump of the only winter specimen before me shows a much larger area of brown than is present in any of the other specimens (all taken in April and May). This may be an indication of a seasonal change.

TYPE OF SPECIES.—A male, registered No. 3. 7. 4. 3. of British Museum Collection, presented by Dr. Y. H. Mills, Skomer Island, April 7th, 1900.

DIMENSIONS IN MILLIMETRES.

	Head and body.	Tail.	Hindfoot.	Ear.
Maximum of 7 males and 5 females,	114	61	19	15
Mean ,, ,, about	110	55·5	18	13·5
Minimum, ...	105	50	17	12

No accurate naturalist could possibly confound the Skomer Vole with the ordinary Bank Vole of Great Britain. The greyish sides, brown rump, far larger size, general proportions, and cranial characters of *E. skomerensis* are such as to mark it as belonging to quite a distinct division of the genus from that containing *E. glareolus britannicus*, Miller, the ordinary British Bank Vole. The following dimensions of a number of the latter form will illustrate my meaning:—

		Head and body.	Tail.	Hindfoot.	Ear.	Greatest length of skull.	Greatest breadth of skull at zygomata.
MALES.	No. of specimens,	29	36	36	11	27	21
		mm.	mm.	mm.	mm.	mm.	mm.
	Maximum, .	104	55	18	12	25	14
	Mean, . .	93	43	16·25	11	23·5	12·75
FEMALES.	No. of specimens,	38	38	36	12	33	25
		mm.	mm.	mm.	mm.	mm.	mm.
	Maximum, .	117	51	18	13	24·75	13.5
	Mean, . .	91·5	42	16·5	11·5	23·25	12·25

The Skomer Voles thus exceed those of Great Britain generally by an average of 18 mm. on the body length, so that they are nearly a quarter as large again, and these proportions are borne out in the average dimensions of the tail, hindfoot, ear, and skull. There is, besides, a difference in the proportionate lengths of the tail vertebrae to the total length of the two forms, that of the ordinary British being about as 31·50, that of the Skomer Voles as 33 per cent. of the total length.

I was much surprised to find that the Skomer Vole is clearly allied to the forms inhabiting Boreal Europe. It is quite closely related to *Evotomys norvegicus* Miller, of Norway, *E. nageri* (Schinz) of the Alps, and *E. vasconiæ* Miller of the Pyrenees.

In a recent paper Mr. Gerrit S. Miller, junior,[1] has, excluding the Arctic *E. rutilus* (Pallas) and the very distinct[2] *E. rufocanus* (Sundevall) of Northern Europe, divided the Bank Voles of Continental Europe into two sets. One of these, consisting of the three species mentioned in the last paragraph, is characteristic of the mountains, and corresponds in its distribution with the Variable Hares. The other includes a number of smaller lowland forms, amongst which is the British, the *E. hercynicus*[3] *britannicus* of Miller.

The Skomer Vole constitutes a fourth member of the Boreal group, which, like its allies, is totally distinct from the Voles of the surrounding country. I regret that I have very few specimens of the other Boreal forms wherewith to compare it. It is, however, less grey than *E. nageri*, of which Mr. Oldfield Thomas has shown me several specimens obtained by himself near Locarno in Italian Switzerland, while it appears to have a shorter tail than *E. norvegicus.* Further, on comparison with the dimensions given in Mr. Miller's tables, it seems to be the smallest Boreal form yet described.

I do not propose to attempt an explanation of the occurrence of this colony of Voles almost indistinguishable from those of Boreal Europe, nor why they appear to be confined to a small, wind-swept island. It is, for the present, sufficient to place the facts on record, noting, however, that the Skomer Vole is in no sense of the word a stunted representative of its genus such as might reasonably be

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[1] "Preliminary Revision of the European Red-backed Mice." Proceedings of the Washington Academy of Science, vol. xi., pp. 83 to 109, July 26, 1900.

[2] A form which Mr. Miller has, I think, somewhat unnecessarily raised to subgeneric rank.

[3] I do not, however, accept the validity of Mr. Miller's arguments for the abolition of the well-known term *glareolus* and the substitution for it of *hercynicus*.

considered to have definite relations to the peculiarly cramped local conditions of a small island. On the contrary, the Skomer Vole is remarkably robust, and apparently only slightly less so than the corresponding types of Boreal Europe. In its robustness it affords a parallel to the long-tailed Field Mice of St. Kilda and of Lewis (*Mus sylaticus hirtensis mihi* and *M. hebridensis*, de Winton), and the House Mouse (*M. muralis mihi*) of the former island.

It cannot, however, be without meaning or importance that we have here on this small, treeless, wind-swept islet, almost facing the home of *Lepus timidus hibernicus*, an animal which belongs to the same type of Fauna as that Boreal mammal. It may be that we may yet find amongst the Welsh mountains further colonies of these Boreal Voles, and the possibility should at least be a stimulus to British Field Naturalists in their collecting expeditions. Meanwhile we may note the parallel between the occurrence of a Boreal Vole at sea-level on Skomer Island and the similar downward extension of the range of the Variable Hare in Ireland, accompanied as it is in the West by the frequent descent to the plains of certain Alpine plants.

IX.

ON THE RELATIONSHIPS BETWEEN THE CLASSES OF THE ARTHROPODA.

By GEORGE H. CARPENTER, B.Sc. Lond., M.R.I.A.,
of the Science and Art Museum, Dublin.

[Plate VI.]

Read May 11, 1903.

Introduction.

Few zoological problems have given rise to wider differences of opinion than that of the relationships that may exist between the various classes of animals included under the term "Arthropoda." For many years, the existence of some rather close affinity between Insects, Centipedes, Millipedes, Arachnids, and Crustaceans was undisputed. Linnè, in 1758, included all these groups in his "Class Insecta"; and the name "Arthropoda," bestowed upon the assemblage by Von Siebold in 1848, was intended to mark them off as a grand primary division of the Animal Kingdom. When the evolutionary doctrine spread, and naturalists began to go ancestor-hunting, there was no hesitation in deriving all the Linnean "Insecta" from a common stock. The development of so many and diverse Crustacea from a Nauplius larva was believed by Müller ('69) to indicate the descent of the whole Crustacean class from Nauplius-like ancestors; and through some primitive Phyllopod, the Arachnida were traced back to the same parent-stem. The six-legged larva of certain Millipedes led to the conclusion that both Insects and "Myriapods" had originated from a Thysanuriform stock, which had been derived, according to Haeckel ('76) and others, from a primitive zoaea-like Crustacean.

During recent years these phylogenetic speculations have been discredited by many zoologists. If too much weight was formerly allowed to larval stages in the discussion of ancestral forms, the tendency at present is to regard such stages as of hardly any importance at all. Then comparisons have constantly been made between Arthropodean and Annelidan organs—between appendages and parapodia, coxal glands and nephridia, tracheal tubes and dermal glands, so that many zoologists think it more instructive to compare various Arthropods with Annelids than with each other. And the demonstration of the Arthropodous affinities of the Peripatidæ has led many students to look upon those worm-like creatures as indicating the probable ancestors of Millipedes, Centipedes, and Insects, and to believe in the derivation of those classes from an Annelidan stock quite independently of the Crustacea. Thus the opinion seems to have been slowly gaining ground that the Arthropoda can no longer be considered as a natural group of the Animal Kingdom (Hutton, &c., '97).

The most extreme view of the multiple origin of the Arthropoda is that put forward by Bernard ('96), who would derive each of the great classes independently from an Annelid ancestry. Most recent writers, however, consider that the present-day Arthropods have developed along two main lines of descent. Kingsley ('94), for example, recognising, with Lankester ('81), the Arachnidan affinities of Limulus, refers the Crustacea and Arachnida to one great group, the Insects, Centipedes, and Millipedes to another. But other zoologists consider the manner of breathing to be the all-important character in deciding the affinities of the Arthropod classes. Lang ('91), for example, divides the Arthropoda into a Branchiate and a Tracheate series, regarding Limulus and the Eurypterida as closely allied to the Crustacea, and believing that the Arachnida were derived from the Insectan (Tracheate) stock by the fusion of the head with the thorax and the disappearance of the feelers.

Supporters of either of these two views agree in supposing a wide divergence between Crustaceans and Insects; they differ as to whether the Arachnida should be associated with the former or with the latter group. The special question of the affinities of the Arachnida will be discussed later. The conflicting views of the various authors mentioned have been briefly sketched as an introduction to the argument of this essay, which will endeavour to show that the various classes of the Arthropoda are indeed truly related to each other, and that ancestors with distinctly arthropodan characters must be predicated for all of them. As has been recently pointed out by Lankester ('97), the structural features in which all Arthopods agree—even if the hard, segmented exoskeleton and the jointed limbs be left out of account—are striking and remarkable. The heart with paired openings; the "pericardium" and the secondarily-formed body-cavity made up of greatly enlarged blood-channels; the reduced cœlom; the variable number of pairs of mesodermal excretory tubes; the uniformly striated muscle-fibres,[1] and the complete absence of ciliated epithelium[1]—all

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[1] Except among the Malacopoda.

these form an assemblage of characters quite unique in the Animal Kingdom. And any attempt to explain their appearance in the various classes of Arthropods as the result of convergent evolution must raise far more difficulties than it can solve.

But the principal view maintained in this essay is one which was suggested nearly sixty years ago by Huxley ('58), and which has been already published in outline by the present writer ('99)—that Crustaceans, Arachnids, and Insects agree closely in the primitive number of their segments. It has been generally believed that the fixed and definite number of segments found in the Malacostraca has been derived by reduction from the numerous segments of Branchiopodan ancestors; that the definite segmentation of Insects has arisen by condensation from some primitive richly-segmented Myriapod. But, as Huxley wrote in 1858, "I venture to think it a matter of no small moment if it can be proved that a Lobster, a Cockroach, and a Scorpion are composed of the same primitive number of somites." If this be the fact, we have well-nigh demonstrative proof that the classes to which these three animals belong are truly akin to each other, and that their allies with very many segments represent abnormal developments. It is almost impossible that a reduction to exactly the same number of segments in three classes of similarly-formed animals could have been independently produced.

It is proposed, therefore, to compare the orders of the various classes of Arthropods so far as it may be necessary to arrive at a conception of the most primitive members of each class, with especial reference to their segmentation. Then the various classes as a whole can be profitably compared and their affinities discussed. The writer would express his special indebtedness to a most suggestive but strangely neglected paper by Hansen ('93). If students of the Arthropoda would follow his example, and compare diligently Arthropods with other Arthropods, before comparing them with specialized Annelids, our phylogenetic studies might advance with greater assurance and less controversy than at present.

Nature of the most primitive Insects.

Any lengthened discussion of the relationship between the various Orders of Insects is needless in view of the almost universal agreement among entomologists in regarding the Thysanura as the most primitive of living groups. Bernard (Hutton, &c., '97) has, indeed, recently revived the suggestion that the caterpillars of Lepidoptera and Sawflies are to be considered as representing the ancestral stock of Insects; and this speculation is tempting to those who seek to derive Insects, independently of other Arthropods, from Annelidan ancestors. But the view will not bear examination. Brauer ('69), Lubbock ('74), and, more recently, Miall ('95), and Packard ('98), have shown conclusively that the active, campodeiform, armoured larva characteristic of the lower orders of Insects must have preceded, in the evolution of insect-metamorphosis, the worm-like eruciform larva characteristic of the more specialised orders. Not only is this evident from a study of the various orders, but from comparison between the families of any one order. Among the Lepidoptera, for example, we find that the caterpillar of a low-type moth, like Hepialus, has, in addition to a chitinous tergite on the first thoracic segment, paired tergal plates on the second and third segments, and in some species on the abdominal segments also, while the legs are strong and relatively long, recalling those of a beetle-larva. But the caterpillar of a high-type moth—a Sphinx, for example—has no distinct tergal plates on any body-segment, excepting the first thoracic, those of the other segments being reduced to tubercles, while its legs are relatively shorter and weaker than those of the Hepialus caterpillar. Thus we see that the worm-like characters of the larva are most markedly shown by the higher moths. Among the beetles a complete transition from the campodeiform to the eruciform type of larva can be traced; while the fact that, in the life-history of certain genera, the former type precedes the latter in the development of the individual, shows conclusively that the active armoured grub preceded the worm-like caterpillar or maggot, which is undoubtedly a specialized secondary larval form. We may, therefore, safely accept the conclusion that the primitive insects were thysanuriform.

But in connexion with the object of this essay it is of the greatest importance to arrive at a correct view as to the segmentation and appendages of the primitive insects. To this we are guided partly by morphological and partly by embryological evidence. Taking, first of all, the head, at least six limb-bearing segments, all primitively postoral in position, can now with certainty be recognised. Foremost of these is the antennal segment bearing the feelers, innervated by the deutocerebral ganglia. Then comes the tritocerebral segment with evanescent appendages clearly detected by Wheeler ('93) in the embryo of Anurida, and by Uzel ('97) in that of Campodea. In the latter insect, indeed, these appendages persist as paired tubercles in the adult. The next postoral segment of the head is that which bears the mandibles.

The next segment has only recently been clearly demonstrated;

and its existence is still ignored by most writers upon Arthropod morphology. Its discovery is due to Hansen ('93), who points out that the paired structures associated with the tongue in the Thysanura and Collembola, and vaguely called "paraglossæ" by most students of those insects, are in reality a pair of jaws situate between the mandibles and the first maxillæ. He gives to them the appropriate name of "maxillulæ." It is strange that so important an observation should have been received with marked neglect for many years, but Howes ('02) has now accepted Hansen's interpretation. A careful examination of these maxillulæ in the Thysanuran, *Machilis maritima*, must convince anyone that there is no escape from Hansen's conclusion. If the mouth-parts are viewed in their natural positions, the tips of

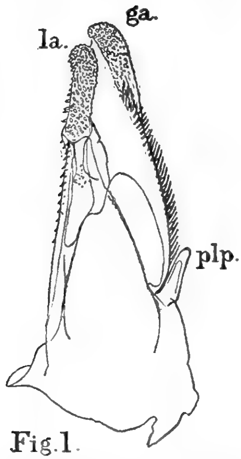

Fig. 1.

Fig. 2.

FIG. 1. Right Maxillula of *Machili maritima*. ×90. ga., galea ; la., lacinia ; plp., palp.
2. Left Maxillula of *Isotoma palustris*. ×260. ga., galea ; la., lacinia.

the maxillulæ are seen to lie just behind the mandibles, and in front of the maxillæ ; while, when dissected out, these organs show all the appearance of a reduced pair of jaws (fig. 1). On the outer edge of each maxillula is a short vestigial palp ; while the tip of the appendage has two very distinct lobes, corresponding with the galea and lacinia of a typical maxilla. Both lobes show a beautiful arrangement of spicules, ridges, and pits ; and the lacinia, at least, is jointed with the basal sclerite. The maxillulæ, at their bases, articulate with the central tongue. In Japyx these organs are still more highly developed, with three-segmented palps, according to Hansen ('93).

A full description of these organs in the Collembolan Orchesella was three years ago published by Folsom ('99); and, although he did not at that time recognise them as a pair of jaws, his figures show that they correspond closely with the maxillulæ of Machilis, though less highly developed than the latter. In Isotoma—perhaps the least specialized genus of the Collembola—the maxillulæ are more strongly developed than in Orchesella. As observed in *Isotoma palustris* (fig. 2), the lacinia is distinctly toothed at the tip; and the series of spines along the inner edge of the basal region are stronger than in Orchesella. The association of the maxillulæ with the tongue is closer in the Collembola than in the Thysanura, as might be expected from the greater specialization of the former group.

A final proof that the maxillulæ (or "superlinguæ") are indeed a distinct pair of appendages has been afforded by Folsom ('00), who has studied their development in the Collembolan *Anurida maritima*. He finds that they arise from paired rudiments like those of the mandibles and maxillæ, and that their association with the central rudiment of the tongue is secondary—exactly as would be anticipated from a comparative study of the adult insects. Although the maxillular rudiments arise between rather than behind the rudiments of the mandibles, a special post-mandibular ganglion and a pair of cœlomic spaces are associated with them. It is evident from the figures given by Eaton ('83) and Heymons ('96) that these appendages are present in the Ephemerid larva, though in a reduced state. According to Hansen, their vestiges can be clearly made out in the Earwigs and Hemimerus, and in a still more reduced condition in the Cockroach and other Orthoptera.

The two pairs of maxillæ ("maxillæ" and "labium" of entomologists) are the appendages of the two hinder postoral somites of the head. A point of considerable interest to be noted is the fact that, in the more generalised Insects at least, the labial segment is incompletely fused with the head-capsule, part of its skeleton forming the cervical sclerites or so-called "microthorax," very evident in the Cockroach. This interpretation of the cervical sclerites, suggested by Huxley ('78), has been established by Comstock and Kochi ('02). We conclude, therefore, that in the Insectan head are six limb-bearing segments, whereof the hindermost, at least in the more generalised orders, is incompletely fused with the rest. It is likely, as will be seen later, that an extra, primitively limb-bearing, ocular segment in front of the feelers must also be reckoned.

Behind the head, the segmentation is comparatively simple. The three thoracic segments, each with its pair of legs, are succeeded by ten abdominal segments. Of these latter, the second to the ninth bear short unjointed appendages in Machilis; while the tenth, in many of the more generalized insects, carries a pair of jointed cercopods. Then comes a small terminal anal segment. But the researches of Heymons ('95) have shown that the segment on which the cercopods arise in the embryo, is in reality the eleventh abdominal, which, as growth proceeds, becomes fused with the tenth. It has long been known that rudiments of limbs appear on the abdominal segments of many insect-embryos. This fact, in conjunction with the abdominal appendages of Machilis and other Thysanura, leads us naturally to conclude that the ancestors of insects had limbs on all the segments of the body, except the anal segment. With confidence, therefore, we can believe that the most primitive insects possessed a head with five post-oral limb-bearing segments, completely fused, a "neck" segment, undergoing fusion with the head, three thoracic segments with well-developed legs, and an abdomen of twelve segments, whereof the first ten carried poorly-developed limbs, the eleventh a well-developed pair of cercopods, while the twelfth or anal segment had no appendages. As no insect is hatched in the winged stage, and as the young of so many insects are Thysanuriform, there need be no hesitation in concluding that the ancestral insects were wingless. And it is reasonable to conclude that the pedigree might be traced farther back still to animals with a head with paired eyes and five limb-bearing segments, and a trunk with sixteen undifferentiated segments, whereof all but the last carried paired appendages. (See Table, pp. 354–5.)

Relationships between Insects, Centipedes, and Millipedes.

But it may readily be objected that Centipedes and Millipedes are less highly organized than Insects—to which class nevertheless they are related—and that they possess a larger number of limb-bearing segments than the Insects have. Therefore, it may be argued, Insects must have been derived from ancestors with numerous segments. This objection, however, is by no means serious, and rests largely on the assumption that "rich segmentation" must, of necessity, be a primitive character among Arthropods. The absence of wings in Centipedes, and the similarity of most of the body-segments and their appendages, are doubtless primitive characters. But it is quite as likely that, compared with the ancestral stock, the number of segments should have increased as that they should have suffered reduction.

And an examination of the relationships of these classes and their orders shows that the former alternative has much evidence in its favour.

The morphological studies of Kingsley ('88) and Pocock ('93A), and the embryological researches of Heymons ('01), have established beyond any reasonable doubt that the "Class Myriapoda" must be abandoned, the Centipedes (Class Chilopoda) being more nearly related to the Insects than to the Millipedes (Class Diplopoda). The Centipedes agree with the Insects in the simple segmentation of the body, in the lateral position of the spiracles, in the anastomosing tracheal tubes, and in the posterior position of the genital openings; while the Millipedes exhibit for the most part a fusion of the segments in couples, so that each apparent segment carries two pairs of legs, the spiracles are ventral in position, the air-tubes are unbranched and do not anastomose, and the genital openings are far forward on the third body segment.

If, then, it is believed that Insects and Centipedes on the one hand, and Millipedes on the other, have diverged from some common ancestral stock, it is natural to inquire whether any living form can suggest approximately what that stock may have been like. The only animals that combine some of the divergent characters of Insects, Centipedes, and Millipedes, are the Scolopendrellidæ, now usually regarded as a distinct class, called, on account of their annectant characters, the Symphyla (Ryder, '80). These small, frail, somewhat degenerate creatures, show the series of similar, simple limb-bearing segments characteristic of Centipedes, the forwardly-situated genital aperture as found in Millipedes, and a number of body-segments identical with that occurring in Insects. Their chief point of specialization is the curious inequality and displacement of the tergites. No surprise need be felt that some students of their structure, like Packard ('98), regard them as representing the ancestral stock of Insects; others, as Grassi ('85), that of Centipedes and Millipedes. But if we are willing to accept the view, admitted as possible by Lang ('91), that most living Centipedes and Millipedes have become what they are by an increase from the number of primitive segments, there is no reason why we should not, with Haase ('86) and Pocock ('93A), regard the Symphyla as approximate to the common ancestor of the Insecta and the Chilopoda on the one hand, and of the Diplopoda (including the Pauropoda) on the other. Haase particularly suggests that the common ancestors of the three great Tracheate classes had as many segments as Scolopendrella.

But Schmidt ('95), to whom we owe the most recent account of this interesting animal, denies that its segmentation is primitive, and suggests that the pointed processes on the coxæ of its legs must be regarded as the vestiges of pairs of limbs belonging to segments which have become closely fused with the present evident segments. He considers Scolopendrella, therefore, to be a very highly specialized Diplopod, the fusion of the segments in couples being so intimate, that the adjacent limbs have coalesced. But this view is surely far-fetched, when we consider in how many points of structure Scolopendrella

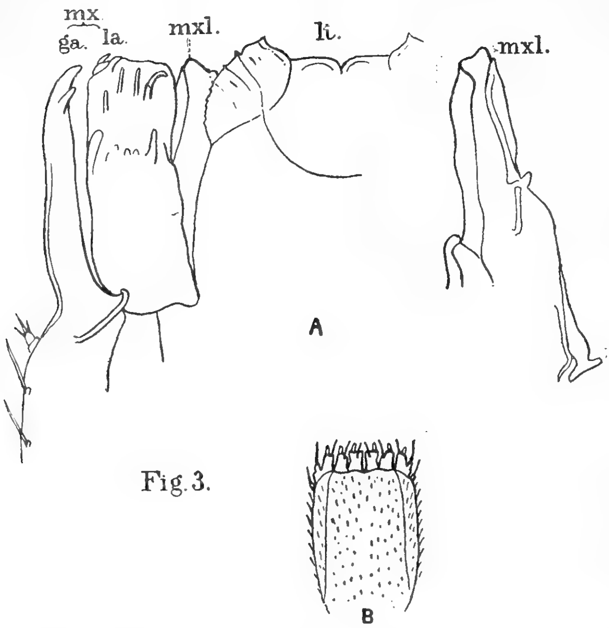

Fig. 3.

FIG. 3. A. Right Maxilla (mx.), tongue (li.), and maxillula (mxl.) of *Scolopendrella immaculata.* The tip of the right maxillula is seen *in situ*; the left maxillula is exposed by removal of the maxilla and part of the tongue. × 390.

B. Second maxillæ (labium) of Scolopendrella. × 90.

approaches the Thysanura. The antennæ resemble closely those of Campodea, and differ in the most marked way from those of any Millipede. The head-skeleton, with its angular epicranial suture, is quite Insectan. Latzel's figures ('84) show clearly three distinct pairs of jaws, the mandibles, maxillæ, and labium corresponding rather closely with the similar structures in the Collembola. And by dissection of the head, I have succeeded in demonstrating the presence of a pair of minute maxillulæ[1] associated with the tongue, and lying between mandibles and maxillæ, just as they do in the Springtails (fig. 3, mxl.). All that is now wanting to bring the segmentation of Scolopendrella into perfect agreement with that of the primitive Insects, is embryological proof of the presence of the vestigial tritocerebral appendages of the head. With confidence, therefore, we may postulate a Scolopendrelloid ancestry for Insects, Centipedes, and Millipedes.

Among the Centipedes we find very great variation in the number of the body-segments, Lithobius and Scutigera having only fifteen pairs of walking-legs, Scolopendra and its allies twenty-one or twenty-three pairs, and the Geophiloids often more than a hundred pairs. Now, according to the view of Haase, adopted by Bollman ('93), the fifteen-legged groups must be regarded as the more primitive on account of the comparative simplicity of the tracheal system in Lithobius, the spiracles having no closing apparatus; and it is especially noteworthy that a correspondingly simple stage is passed through in the development of the Scolopendridæ. Although the tracheal system of Scutigera is highly specialised and the spiracles dorsal in position, the head and mouth-parts of that animal retain many primitive characters.

But the important discovery recently announced by Pocock ('02) of a Tasmanian genus of Centipedes (Craterostigmus) with fifteen pairs of legs like a Lithobioid, and twenty-one tergites like a Scolopendra, is believed by him to indicate the descent of the Lithobioids from Scolopendroid ancestors through the loss of six segments—the 3rd, 6th, 9th, 11th, 14th, and 17th. He suggests that, in Craterostigmus, the tergites of these segments are still retained. Two objections may be made to this view. It is hard to imagine a reduction in the number of segments by the loss of a scattered series such as this. And the derivation of the Lithobioids from the Scolopendroids, through Craterostigmus, would destroy the remarkably close correspondence between the position of the spiracles on the 1st, 3rd, 5th, 8th, 10th, 12th, and 14th body-segments of Lithobius and the corresponding segments (except the 1st) of Scolopendra. As Craterostigmus exhibits several Geophiloid characters, it is more likely that its six "minor" tergites should be compared to the smaller sections of the incompletely-divided dorsal plates of the Geophilidæ.

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[1] While this paper is passing through the press, I find that the maxillulæ of Scolopendrella have been seen and figured by Hansen ('03).

There is good reason, therefore, for considering that the richly-segmented Centipedes are abnormal developments from forms with a moderate number of segments. The palæontological evidence of the subject is very meagre. In Carboniferous times, we know from the researches of Scudder ('90) that Latzelia, a form resembling Scutigera, but without the specialised dorsal tracheal system, existed. The fossils referred by Scudder to the Eoscolopendridæ are too imperfect for any certain conclusions to be drawn from them. If the bristle-bearing animal Palæocampa, referred by him to a special order, the Protosyngnatha, were indeed a Centipede, its body-segments were but few in number. Embryological researches on the Centipedes, the latest of which is Heymons' exhaustive treatise on the development of Scolopendra ('01), show the close correspondence between the Chilopodan and the Insectan head. The presence of a tritocerebral rudiment in the Centipedes has been established, so that the feelers, mandibles, maxillæ, maxillulæ, and labium of the insect correspond respectively with the feelers, mandibles, two pairs of maxillæ, and poison-jaws of the Centipede. The freedom from the head of the segment bearing the last-named limbs in the Centipedes shows that their ancestors must have diverged from the primitive stock at a very early period. In this respect, the head of Scolopendrella is specialised as compared with the Centipede-head; and in the Symphylan ancestral stock of Centipedes and Insects, the pair of limbs that now forms the plate-like labium in Scolopendrella and the Collembola, must have been free and leg-like.

One of Heymons' most startling discoveries is the presence of a pair of pre-antennal rudimentary appendages on the head of the Scolopendroid embryo. The segment bearing these he regards as post-oral; and he ranges it with the optic segment of the insect head. Its existence strongly suggests that the eyes of the far-off ancestors of Centipedes were stalked and appendicular. As the development of the lateral simple eyes in Scolopendra does not support the theory that they are degraded compound eyes, it is to be presumed that the ancestral compound eyes have been lost, except in the Scutigeridæ.

Turning next to consider the Millipedes, we find that they, like Centipedes, exhibit a wide divergence in their segmentation. It is impossible to lay any stress on the hexapod condition of their larvæ, as indicating relationship to the Insects, as the segments on which the three pairs of legs occur are not successive, and vary in different groups. But the strongest evidence for the derivation of the Diplopoda from the same stock as the Chilopoda and the Insecta is afforded by the fact that in Scolopendrella the genital opening is far forward, as in the Millipedes, while the curious group of the Pauropoda, which show many points of correspondence with the Symphyla, have been proved to exhibit (Kenyon, '95) marked Diplopod affinities. Kenyon, indeed, places the Pauropoda, together with the Pselaphognatha (Polyxenidæ), in a group which he calls the Protodiplopoda. Pauropus has only nine pairs of legs; and its segments are imperfectly fused. There can be little doubt that this form has undergone secondary shortening; but Polyxenus has thirteen leg-bearing segments followed by two limbless segments, so that its segmentation agrees exactly with that of Scolopendrella and the primitive Insects. The mandibles of Pauropus and Polyxenus resemble those of the Collembola. In other Millipedes, these jaws are complex, being composed of several sclerites —a condition which, like that of the mandibles in certain Scarabæid beetles, must perhaps be regarded as a secondary adaptation. The "lower lip" or "gnathocilarium" of Millipedes seems to be certainly formed by the union of two pairs of appendages which probably represent the maxillulæ and maxillæ of Insects; while the labial segment of Insects is represented by an embryonic limbless segment (Heymons, '97). (See Table, pp. 354–5.)

What palæontological evidence we possess of the history of Millipedes shows that richly-segmented forms, in which the segments were already beginning to fuse together in couples, were living in Devonian times. But as winged Insects have been traced back to the Silurian, we have nothing but comparative studies in living forms to guide us as to the nature of the common ancestor of Insects and Millipedes. Morphological evidence shows clearly that Millipedes might well have arisen, through some form combining the primitive characters of Pauropus and Polyxenus, from a Scolopendrelloid stock. The fusion of segments in couples would not be likely to take place until the number of segments had become very great. It is suggestive to notice in this connexion that, in the Pauropoda and Pselaphognatha, the fusion of segments has hardly begun. The earliest truly "diplopodous" forms would have been elongate Juloid Millipedes. Thence, by a reduction in the number of segments, the Glomeroid forms may have sprung.

The difficulty that arises in bringing together two groups which, like the Millipedes on the one hand, and the Insects and Centipedes on the other, exhibit a great difference in the position of the genital aperture, will be discussed later in connexion with the relationship between Insects and Crustacea. For the present it is enough to repeat the fact that in Scolopendrella, despite its marked Insectan affinities, the genital opening is far forward, as in Millipedes. Therefore the difference in the position of the genital opening cannot by itself indicate a very radical divergence. Although Centipedes are more nearly related to Insects than to Millipedes, it is likely that the kinship of Insects to the two classes of "myriapods" is equally close. The Insects represent the main stem, the Centipedes and Millipedes two divergent branches.

Relationship between the Orders of Crustacea.

Turning next to consider the probable nature of the most primitive Crustaceans, we find the prevailing opinion among modern zoologists to be that the Phyllopoda, as exemplified by the many-segmented Apus and Branchipus, represent, more nearly than any other living order, the ancestral stock of the class. According to this view, the evolution of the Crustacea has been effected by a reduction in the number of body-segments until the definite and limited number characteristic of the higher orders (Malacostraca) has been reached. But Packard ('82), Sars ('87), and Hartog ('88) have argued that the Copepoda are more primitive than the Phyllopoda.

Now if we consider the lower orders (Entomostraca) as a whole, we are struck by the quite exceptional presence of a rich segmentation. In the Phyllopoda the number of pairs of legs may vary from four to over sixty; whilst, in the other recent orders of the Entomostraca, the limb-bearing segments are always few. We now know that Phyllopods, closely related to Apus (Protocaris), and Ostracods, had already been differentiated in the Cambrian period. Therefore, whatever may have been the segmentation of the primitive Crustaceans, there had been great modification before the dawn of the earliest life-epoch known to us by fossil evidence. No doubt can be entertained that such poorly-developed segmentation as is shown by the Ostracods must be due to reduction. But has such reduction been the constant rule in Crustacean development? It may be of interest to consider in this connexion that most ancient of Crustacean orders known to us—the Trilobita.

Nearly all Trilobites are composed of a number of segments greater than that characterising the Malacostraca. After the recent researches of Beecher ('00) and others, there can be no reasonable doubt that these animals were true Crustacea, and that they combined to some extent the characters of the Branchiopoda and the lower Malacostraca.

What is the history of their evolution as regards segmentation? Olenellus is the oldest known genus; and, according to Peach ('94), *O. Kjerulfi* is its most primitive species. This Trilobite had sixteen body-segments, in addition to the five-segmented head—only one more than the typical Malacostracan and Insectan number. And if we study the segmentation of Trilobites generally, we find a slow but steady increase in the number of segments from the Cambrian on to the dying-out of the order in the Carboniferous. Taking from Zittel ('87) the genera whose segmentation is clearly known, it is found that the average number of body-segments present in the Trilobites of each great period of the Primary Epoch work out as follows:—

Period.	No. of Genera.	Average number of body-segments.
Cambrian	12	17·66
Ordovician	23	18·58
Silurian	16	19·34
Devonian	10	20·70
Carboniferous	2	20·75

It is also noteworthy that in the Ordovician period, when the Trilobites seem to have reached their culminating point, there lived two genera with the largest number of trunk-segments actually known (thirty-two).

The history of the Trilobites suggests, therefore, that a steady increase in the number of trunk-segments characterised the evolution of that order; and, as we have seen, the most primitive Trilobite known to us possessed only sixteen trunk-segments. It may be fairly inferred from this that the ancestral Trilobites were by no means "richly segmented" animals. It may also be inferred that the rich segmentation of such a Phyllopod as Apus is at least as likely to be a secondary as a primitive character, and that the most generalised Crustacean we can imagine might have had no greater number of segments than a modern lobster.

What further light can be thrown on the nature of the earliest Crustacean type? Grobben ('92) has suggested that the Entomostraca cannot be regarded as a primitive group to be set over against the Malacostraca; but that, from a Phyllopod-like ancestry, the various groups of the Entomostraca that have undergone either reduction in their segmentation or degeneration, as well as the higher Malacostracan orders, must be derived. But almost every student of the Crustacea has seen in the Leptostraca something of a connecting-link between the Malacostraca and the Phyllopoda. Some writers, like Claus ('72), have laid stress on their affinity with the former group, others, like Sars ('87), on their relationship with the latter. Most zoologists, regarding the Phyllopods with their very extended segmentation as the most primitive of all Crustacea, see in the Leptostraca, transition-forms between the Phyllopods and the Malacostraca. But if this isolated and very ancient group—with representatives like Hymenocaris and Ceratiocaris going back into the Cambrian Period—combines, in many respects, the characters of the Phyllopoda and the Malacostraca, is it not more natural to regard it as a direct offshoot—modified, of course, in some particulars—of the common Crustacean stock whence both Phyllopoda and Malacostraca sprang?

In Nebalia and its few allied genera, which alone represent the Leptostraca at the present day, we find a head bearing stalked eyes and the usual five pairs of appendages, a thorax with eight pairs of simple limbs, with lamelliform exopodites and jointed endopodites, and an abdomen with eight segments, whereof the first six bear paired pleopods, while the eighth (anal segment) is provided with two furcal processes. Now a comparison between the head-appendages of Nebalia and those of Apus or Branchipus shows that the former retains decidedly the more primitive characters. In Nebalia the feelers of both pairs are elongate and normal; in the Branchipoda they are greatly reduced. The mandible in Nebalia, with its long endopodite (palp), is among the least specialised of all Crustacean mandibles. From it the Malacostracan mandible with its reduced palp, or the Branchiopodan with no palp, could be both readily derived, while it most certainly could never have arisen from the last-named type. So also with the maxillæ: in Nebalia those of both pairs have jointed endopodites, while in Apus those of the first pair are small limbless masticating plates, those of the second vestigial with hardly recognisable parts. Passing to the thoracic limbs, we find in those of Nebalia, the protopodite with the three segments, which Hansen shows to be the primitive number, a narrow segmented endopodite and a broad branchial exopodite; in Paranebalia the expodite is slender and fringed. From such a limb as this can be derived on the one hand, through the Schizopoda, the legs of the specialised Malacostraca, on the other the complex lamellate appendages of Apus; while it would be hard to imagine how the limb of Nebalia could have arisen from the Branchiopodan limb. The Leptostraca are specialised in the great development of the carapace; this probably accounts for the small size and crowded arrangement of the thoracic segments, which, nevertheless, remain free from each other and from the head. The abdomen of Nebalia shows a remarkable likeness both to the abdomen of the higher Malacostraca and to that of the Phyllopoda. It agrees with the latter and differs from the former in the reduction of the limbs on the hinder segments and in bearing a terminal furca; while it approaches the Malacostracan abdomen in the limited number of its segments, eight being present, the last two of which are limbless. In the Malacostraca there are seven abdominal segments, the sixth bearing a strong pair of appendages. (See Table, pp. 354–5.)

Having seen that the structure of the cephalic and thoracic limbs in Nebalia leads us to regard it as more primitive than Apus, we are prepared to compare the abdominal region in the two animals, and to admit that the numerous abdominal segments in the latter may well have arisen by the multiplication of a primitively moderate number. On the other hand, if the Malacostraca have developed, as is almost universally believed, from Leptostracan ancestors, it is easy to conceive that one abdominal segment has been lost, in connexion probably with the strong development of the Malacostracan uropods. If these limbs belong to the true sixth abdominal segment, then there may be two fused segments in the telson; or, as is perhaps more probable, when the formation of the Insect abdomen is recalled, the uropods may be in reality the limbs of the seventh abdominal segment which has become united with the sixth. Future researches on the embryology of the Malacostraca will doubtless clear up this point.

If we carry our investigation still further back, and speculate as to the nature of the ancestors of the Leptostraca, we naturally compare them with that other ancient group—the Trilobita. Beecher's restoration ('00) of the appendages of the Trilobites, as suggested by the study of Triarthus, is now well known. The head bears a pair of simple feelers and four pairs of biramous limbs, not differing from the succeeding limbs of the trunk. The hinder trunk-limbs are specially modified as swimmerets by the flattening of the endopodital segments, and not, as in Apus, by the foliation of the protopodite. There can be little doubt that the feelers of the Trilobite are Crustacean antennules; and that the other four head-appendages represent the antennæ, mandibles, and two pairs of maxillæ. Now the distinct and conspicuous palps of the mandibles and maxillæ in Leptostraca carry us some way towards the very primitive condition of the appendages of the Trilobites, as do also the comparatively simple biramous thoracic limbs of Paranebalia (Sars, '87). There need be no hesitation, therefore, in deriving the Leptostraca from an ancestral form in which all the trunk-segments, then not covered by a carapace, were similar—no differentiation between thorax and abdomen existing—and the head- and trunk-appendages alike. Such ancestors must have lived in pre-Cambrian times, and the segmentation of the Trilobites suggests, as we have seen, that similar pre-Cambrian ancestors—with five head- and fifteen trunk-segments bearing limbs—may be most reasonably imagined for them. As Bernard ('94) has pointed out, the head of the Cambrian Microdiscus had apparently only four segments, suggesting that the hinder head-segments were successively absorbed from the trunk. It is evident that those most generalised Crustacea must have combined the primitive characters of the Leptostraca and the Trilobites, and that they had the typical Arthropodan number of body-segments. A furca or a spinose telson was undoubtedly attached to the anal segment. The eyes were stalked, the Leptostraca in this respect being more primitive than the Trilobites. The probability that the stalked eyes represent an additional post-oral pair of limbs, anterior to the antennules, will be discussed later.

Relations between the Orders of Arachnids.

Some reference has already been made to the controversy regarding the affinities of the Arachnida as a whole. As an introduction to the closer study of this question, some discussion of the relationship existing between the various orders that are undoubtedly referable to the Arachnid class is necessary. On this subject very diverse opinions have been expressed by zoologists. The question depends largely on how we regard the Scorpions.

That Scorpions are specialized Arachnids has been argued from two points of view. The complete fusion of their cephalo-thoracic segments is compared with the presence of free or partially free segments in such forms as the Palpigradi and the Solifugida. And the writers who, like Lang and Bernard, believe that the lung-books of Scorpions have been derived from tufted tracheæ, naturally regard the order as, in that respect at least, more specialized than those Arachnids that breathe chiefly or wholly by means of air-tubes.

It may help to clear the ground if, leaving the Solifugida and Palpigradi aside for awhile, we compare the Scorpions with the other prominent orders of living Arachnids,—with the Pedipalpi, the Araneida, the Phalangida, and the Acarinida. And if that be done, there seems no escape from the conclusions of Lankester ('81) and Pocock ('93B), that the sequence in which these orders have just been mentioned is, on the whole, an ascending sequence. The reduction and fusion of segments in the hind-body may be regarded as evidence of specialization, as strong as similar fusion in the head-region. The Scorpions have a well-developed abdomen with twelve free segments. In the Pedipalpi the twelve segments are still recognizable, but the hindmost are reduced and crowded. In the Spiders only a single genus (Liphistius) retains any certain trace of abdominal segmentation; all other spiders have the abdominal segments fused into a compact hind-body constricted off from the cephalothorax by a narrow waist (the pre-genital segment). In the Phalangida the segmentation of the abdomen may be more or less apparent, though the anterior segments tend to disappear, or to become fused with the cephalothorax. And lastly, in the Mites we find cephalothorax and abdomen fused into a single ovoid mass, all trace of segmentation having vanished.

Now, it is surely a very striking fact that we find this condensation and fusion of the hind-body region correlated with a replacement of lung-books by tracheal tubes as breathing-organs. In the Scorpions, four pairs of lung-books are present; in the Pedipalpi and the Avicularian Spiders, two pairs, which belong, however, to the genital and post-genital segments, and do not therefore correspond with any of the Scorpions' lungs; in the vast majority of Spiders one pair only, the hinder pair being replaced by tracheal tubes. And in the Phalangids and Mites, no lung-books whatever are present, the breathing being entirely tracheal. Considering more particularly the Spiders, it might seem needless to insist that the Dipneumonous families are higher than the Tetrapneumonous, were it not that the true relationship of the Arachnid orders depends so much on the appreciation of this point. For if the relationship between the two great divisions of the Spiders be as just stated, it is certain that among the Arachnids, lung-books are more primitive organs of respiration than are tracheal tubes. Compare the two pairs of respiratory slits in Avicularia, all leading to lung-books (fig. 4A), with the similarly situated two pairs in one of the lower Dipneumonous Spiders—Dysdera (fig. 4B), for example—in which the hinder pair lead to tracheal tubes; then with a higher type such as Anyphæna (fig. 4C), in which the hinder pair of openings have coalesced to form a median slit, half-way back along the ventral surface of the abdomen; and, lastly, with a highly organised Spider like Epeira (fig. 4D), where the median slit is far back just anterior to the spinners. Is it possible to regard such a series without being forced to the conclusion that the arrangement in Avicularia is the most primitive, in Epeira the most specialized? And a corresponding specialization in the secondary sexual organs may be seen in the four types just mentioned; the copulatory apparatus on the male's palp is far more complex in the two-lunged than in the four-lunged spiders, in Anyphæna than in Dysdera, in Epeira than in Anyphæna (fig. 4, a, b, c, d). Again, therefore, we are forced to the conclusion that, among the Arachnida, tracheal tubes are derivable from lung-books—and not lung-books from tracheal-tubes. And palæontological evidence confirms, so far as it goes, the teaching of morphology on this question. For remains of Scorpions occur in the Silurian rocks, of Pedipalpi and Aviculariform Spiders in Carboniferous; while the Dipneumonous Spiders, Phalangids, and Mites are not certainly known until the Eocene. Therefore, without supposing that Spiders are actually derivable from Pedipalpi, or these from Scorpions—each

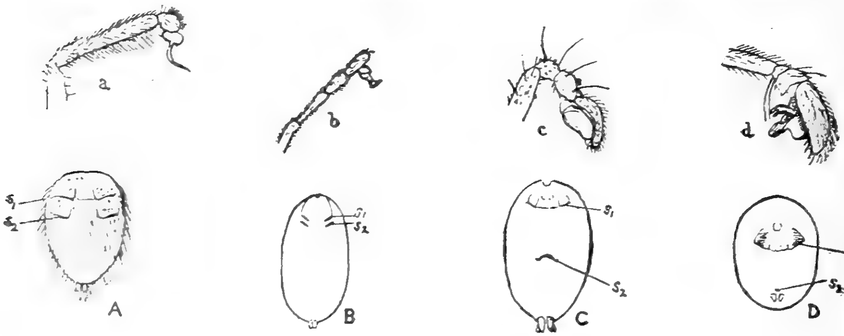

Fig. 4.

Fig. 4. Ventral view of the abdomen in four spiders. A, Aviculaira (nat. size); B, Dysdera × 2; C, Anyphæna, × 3; D, Epeira, × 2; S^1, S^2, air-openings. Also terminal portion of palps of the male in the same four genera. *a*, Avicularia, × 2; *b*, Dysdera, × 3; *c*, Anyphæna, × 8; *d*, Epeira, × 8; to show increase in complexity of the copulatory organ.

order having of course undergone specialization along its own lines (the Scorpion's post-abdomen, for example)—we are fully justified in placing the origin of the Scorpions lower on the Arachnid stem than we place the origin of the Pedipalpi, and that lower than the origin of the Spiders.

Embryological researches also support strongly the view just set forth. The development of Spiders' lungs has been recently studied by Simmons ('94) and Purcell ('95), and there can be no doubt from their observations that the respiratory plates arise as outgrowths from the hinder aspect of an abdominal appendage comparable to the gill of Limulus. Purcell, in particular, has shown that the plates begin to be developed while the appendage still stands out distinctly from the ventral surface of the body; as growth proceeds, the appendages simply sink in, "without any inversion or other complications," as Simmons remarks, and the lung-book is thus formed. And the tracheal tubes in spiders arise as in-pushings behind the appendage of the third abdominal segment, the appendage bearing evanescent foldings resembling those that give rise to the lung-book on the appendage of the second abdominal segment. Could stronger evidence be desired that lung-books are more primitive among the Arachnids than tracheal tubes, and that they were preceded by lamellate appendicular gills? Moreover, Purcell shows that, in most Dipneumonous Spiders, part of the tracheal system, and in the Attidæ nearly the whole of it, arises from the ectodermal in-pushings that form the entapophyses, so that the tracheæ have not, in all cases, a similar origin. Clearly it was these entapophysial imaginations that gave rise to Jaworowski's statement ('94) that the tracheal tubes precede the lung-books in the development of Trochosa. It follows from these researches on the development of Spiders' lungs and tracheæ, that the latter are the later development among the Arachnida, that they are not constant in their mode of origin, and that they must have arisen altogether independently of their origin among the Insects.

These considerations show that the tracheal respiration of the Solifugida cannot be invoked as an argument that the Arachnida as a whole are "Tracheata," still less, as suggested by Thorell, that the Solifugida are Insects! For granting that, in their segmented fore-body, the Solifugida have retained a primitive character lost by the Scorpions, their abdominal segmentation is reduced and condensed as compared with that of the latter, and their chelicerae are the most powerful and specialized to be found in the whole class. The existence of these very powerful limbs, and the extreme rapidity of locomotion attained by these animals is sufficient to explain the exceptional development of spiracles among them on the fourth limb-bearing segment of the cephalothorax. Even if, as Bernard ('96) claims, these spiracles suggest the presence of breathing-organs on nearly all the segments of the primitive Arachnid, there is no impossibility in such a conception. But the fact that cephalothoracic breathing-organs are found only among the Mites and the Solifugida —the former in all respects, and the latter in some respects, highly specialized forms—suggests rather that breathing-organs among primitive Arachnids were confined to the hind-body, as has been ably maintained by Wagner ('95).

But whatever may be the truth as regards this point, there can be no reasonable doubt that in their free thoracic segments, the Solifugida and the Palpigradi (Hansen and Sorensen, '97) retain a primitive character. This then must be taken into account, together with the indications furnished by the abdominal segmentation of the Scorpions and Pedipalpi. When we come to speculate on the nature of the primeval Arachnids, we are clearly led, in this way, to imagine an Arthropod with a head carrying three pairs of limbs, whereof the foremost were three-segmented cheliceræ, a thorax with three free segments, each with a pair of limbs, and an abdomen of thirteen segments—the foremost the pre-genital or waist-segment, detected in the embryo scorpion by Brauer ('95), and in the embryo of Spiders by many observers, represented by the metastoma of Eurypterids, and perhaps by the sternum of the Scorpions. Each abdominal segment from the second to the seventh, inclusive, had a pair of appendages carrying gill-plates. Of these the two foremost pairs are represented in the Spiders, the four hindmost in the Scorpions. There was, of course, no specialized "post-abdomen," as in Scorpions; but the segments tapered gradually towards the tail-end, the hindmost bearing some kind of telson. This conception of the ancestral Arachnid agrees closely with that figured by Pocock ('93B), except that he supposes a completely fused cephalothorax, thereby allowing no weight to the evidence of the free thoracic segments in the Solifugida and the Palpigradi.

Having arrived at this result, we are now in a position to inquire whether the "Gigantostraca"—the Limuloids and Eurypterids—should be considered as belonging to the Arachnid class. That Limulus is nearly related to the Merostomata, and can probably be derived from the same ancestry as that order, through such forms as the Silurian Bunodes and Hemiaspis, and the Carboniferous Belinurus and Prestwichia, can hardly admit of doubt. And it is further evident that Eurypterus and the Limuloids could, like a Scorpion or a Galeodes, be derived from the ancestral Arachnid that we have just imagined. The correspondence in the segmentation of Eurypterus and the Scorpion is so close and remarkable, that we are forced to admit an affinity. This point has been sufficiently argued by Lankester and others; but to claim that both the Merostomata and Xiphosura ought to be classed as Arachnida does not involve the belief that Scorpions are descended from Eurypterids, still less from King-crabs! In view of the specialized fusion of both cephalo-thoracic and abdominal segments in Limulus, anything like an ancestral standing for that animal is unthinkable; while the Eurypterids, although primitive in their abdominal segmentation, had the cephalothorax completely fused, and the sixth pair of limbs specialized as paddles. Moreover, they were contemporary with the earliest Scorpions. Howes, in a recent criticism ('02) on the upholders of the Arachnidan affinities of Limulus, has pointed out that the Limuloid type is simplified by the Eurypterids, as the modern Scorpionoid type is by Palæophonus. This is just criticism; but it should not prevent us, led by the close correspondence between the segmentation in the primitive Scorpion and in the Eurypterids, from carrying the simplification still farther back, and deriving the Gigantostraca on the one hand, and all the modern air-breathing Arachnids on the other from aquatic Arachnid ancestors, with three free thoracic segments. In the detailed account of the Silurian Scorpion (Palæophonus) lately given by Pocock ('01), it is especially noteworthy that the post-abdomen is relatively thick, and that the appearance of the ventral surface suggests aquatic respiration by lamellate gills.

Bernard ('96) has contrasted the ventral position of the mouth in the Gigantostraca with its terminal position in the undoubted Arachnida, and has founded on this contrast a plea against the union of the former with the latter group. But this argument surely lays too great stress on an adaptive character. It might forbid us to derive Scorpions and other predaceous Arachnids directly from Eurypterids, but not to trace both back to a common ancestry. And further, if the forward position of the mouth, as in Galeodes, characterised the most primitive Arachnids, then the chelicerae must be the foremost appendages, and there can be no limbs missing from the Arachnidan head. This view has indeed been recently put forward by Heymons ('01), and adopted by Borner ('02); but it is in direct conflict with the embryological observations of Jaworowski ('91 and '92), who described a pair of evanescent antennæ in the embryo of Trochosa, and of Brauer ('95), who describes and figures two ganglionic rudiments in front of the cheliceral ganglia in the embryo Scorpion. That the appendages of one or two segments have been lost from the Arachnid head seems therefore certain; if so, the mouth of the precursors of the class must have been ventral.

The composition of the head in the Arachnida is of great importance with regard to the subject of the present essay. Doubt has been thrown by later observers on Jaworowski's observations; but the appendicular nature of the vestigial antennæ that he figured

('91) seems likely, although the fact that they sink into pits and occupy the position of the cheliceral ganglia, makes his interpretation uncertain. The pre-antennal segments that he described later ('92) do not seem to rest on very clear evidence; while the two pairs of vestigial appendages lately described and figured by Pokrowsky ('99), in the embryo of Pholcus, are not convincing. But the presence of a pre-cheliceral segment is clearly indicated by the segmentation of the Scorpion's brain as interpreted by Brauer ('95). Anterior appendages are perhaps to be found in the paired rudiments of the rostrum, as suggested by Croneberg ('80). These are conspicuous in the embryo of *Trochosa ruricola* (fig. 5), which I have examined in the vain hope of seeing Jaworowski's antennæ. They are also clearly shown in Brauer's figures of the embryo Scorpion, ultimately becoming fused

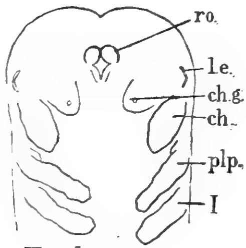

Fig. 5.

Fig. 5. Front portion of germ-band of *Trochosa ruricola*; ro., ch., plp., l., rudiments of rostrum, chelicerae, pedipalps, and first pair of legs; ch. g., cheliceral ganglion: l.e., lateral eyes, × 28.

together. Lendl (*fide* Korschelt ('99)) has described vestigial appendages between the cheliceræ and the pedipalps of Spiders. The former existence of a limb-bearing segment there is indicated by the structure of the Pycnogonida, which seem to be an aberrant order of Arachnida. Not only do the embryological history, as described by Morgan ('91), the possession of cheliceræ as the foremost pair of limbs, and the four pairs of walking-legs suggest Arachnid affinities, but also the fact that the segments bearing the three hinder pairs of legs are, in the generalized families of Pycnogonida, as in the Solifugida, not fused with the cephalic segment on which the four front pairs of limbs are borne. This indicates that the pycnogonid appendages, not present in Arachnida generally, are the palps. Therefore, it is safe to conclude that the Arachnidan head with three pairs of limbs, was preceded by a head with four pairs, and that the far-off ancestors of the Arachnida had a head with five pairs of limbs, the foremost of which were feelers. (See Table, pp. 354–5.)

Relationship between Insects and Crustaceans.

Belief in the multiple origin of the Arthropoda rests chiefly on a supposed radical divergence between Insects and Crustaceans. It has been shown in the previous chapters of this essay that Insects, as well as Centipedes and Millipedes, can be traced back to ancestral Arthropods with five limb-bearing head-segments, and fifteen limb-bearing trunk-segments; and that Crustaceans and Arachnids can be traced back to an ancestral stock showing precisely similar segmentation. It has been further pointed out that the identity of segmentation in three distinct classes cannot be reasonably explained as the result of convergence. The strongest presumption is raised for a real kinship between Insects and Crustaceans. It is desirable, therefore, to compare the two classes in some points of detail with the view of more firmly establishing their relationship.

General agreement now exists among zoologists that the feelers, tritocerebral vestiges, and mandibles of Insects represent respectively the antennules, antennæ, and mandibles of Crustaceans. Both the general form of the appendages and the ganglia from which they are innervated afford evidence that this view is correct; and Hansen ('93) has brought forward facts that tell most strongly in support of the homology of the Crustacean with the Insectan mandibles. He points out that there is a very close likeness, both in form and musculature, between those jaws in the Thysanura and Collembola on the one hand, and the lower Malacostraca, especially the Cumacea, on the other. Indeed there is a much closer likeness between the mandibles of Diastylis and those of Machilis than between the latter and the mandibles of Blatta or any winged Insect.

Most writers on Arthropod morphology have not hesitated to range the two pairs of Crustacean maxillæ with the similarly-named appendages in Insects. But, as we have already seen, the researches of Hansen ('93) and Folsom ('00), supported by the facts brought forward early in this essay (pp. 324–5), compel us to recognise the maxillulæ of the Thysanura as a pair of jaws anterior to the two pairs of maxillæ. Hansen has further called attention to the points of likeness in detail between them and the first maxillæ of Crustaceans, and between the first maxillæ of Insects and the second maxillæ of Crustaceans. We need not hesitate, therefore, to consider the latter correspondence as accurate, and to compare the second maxillæ (labium) of Insects with the foremost thoracic legs of Crustaceans. That this correspondence is correct is shown by the fact that the labial segment in Centipedes (whereof the poison-feet are the appendages) is not fused with the head-capsule, while in the more generalised Insects it is only partially fused. Among the Crustacea, we find that the foremost trunk-segment is added to the head in the Malacostraca—notably in the Amphipoda and the Isopoda; while the same thing seems to have happened among some of the more specialised Trilobites—*e.g.*, Ogygia. Behind the head we find, in a typical modern Insect, three thoracic and ten abdominal segments, all of which must have carried appendages primitively. And embryological researches have shown that eleven limb-bearing abdominal segments and a limbless twelfth anal segment must have been present in the ancestors of Insects. Comparing the segmentation of an Isopod with that of an Insect, we find exactly the same number of body-segments in each. And the hindmost limb-bearing segment of the primitive insect, revealed only by embryological research, is paralleled by the extra segment in the abdomen of the Leptostraca. There is no improbability in the assumption that this segment originally carried limbs. There is every reason, then, for tracing back the Insecta and the Malacostraca to common Arthropod ancestors with twenty-one limb-bearing segments, and for considering that the abnormally numerous segments found in Centipedes, Millipedes, and certain Trilobites and Phyllopods have arisen by increase from that originally limited number. (See Table, pp. 354–5.)

In comparisons between Insects and Crustaceans, allowance must be made for the possibility that the stalked eyes in the former class represent yet another pair of head-appendages. The fact that they may be abnormally developed as jointed limbs is hard to explain on any other view. They may be matched in the Insectan branch of the Arthropoda by the rudimentary appendages of the pre-antennal segment recently described by Heymons ('01) in the embryo Scolopendra. This segment, as previously mentioned, is compared by Heymons with the hinder part of the protocerebron in Insects, to which the compound eyes belong. We see in this correspondence suggestion for a close comparison between the Insectan and the Crustacean compound eye.

If true kinship between Insects and Crustaceans be thus established, it remains that the nature of such kinship be discussed. Have the Insects and their allies actually branched off from the Crustaceans? Or is it more reasonable to regard Insects and Crustaceans as divergent stems from a common far-off Arthropod ancestry?

With regard to this question, the conclusions of Hansen incline towards the former view. Although (Hutton, etc., '97) he "dislikes ancestor-hunting and pedigrees," he expresses the opinion that "the lower Malacostracous Crustacea and the Thysanura are more closely related to each other than hitherto recognised." And Lankester ('81) admitted the possibility of deriving the Insecta from the Isopoda, although more recently ('97) he has suggested a wide divergence between all Insects and all Crustaceans. As we have already seen, there is a close agreement in the segmentation of both head and body in the two groups. When we find further that there is a striking similarity between the Thysanuran and Crustacean mandibles, that Insects agree with Amphopods and Isopods in possessing sessile compound eyes, and that the minute structure of these eyes in certain Thysanura, as shown by Oudemans ('88), agrees with that of the Crustacean eye in the presence of a hypodermal layer, wanting in the higher Insects, between the corneal facets and the crystalline cones, it must be at least admitted that the origin of Insects from the lower Malacostraca is worthy of discussion. To imagine a close connexion between Insects and Isopods is easy on account of the adaptation to a terrestrial life shown by the Oniscidæ. But in Isopods, the hinder pair of feelers are strongly developed; while in Insects these appendages are represented only by embryonic rudiments; and the Thysanuran mandibles resemble those of the Cumacea much more closely than those of the Arthrostraca. We seem forced, therefore, to the conclusion that the base of the Insectan stem cannot be sought above the base of the whole Malacostracan series, and that such characters as the sessile condition of the compound eyes common to the Insecta and Arthrostraca have been independently gained. Nevertheless, convergence of so striking a nature could only be possible in two groups somewhat nearly akin to one another.

But if it is not possible to believe in the origin of insects from any of the orders of Malacostraca as at present developed, there is something in favour of the view that they branched off from the immediate ancestors of the Malacostraca. In connexion with this point, the remarkable Tasmanian "Arthrostracous Schizopod" Anaspides, lately described by Thomson ('94) and Calman ('96), is suggestive. In this animal, the mandible is of the Thysanuran-Cumacean type, but it possesses a palp; while the first maxilla shows much likeness to the maxillula of the Collembola. The exopodite is greatly reduced in some of the thoracic legs, and there is less distinction between the thoracic and abdominal regions than in most Malacostraca. For the ancestors of Insects and Myriapods, we must suppose animals without a carapace and with all the limb-bearing trunk-segments similar. Such forms might conceivably have existed among the earliest Malacostraca; and Anaspides and its Palæozoic allies (Palæocaris, etc.) come nearer to the ideal than any other Malacostraca known to zoologists. Nevertheless there is a great difficulty in supposing that an Arthropod with similar body-segments could be developed from one in which differentiation between thorax and abdomen had set in. On the whole, therefore, it is most reasonable to believe that the ancestors of Insects, Millipedes, and Centipedes were an offshoot from the progenitors of the primitive Leptostraca. The head and its appendages show such close correspondence in the Insects and Crustaceans, that the Tracheate branch must have arisen above the branch that had given origin to the Trilobites, in which there was no differentiation between the head- and body-limbs. The result of our inquiry, therefore, is to trace back the Insecta to ancestors that are essentially Crustacea, although Crustacea of a very generalised type.

It will now be convenient to discuss the meaning of the position of the genital aperture or apertures. In this there is a marked difference between the Insects and the Centipedes, in which the ducts open near the hinder end of the body, and the Millipedes, Symphyla, and Crustaceans, in which they open more or less anteriorly. This divergence has often been considered very radical, only explicable by imagining common ancestors with a large series of paired, segmental, cœlomic ducts which served to carry off the germ-cells. Now it is very hard to believe that the primeval Crustaceans, which seem to have been ancestral to all these classes, could have possessed such a very generalised reproductive system as that. It is impossible to suppose, on the other hand, that any sudden shifting of the genital aperture from one region of the body to another could have taken place.

Two sets of facts, when taken together, seem to give the solution of this problem. There is sometimes not absolute constancy in the position of the apertures within the same group. And if the Insects, Crustaceans, and Millipedes be compared together, it is found that the apertures of the Leptostraca and Malacostraca lie on segments of the body situated between the genital segments of the Millipedes on the one hand, and of the Insects on the other. It is found, taking the antennular segment as the first, that, in the Diplopoda, the genital ducts open between the eighth and ninth or on the ninth segment; in the Symphyla between the ninth and tenth segments; in the Malacostraca generally on the eleventh (female), and thirteenth (male); in most Insects between the sixteenth and seventeenth (female), and on the eighteenth (male). (See Table, pp. 354-5.)

From this survey a strong presumption arises that the median position which still characterises the Crustacea is primitive, and that a very slight shifting forwards, or a more extended but gradual shifting backwards, has led to the position of the apertures in the other classes. According to this view, the common ancestors of Insects, Centipedes, and Millipedes had the genital ducts opening about the eleventh segment. In the Symphyla and Diplopoda their position has been shifted forwards, in the Insecta and Chilopoda backwards. The structure of the ovaries in the Thysanura suggests that the genital ducts of Insects are not the representatives of some special pair of segmental organs, but longitudinal mesodermal vessels, analogous to the archinephric ducts of Vertebrates, into which the cœlomic segmental ducts open. There is no unlikelihood, therefore, in the gradual shifting far backwards of the reproductive openings among the Insects.

Relationship between Arachnids and Crustaceans.

The discusion in a former section of this essay on the relationship between the various orders of Arachnida led to the conclusion that the primitive Arachnids were aquatic animals, breathing by means of appendicular gills. Naturally, therefore, we compare the Arachnids with the Crustacea rather than with the Insecta. The immediate progenitors of the Arachnida appear to have possessed a head with four pairs of limbs, a thorax with three segments, and an abdomen with thirteen segments and a telson, only six of which can be clearly shown by comparative morphology to have carried appendicular gills. But embryological evidence enables us to postulate with confidence still more remote ancestors in which the head carried well-developed compound eyes and five pairs of appendages, while it may be supposed that all the abdominal segments, except the anal, bore limbs. In these very ancient Arthropods, all the limbs, except the feelers, had ambulatory and branchial branches; and one important feature in the evolution of the Arachnida must have been the division of labour between the anterior and posterior limbs, the former becoming specialised for locomotion, the latter for breathing. Another was the loss of the feelers and the degeneration of the compound eyes. Thus we are led to trace the Arachnida (including the Merostomata and Xiphosura) back to ancestors which cannot be regarded as Arachnids, but which were identical with the primitive Trilobites, and near the ancestral stock of the whole Crustacean class.

According to this conception of the primeval Arachnids, they early lost the Crustacean antennules; and the primitively compound eyes underwent more or less degradation. The foremost of the ordinary appendages, that, in the Crustacea, became the antennæ, took on in the Arachnida the function of cheliceræ; this homology is supported by a comparison between the antennal glands of the former class and the poison or spinning-glands found on the cheliceræ in several orders of the latter. The Crustacean mandibles seem to be represented among the Arachnida only by the palps of the Pycnogonida, while the pedipalps of typical Arachnids (ovigerous legs in the Pycnogonida) and the first pair of walking-limbs correspond respectively with the two pairs of Crustacean maxillæ. Thus we come to the hind margin of the ancient Arthropod head. (See pp. 354–5.)

Jaworowski's interpretation ('91) of the embryonic limbs of Spiders as consisting of protopodite, endopodite, and exopodite (which develops into the actual leg), would support the Crustacean relationship of the Arachnids, at the expense of the homology of the walking-legs in the two classes. In Crustacea, the endopodite is the ambulatory branch, and doubtless this is also the case in the Arachnida. The "endopodite" of Jaworowski seems to be the basal masticatory region of the appendage.

It is strange what differences of opinion have prevailed regarding the possibility of near relationship between the Trilobites and the Limuloids. For example, Bernard ('94) considers such a relationship unquestionable, deriving the Limuloids directly from the Trilobites, and referring both orders unhesitatingly to the Crustacea. Lankester ('97) also claims a relationship between the two orders; but he refers the Trilobites, despite their antennæ and biramous limbs, as well as the Limuloids, to the Arachnida. Kingsley ('94) considers the Limuloids akin to the Arachnida, and the Trilobites to the Crustacea, denying any close relationship between the two orders. According to the view here adopted, the Xiphosura and Merostomata are to be referred to the Arachnida, while the antennæ and biramous limbs of Trilobites oblige us to class them with the Crustacea. A direct descent of Limuloids from specialized Trilobites cannot be maintained, since the Merostomata, which are certainly more primitive than the

Limuloids, show less than they a superficial resemblance to Trilobites. But though the cephalothoracic carapace of Limulus does not correspond with the head shield of a Trilobite, the former may, in all probability, have arisen by the fusion of three trunk-segments with the primitive head-shield of the Proto-Trilobita. There is no difficulty in tracing back the Merostomata, the Xiphosura, and the Trilobita to a common ancestry; and thus the Arachnida as a class, like the Insecta, have been evolved from Crustaceans. Except among the Pycnogonida, where the reduction of the abdomen has necessitated a shifting forwards, the genital openings in the Arachnida are only one segment in front of the position of the female genital openings in the typical Crustacea.

The sessile eye of the Trilobites, the median telson in their more primitive genera (contrasting with the tail-furca of the Leptostraca and Phyllopoda), and the trilobite-larva of Limulus, all suggest the probability that the Arachnida arose from the base of the Trilobitan branch, rather than from the main Crustacean stem. And the loss of the antennules, together with other specialized characters, shows that the Arachnida have diverged much more widely from the Crustacea than the lowest Insecta have.

The Ancestry of the Arthropoda as a whole.

We have seen that the Insecta, the Chilopoda, the Diplopoda, the Crustacea, and the Arachnida can all be traced back to common Arthropodan ancestors, with a definite number of segments. The origin of these primitive Arthropods now demands consideration. They were distinctly Crustacean in character, so the question of their history may practically be reduced to that of the very remote ancestry of the Crustacea. Two theories on this subject need to be discussed—the older view that the Nauplius larva represents the primitive Crustacean; and the newer, according to which the Crustacea must be directly derived from Annelidan ancestors, the nauplius being regarded merely as a modified trochophore with certain adult Crustacean characters precociously developed.

As an introduction to the examination of the Annelidan theory, we must try to ascertain the relationships of the Malacopoda (Peripatidæ), since they show more Annelidan characters than any other group that can be considered as belonging to the Arthropoda. Although the Malacopoda have not jointed limbs, there need be no hesitation in grouping them with the Arthropoda, since they possess the more fundamental characters of the Phylum—the ostiate heart, the pericardium and secondarily formed body-cavity consisting of swollen blood-spaces, and the greatly reduced cœlom (Sedgwick, '87). In their soft skin and simple segmentation, these animals strongly recall the Annelids. Only three pairs of limbs (or two, if the feelers be, as believed by some, primitively pre-oral) are carried on the head, instead of the five usual in Arthropoda. But perhaps the most striking feature in which the Malacopoda differ from other Arthropods, is the presence of paired cœlomic excretory ducts in all the body-segments. These have been constantly compared with the nephridia of segmented worms.

The number of body-segments varies greatly in the different genera of the Malacopoda; and it is hard to determine whether the ancestral stock of the class had few or many segments. Bouvier ('00) regards the Tropical American genus Peripatus, with from twenty-two to over forty pairs of legs, as the most primitive, pointing out that in this genus the genital opening is situated between the penultimate legs, while in most of the other genera it is between the hindmost existing pair, those corresponding with the hindmost in Peripatus having been lost. But in their method of development, the Australian Peripatoidinæ, with their large, yolked eggs, in some cases hatched outside the body of the mother, are certainly the most primitive members of the class, the views of Sedgwick ('88), adopted by Korschelt ('99), being much more reasonable than the suggestion of Willey ('98) that the acquisition of yolk in this class has been recent. It is very interesting to note, then, that the segmentation of these animals agrees closely with that of the typical Arthropods. They have from fourteen to sixteen pairs of legs, so that, allowing for the head appendages and the lost pair of legs on the post-genital segment, we arrive at from eighteen to twenty limb-bearing segments. As regards their segmentation, therefore, the Malacopoda might have been derived from the typical Arthropodan stock, although the number of segments in the class is too variable to justify any definite theory on this subject. And such very primitive characters as the set of paired segmental organs and the simple nature of the eyes, obliges us to consider the Malacopoda as an offshoot from the far-off ancestral stock of the other Arthropodan classes. As pointed out by Sedgwick ('95) and Lankester ('97), they stand far below the rest of the Arthropoda. Any attempt to derive the Insecta directly from them, through the Chilopoda, is vain in view of the numerous correspondences between

Insects and Crustaceans—unless we are willing to explain any likeness whatsoever as the result of "convergence."

The concealed situation in which the Peripatids live might incline us to the view that they have lost an originally firm exoskeleton. Insect-larvæ that live in wood are soft-skinned, while their allies in the outer world are well armoured. Yet there is an undegraded aspect about a Peripatid that makes such a view hard to accept; and it is more reasonable to regard the type as a very ancient one that has come down, like certain Brachiopods, from a remote period, with very little modification. But granting this, do the Peripatids really help to bridge the gap between other Arthropods and Annelids? The soft skin, the simple eyes, and the segmental organs are really the only distinctly Annelidan characters of the Malacopoda, and the force of the last-named and most important of these is greatly weakened if Goodrich's view ('97), accepted by Lankester ('00), be established, that the cœlomic ducts of Arthropods (to which category the segmental organs of Peripatus must certainly be referred) have nothing to do with true Annelidan nephridia. Certainly the legs of Peripatus resemble Annelidan parapodia as little as they resemble Crustacean appendages. On the whole, then, the Malacopoda are low-type Arthropoda, of uncertain segmentation, but with the fundamental characters of the phylum, and showing only a superficially Annelidan appearance.

The question of the Annelidan ancestry of the Arthropods must remain, then, a matter for speculation. To the present writer it seems unsound morphology to compare closely the most highly-developed class of worms (Chætopoda) with the most highly-organised of all Invertebrates (Arthropoda). The presumption must always be, in such cases, that each group has become specialised along its own lines, and it is most unlikely that the one can have developed directly from the other. Both may have diverged from a common ancestry; but the closed blood-vascular system and cœlomic body-cavity of the Chætopoda point to the period of such an ancestry as immensely remote.

As contrasted with the vast difficulties involved in the transformation of Polychæte worms into Phyllopods, the derivation of the primeval Arthropods from Naupliiform ancestors by a gradual increase in the number of segments is perfectly simple; and, before many years have passed, zoologists are likely to revert to Müller's theory of Crustacean origins. The occurrence of the Nauplius larva, or its representative, in all the great groups of Crustacea back to the Trilobites raises the strongest presumption of some phylogenetic meaning;

and just as the origin of a Crustacean from a Nauplius is reasonable and natural, so the origin of the Nauplius itself from some soft-skinned, poorly-segmented trochophore-like form, is quite possible. Perhaps belief in the Rotifera as the connecting links between the Annelids and Arthropods, will yet be justified, for the divergence between the great main types of animal structure must have begun when all the life-forms were aquatic and all microscopic.

This view of the relationship between Arthropods and Annelids throws light on the origin of the Peripatids. Before they became adapted to life on land they must have been marine forms with free-swimming larvæ. The three pairs of Naupliar appendages correspond with the three pairs of appendages in the head of Peripatus. Therefore it is probable that the microscopic ancestors of the Malacopoda had acquired three pairs of appendages, but that these had not yet become jointed or chitinised. Thus the far-off ancestors of the Arthropoda gave origin to a lower soft-skinned branch, whence sprang the Malacapoda, subsequently adapted to a terrestrial life; and to a higher firm-skinned, and truly "arthropodous" branch, with a definite number of segments, from which have descended the Crustacea, the Insecta and their allies, and the Arachnida.

Conclusion.

It may be convenient briefly to sum up the principal conclusions set forth in this essay :—

1. The Arthropoda are a natural, monophyletic assemblage of animals.

2. There is exact numerical correspondence between the segmentation of typical Insects, Crustaceans, and Arachnids.

3. Such correspondence in three distinct classes cannot reasonably be explained as the result of convergent evolution from ancestors with very numerous segments, which independently became diminished to exactly the same extent.

4. The ancestral Arthropods must therefore have possessed a fixed and definite segmentation; and the various forms with very numerous segments (Phyllopods, Millipedes, &c.) have undergone abnormal elongation.

5. The Insecta, Chilopoda, and Diplopoda may be derived from common Symphylan ancestors, which branched off from the primitive Crustacea (proto-Leptostraca).
6. Among the Crustacea, the Leptostraca and the Trilobita show the most primitive characters. The proto-Trilobita had the typical Arthropodan number of segments.
7. The Arachnida, including the Merostomata, Xiphosura, and Pycnogonida, arose from the proto-Trilobita.
8. The Malacopoda must be regarded as Arthropoda of low type. They have no close relationship to Chilopoda or Insecta, and their Annelidan affinities are doubtful.
9. The Arthropoda, as a whole, probably sprang from Naupliform ancestors, and not from well-developed Annelid-worms.

The genealogical "tree" (Plate VI.) may serve to show these conclusions in a graphic form.

[Table.

TABLE SHOWING THE NUMERICAL CORRESPONDENCE I

Segment.	Arachnida.			Crustacea.	
	Scorpionida.	Merostomata.	Pycnogonida.	Trilobita (Olenellus).	Leptostraca
1A	Ocular Segment	—		Ocular Segment	Stalked Eyes
1	Deutocerebral Segment	—		Antennules	Antennules
2	Chelicerae	Chelicerae	Chelicerae	1st Biramous limbs of Head	Antennæ
3	—	—	Palps.	2nd ,, ,,	Mandibles
4	Pedipalps	1st Legs	Ovigerous limbs	3rd ,, ,,	1st Maxillæ
5	1st Legs	2nd ,,	1st Legs ♀	4th ,, ,,	2nd ,,
6	2nd ,,	3rd ,,	2nd ,, ♀	1st Trunk limbs	1st Thoracic
7	3rd ,,	4th ,,	3rd ,, ♂ ♀	2nd ,, ,,	2nd ,,
8	4th ,,	Paddles	4th ,, ♂ ♀	3rd ,, ,,	3rd ,,
9	Pre-genital Segment	Metastoma	[Abdomen greatly reduced & condensed]	4th ,, ,,	4th ,,
10	Operculum ♂ ♀	Operculum ♂ ♀		5th ,, ,,	5th ,,
11	Pectines	1st Gill-plates		6th ,, ,,	6th ,,
12	1st Lung-books	2nd ,,		7th ,, ,,	7th ,,
13	2nd ,,	3rd ,,		8th ,, ,,	8th ,,
14	3rd ,,	4th ,,		9th ,, ,,	1st Pleopods
15	4th ,,	5th ,,		10th ,, ,,	2nd ,,
16				11th ,, ,,	3rd ,,
17	1st Tail-Segment			12th ,, ,,	4th ,,
18				13th ,, ,,	5th ,,
19				14th ,, ,,	6th ,,
20				15th ,, ,,	Limbless Se- ment
21	Anal Segment	Anal Segment		Anal Segment	Anal Segme
	Telson	Telson		Telson	Furca

The line after Segment 5 indicates the hind-margin of the primitive Arthropodan Head.

EGMENTATION BETWEEN THE CLASSES OF THE ARTHROPODA.

alacostraca (Astacus).	Insecta (Machilis).	Symphyla (Scolopendrella).	Diplopoda (Polyxenus).	Chilopoda (Lithobius).
alked Eyes	Ocular Segment	—	Ocular Segment	Pre-antennal rudiments (Scolopendra)
ıtennules	Feelers	Feelers	Feelers	Feelers
ıtennæ	Tritocerebral Segment	—	—	Tritocerebral Segment
andibles	Mandibles	Mandibles	Mandibles	Mandibles
t Maxillæ	Maxillulæ	Maxillulæ	Gnathochilarium	1st Maxillæ
ıd ,,	1st Maxillæ	1st Maxillæ		2nd ,,
t Maxillipeds	2nd Maxillæ (Labium)	2nd Maxillæ	[Vestigial Segment]	Poison-feet
d ,,	1st Legs	1st Legs	1st Legs	1st Legs
d ,,	2nd ,,	2nd ,,	2nd ,,	2nd ,,
ıelæ	3rd ,,	3rd ,,	3rd ,, ♂ ♀	3rd ,,
t Legs	1st Abdominal Segment	4th ,, ♂ ♀	4th ,,	4th ,,
d ,, ♀	1st Abdominal Limbs	5th ,,	5th ,,	5th ,,
d ,,	2nd ,, ,,	6th ,,	6th ,,	6th ,,
h ,, ♂	3rd ,, ,,	7th ,,	7th ,,	7th ,,
t Pleopods	4th ,, ,,	8th ,,	8th ,,	8th ,,
d ,,	5th ,, ,,	9th ,,	9th ,,	9th ,,
d ,,	6th ,, ,,	10th ,,	10th ,,	10th ,,
h ,,	7th ,, ,, ♀	11th ,,	11th ,,	11th ,,
n ,,	8th ,, ,, ♂	12th ,,	12th ,,	12th ,,
	Cercopods	Reduced Limbs	13th ,,	13th ,,
opods		Cercopods	Limbless Segment	14th ,,
ıal Segment	Anal Segment	Anal Segment	Anal Segment	15th ,,
lson				Genital limbs ♂ ♀
				Anal Segment

The signs ♂ ♀ indicate the positions of the male and female genital openings, respectively.

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X.

THE INTRUSIVE GNEISS OF TIRERRILL AND DRUMAHAIR.

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Read June 8, 1903.

The beautifully contrasted scenery between Ballysadare and Manorhamilton, in the counties of Sligo and Leitrim respectively, is due to the ridge of ancient gneiss, with its irregular and rounded summits, which here appears through Lower Carboniferous strata. On the south-east rises a broad upland, that culminates in the coal-field of Lough Allen; on the north-west, the Carboniferous Limestone weathers out in huge scars and terraces, from the cliffs of Glenade and Benbulben, to the massive outlier of Knocknarea.[1] The conspicuous gneissic axis, running north-east and south-west, in continuation of the line of the Ox Mountains, has been the subject of various investigations.

By its general character and trend it is to be classed with the Caledonian folds of M. Bertrand, as a mass which was brought into its present position by earth-movements in earliest Devonian times. In this it agrees with the main axes of folding throughout the county of Donegal; but it is well recognised that the rocks thus brought into prominence and re-arranged may be much older than the Caledonian epoch of earth-movement. Prof. Hull[2] included the gneiss now under consideration "provisionally" in his Laurentian group; and I cannot bring forward any conclusive proofs that it is of later age than the close of the Archæan era. The Hercynian movements sent earth-waves against it, which uptilted the Carboniferous strata on its flanks, while preserving its north-east and south-west trend. As

[1] Compare A. B. Wynne, "On the Geology of Parts of Sligo, &c." *Journ. Geol. Soc., Dublin*, vol. x. (1863), p. 34.

[2] "On the Laurentian Rocks of Donegal and of other parts of Ireland." Trans. R. Dublin Soc., vol. i. (1882), p. 252.

the Geological Survey Maps, sheets 43 and 55, so excellently show, faults were at the same time produced, which enabled the ancient crystalline mass to assert itself above the denuded Carboniferous Limestone as a "horst."

Those who have hitherto examined the gneiss of the ridge do not seem to have greatly concerned themselves with its mode of origin. Mr. G. H. Kinahan[1] classes the gneiss of the Ox Mountains, with other western gneisses, as a highly altered sedimentary series. In dealing with such rocks in Galway, he speaks[2] of schists that graduate into "metamorphic granite and granitoid gneiss"; even when he states that "rocks of the older groups are absorbed into the granite and gneiss," it appears that we must not read into these words the modern view that the granite is intrusive and is responsible for much of the metamorphism. The words "changed into gneiss or granite" occur later, and indicate the prevalent attitude of the Irish surveyors twenty years ago. Mr. E. T. Hardman's[3] paper, in the same volume, is a solid contribution to the geology of the Ox Mountains, and deals specially with the north-east portion of the range. The gneiss is clearly regarded as of sedimentary origin, and attention is called for the first time (p. 358) to "a curious band of conglomerate," near Ballydawley Lake, consisting of "a coarse granitoid gneiss, containing lenticular blocks and rounded pebbles of diorite or hornblendic rock weathering out on the surface." The importance of these inclusions as indicating some earlier mass of hornblendic rocks is duly noticed.

The mineral notes in Mr. Hardman's paper are somewhat incomplete, and are subordinate to a very detailed description, by the author and Prof. Hull, of the dyke of serpentine in the valley of Correagh. I venture to question if olivine is disseminated in the gneiss at any point, as is implied on p. 361; the granules observed were probably a green pyroxene, like that derived from eclogite in Glennagoolagh. Very scant justice, on the other hand, is done to garnet, which simply abounds throughout the range.

The Memoir to Sheet 55 of the Geological Survey of Ireland was written by Mr. J. R. Kilroe, and was published in 1885. Simultaneously Mr. A. B. Wynne's Memoir to Sheets 42 and 43 appeared, which includes the gneissic areas of the Rosses and Manorhamilton.

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[1] "Palæozoic rocks of Galway and elsewhere in Ireland, said to be Laurentians," Sci. Proc. R. Dublin Soc., vol. iii. (1882), p. 348.

[2] *Ibid.*, p. 353.

[3] "On the Metamorphic Rocks of Counties Sligo and Leitrim, and the enclosed minerals," *ibid.*, p. 357.

Both authors speak of the "bedding" of the gneiss; and the general variations in its structure are well described. Mr. Kilroe[1] notes its tendency to pass into quartzite, by the disappearance of felspar and mica; and these quartzose areas are shown upon the map. The same author lays proper stress on the hornblendic inclusions observed by Mr. Hardman, and gives excellent figures of them. He declines, however, to regard the rock as a conglomerate, and makes the important observation that "thin streaks of hornblendic schist and gneiss also occur in the same place which bifurcate, and thus become lost in the containing rock." Sir A. Geikie is quoted in a foot-note as considering the basic masses as "geodes—segregations of hornblende rock in the gneiss." At that date this was the common way out of all such difficulties, and Professor Sollas[2] was probably one of the first British geologists to enter a protest against the assumption of local segregation as opposed to igneous absorption and inclusion.

From experience gained in southern and central Donegal,[3] I was led to conclude that these interesting rounded masses of amphibolite, and the conspicuous banding of the gneiss throughout the ridge, were phenomena of igneous intrusion, *i.e.*, that a granite magma had penetrated an earlier series of rocks along the axis of the Ox Mountains. Nothing could be better, from this point of view, than Mr. Kilroe's descriptions and figures of the phenomena near Ballydawley Lough; and it is noteworthy that this author refrained from drawing any conclusion on his own account. I am fortunately able to add details of similar features from other portions of the baronies of Tirerrill and Drumahair, which will, I think, materially assist in a correct appreciation of the ground.

Taken as a whole, the gneiss of the area may be regarded as a granitoid rock, consisting of quartz and potash-felspar, fairly free from mica, but occasionally containing biotite. The micaceous portions are arranged in strings and bands, and sometimes impart a superbly gnarled and striped character to the mass. In the townlands of Dromore, Crossboy, and Killery, east of the Correagh or Slishwood valley, white quartz-veins have penetrated the rock along

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[1] Memoir to sheet 55, p. 15.

[2] "Relation of granite to gabbro of Barnavave," Trans. R. I. Acad., vol. xxx. (1894), p. 502.

[3] "On metamorphic rocks in Eastern Tyrone and Southern Donegal," Trans. R. I. Acad., vol. xxxi. (1900), pp. 453 and 464.

"On composite gneisses in Boylagh," Proc. R. I. Acad., vol. xxiv., section B (1902), p. 203.

the foliation-layers, and still further emphasise its handsome structure. In Castleore, on the other hand, just above the Correagh hamlet, the quartzose type prevails, and may easily be taken for a true quartzite in the field. In sections under the microscope, however, the rock is seen to be still felspathic, and a good type of that fluidal aplite, affected locally by pressure, which forms the basis of the gneiss of north-west Ireland.

In Castleore, the rocky bosses of brown gneiss show a delicate banding, which is mainly due to abundant strings of garnets carried out along the general lines of flow (fig. 1). Where blocks of amphi-

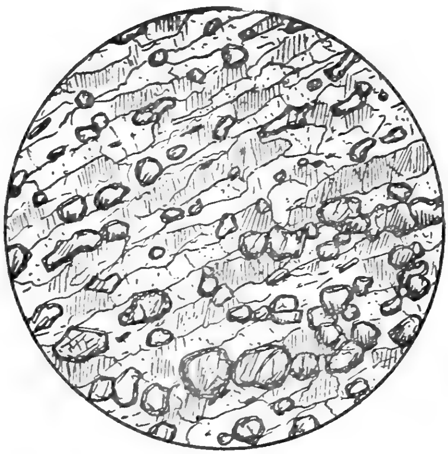

Fig. 1.

Microscopic section of fine-grained gneiss (fluidal aplite) with abundant garnet. Castleore. × 18. The garnet is derived from the included eclogites and amphibolites.

bolite occur in the gneiss, the banding becomes emphasised, and the flow-surfaces fold round them. At its junction with one large mass, the gneiss sends off dykes into the amphibolite, and cuts into it along a zig-zag surface, the flow-lines following the serrated margin (fig. 2). The appearance of sharp folds thus produced in the gneiss is due to its having worked its way into the amphibolite along joints or planes of weakness. In one place a dyke arose; in another the amphibolite became deeply notched; and the crest of the "infold" of gneiss occupying the notch sometimes runs on as a thin sheet into the crack which determined its position. The case is conclusive against the production of the foliation in the gneiss by subsequent pressure. The banding is due to primary flow; the metamorphic effect of the hot magma on the amphibolite can be clearly traced; and the accumulation of garnets locally in the gneiss, at the expense of the amphibolite, is easily observable in the field.

The absence of marked alteration in the colour of the aplitic gneiss indicates, however, that little absorption of basic amphibolite has here gone on. I have elsewhere[1] given reasons for regarding streaks and layers of garnet in this type of gneiss in north-west Ireland as distinctly derivative; but we may conceive that the foreign material absorbed in Castleore was a series of quartzites, schists, and limestones, containing only a few basic igneous rocks. In this and similar cases, we may picture the garnets as arising during the early stages

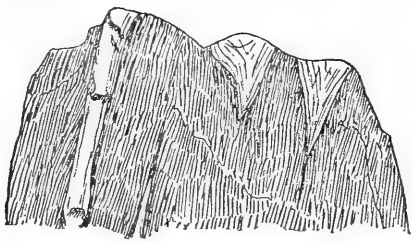

Fig. 2.

Dykes and trough-like intrusions of gneiss (fluidal aplite) in amphibolite, Castleore. From a photograph by the author. Width of the block shown, 80 cm.

of metamorphism of the invaded masses, and then being carried off, and frequently dissolved, in the dominant intrusive rock, which in the first instance promoted their growth along the contact-zone. In other cases they may have formed a constituent of an already metamorphosed and schistose series, into which a granitic magma penetrated, inducing the formation of sillimanite, altering amphibole to biotite, but without effecting much else in the way of crystallisation.

In confirmation of the above observations, it should be stated that in a section in the Geological Survey collection, cut from a granulitic gneiss near Slishwood, the garnets are associated with patches of biotite,

[1] *Op. cit.*, Trans. R. I. Acad., vol. xxxi., p. 457; also p. 456.

which is probably a relic of amphibole, absorbed into the aplitic intruder. Again, on the rocky crest about one mile from Drumahair, beside the mountain-road to Lurganboy, the various stages of absorption can be traced with the unaided eye. Lumps of amphibolite seem to swim in the gneiss, and to fade off into it, as if melting before our eyes. The gneiss becomes enriched with streaks of basic matter, in which biotite begins to predominate over amphibole. Over a wide area it passes into a banded biotite gneiss, in which the lens easily reveals the pale brown garnets, derived from the amphibolite, still surrounded in most cases by a retinue of biotite-flakes. A mile westward, in Stonepark, down against the road to Lough Gill, the evidence of the intrusive character of the Leitrim gneiss is still more marked. The blocks of dark included rock here consist of eclogite, containing a deep green pyroxene, abundant garnet, magnetite, quartz, granular triclinic felspar, and a variable but subordinate amount of hornblende and brown mica. On the margins, in contact with the gneiss, biotite has freely developed, so that some lumps, before they are broken across, resemble mica-schist. Biotite similarly appears along the margins of the aplitic veins sent off into the larger masses of eclogite from the gneiss.

The gneiss of Stonepark is in consequence beautifully flecked with dark absorption-products, grouped along the lines and surfaces of flow. Under the microscope these black flecks prove to consist largely of biotite and garnet (fig. 3), as in the slide prepared by the Geological Survey from the Slishwood mass. Muscovite, however, is also present, and here and there a prism of pale pyroxene remains. Isolated garnets lie in the gneiss, which is also speckled by a number of crystals of a spinelloid. This black mineral, by its red alteration-products, seems to be ordinary magnetite, which is an abundant constituent of the amphibolites.

I have similarly no hesitation in assigning a composite origin to a rock styled "hornblende-omphacite-gneiss," No. 1966 of the Survey collection, from the east end of the metamorphic area of the Rosses. Another slide in the same collection, from the south of Lough Cooney, and about one and a half miles south-west of Ballysadare, shows clearly the derivation of garnetiferous material from the amphibolite. The label, "amphibolite penetrated by granite," indicates that a revision of the area by the officers of the Survey would probably have led to the conclusions expressed in the present paper. No suggestion, however, as to the relations of the granites to the amphibolites is given in the "Guide to the Collections of Rocks and Fossils," published in

1895 (p. 52), though important remarks on the structure of the Ox Mountains appear on p. 42 of that valuable work. Here it is stated, however, that the amphibolites penetrate the gneiss in the region to the west. This is contrary to my experience elsewhere. It is of interest also to observe that the geological map of Sir R. Griffith, edition of 1855, shows a patch of "gneiss passing into granite" on Benbo, near Manorhamilton. This gives us no clue, however, as to whether the granite was regarded as intrusive; we may almost safely presume that the metamorphic view was then adopted.

Fig. 3.

Microscopic section of gneiss, with inclusions of light and dark mica, garnet, and pyroxene, derived from the adjacent eclogites. Stonepark, near Drumahair. × 18.

A variation on the prevalent type of composite gneiss is seen in the strongly banded masses east of Castleore. A granulite with pale pyroxene and biotite has here arisen, with obvious residual inclusion-flecks containing both these minerals. I have not been able to trace the original pyroxenic rock in this instance; but colourless pyroxene occurs in many of the amphibolites and eclogites of southern Donegal. Such basic crystalline rocks arise as products of metamorphism from very different materials, when these become invaded by and immersed in a granite magma; and the variety of mineral constitution in the

Leitrim gneiss points to a corresponding variety in the rocks forming the more ancient series traversed by it.

The characteristic blocks of hornblendic rock in the gneiss are well seen again at the north-east termination of the chain, in the townland of Pollboy, $1\frac{1}{2}$ miles west of Manorhamilton (fig 4). The basic inclusions, which do not seem to have attracted attention in this area, are as striking as those of Glennagoolagh, near Ballydawley Lough. They similarly weather away more rapidly than the surrounding gneiss, leaving in places mere lenticular cavities. In section they resemble dull and altered diorites, rich in hornblende.

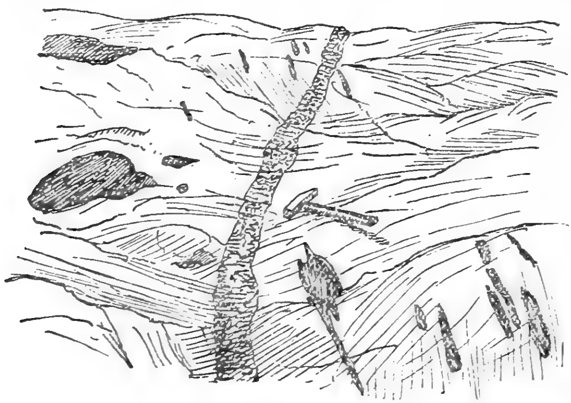

Fig. 4.

Glaciated surface of banded gneiss, showing included blocks of amphibolite (aphanite and diorite), which are often drawn out parallel to the general flow. A dyke of later granite cuts the whole. Pollboy, near Manorhamilton. From a photograph by the author.

The gneiss has here become much darkened by biotite, and is traversed by later veins of coarse white granite, corresponding with those so frequently seen in Donegal.

Returning now to the instances of amphibolite originally observed by Mr. Hardman, we have no difficulty in recognising them as inclusions in the gneiss.

The typical gneiss in Glennagoolagh is banded and rich in biotite; and garnet and green pyroxene occur in the micaceous bands. The rock is obviously darkened in the neighbourhood of the inclusions, which consist of amphibolite, rather poor in garnet. Neither in the Survey collection nor my own have I found an eclogite from this area; yet the handsome occurrences of eclogite in Stonepark make it probable that some such rock has furnished the green pyroxene to the gneiss of Glennagoolagh. The marked banding of the gneiss is again clearly associated with an abundance of inclusions; and we have now sufficient evidence from various parts of Tirerrill and Drumahair to show that this is a normal characteristic.

The gneiss, then, of the ridge on the south side of Lough Gill repeats the features of the granite floor of Donegal, and was probably formed during the same epoch of intrusion. It has certainly absorbed a Dalradian series on its margins; and one is tempted to regard it as of the same age as the Caledonian earth-movements. Yet we must remember that the Gotlandian (Upper Silurian) conglomerates of Lough Nafooey, in County Galway, contain pebbles of granite, associated with quartzite, and prove that an earlier intrusion of granite had taken place in these western highlands. It is always possible that the composite rocks formed in Archæan times may have been brought to the surface at a far later epoch, and that they then underwent a certain amount of mechanical deformation. While I do not think that such deformation is a prominent feature in Tirerrill and Drumahair, it has been sufficient in other cases to lead to a misapprehension as to the origin of the banding and flow-structure throughout the gneissic mass.[1]

In conclusion, now that the composite origin of banded gneiss is becoming a matter of general acceptance by geologists, it is well to refer back to the views of M. Michel Lévy, summarised by him in 1887.[2] Sixteen years ago M. Lévy emphasised the similarity between more recent ribboned gneisses, formed by parallel intrusions of granite into metamorphosed sediments, and the ancient yet complex masses, which were commonly regarded as the primitive crust. Sederholm in Finland, working on the earlier masses, and Duparc and Mrazec, dealing with far more modern intrusions on Mont Blanc, may be cited among those who have verified the master's generalisations. Similar views have even found their way into the text-books; and now that Mr. A. Harker[3] has given us a convincing study of a

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[1] Compare *op. cit.*, Proc. R.I. Acad., vol. xxiv, sect. B., pp. 220 and 221.

[2] "Sur l'origine des terrains cristallins primitifs," Bull. Soc. géol. de France, 3me. sér., t. xvi. (1887–8), pp. 102–113.

[3] "The Overthrust Torridonian Rocks of the Isle of Rum, and the Associated Gneisses," Quart. Journ. Geol. Soc. London, vol. lix. (1903), pp. 207–215.

Cainozoic example in the Isle of Rum, we may be sure that the theory of the formation of banded gneisses by admixture will receive adequate recognition throughout the British Isles.

As will have been seen, I am much indebted to the officers of the Geological Survey for permission to examine the specimens and rock-slices in their collection. Mr. A. M'Henry has been especially generous in discussing material gathered by himself from the Ox Mountains, which will form the basis of a report to be presented by him shortly to the Academy; and I am glad to think that our views are likely to be in complete harmony as to the intrusive nature of the gneiss.

XI.

REPORT ON THE OX MOUNTAIN ROCKS AND THEIR PROBABLE CONTINUATION FROM GALWAY AND MAYO INTO DONEGAL, TYRONE, AND LONDONDERRY.

By ALEX. M'HENRY, M.R.I.A.

Read June 22, 1903.

The range of hills of which Slieve Gamph and the Ox Mountains form the main portion, begins a little to the north-west of Castlebar, and continues in a somewhat sinuous north-east course past Foxford, Coolaney, and Lough Gill to Manorhamilton, where the older rocks forming it sink beneath the Carboniferous strata of the plain, which formation bounds the range on both sides along its whole course of sixty-five miles.

The several great divisions of the metamorphosed sedimentary rocks of the range are similar in every respect to those lying to the west in Galway and Mayo, and are, in fact, a continuation of them. These rocks were originally considered by the Geological Survey to be mainly metamorphosed Lower Silurian strata;[1] and this opinion I believe to be correct; with the exception that in places, such as south of Clew Bay, in Croagh Patrick Mountain, rocks of Upper Silurian age must be included in the metamorphosed group, as was proved by my colleague, Mr. Kilroe.[2]

The main divisions of this metamorphosed sedimentary series that are so persistently and well recognised in other districts in Ireland are well marked at several places in the south-west end of the range, to the north of Castlebar, and to the east and north-east of Foxford, in the vicinity of Loagh Talt.

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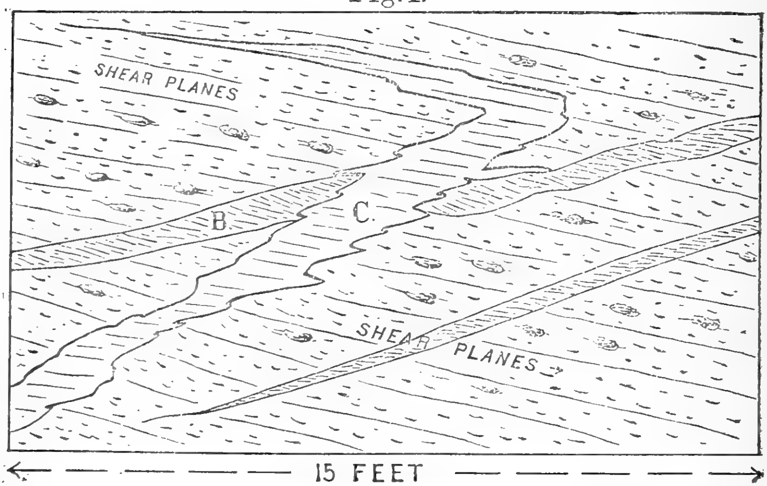
[1] Explanatory Memoirs of the Geological Survey of Ireland, Sheets 73, 74, 83, and 84 (1876), and Sheets 93 and 94 (1878).

[2] Annual Report of the Geological Survey for the year 1896, p. 50.

These divisions consist of quartzite at the top of the series, then a pebbly or conglomerate zone ("Boulder Bed"), which passes down into a limestone that is sometimes also pebbly. Associated with the limestone, and mostly below it, comes a series of black shales and grits, the shales being sometimes graphitic, and the lowest of all a great series of pebbly grits, with occasional thin black shale or schist beds, which in the south-western extension of the series north of Castlebar, around Westport, and along the south shore of Clew Bay, have been locally designated by myself and my colleague, Mr. Kilroe, as the "Westport grits."

Fig. 1.



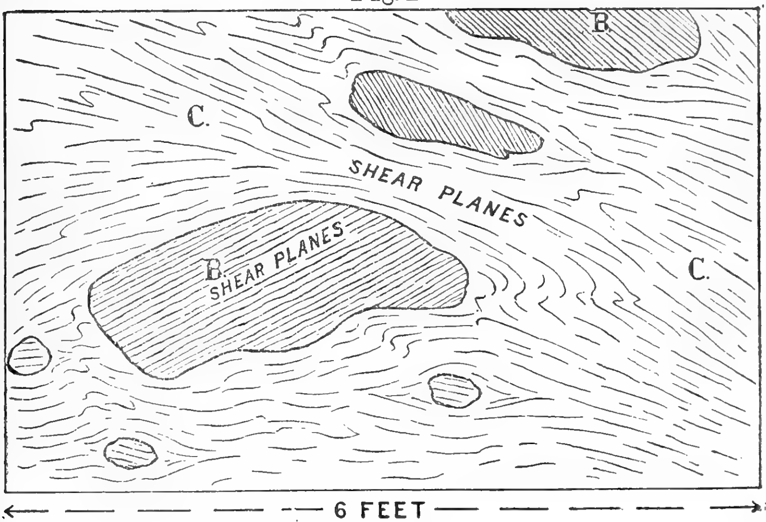
Sheared pebbly grit (quartzite) cut by early basic (B.) and later acid granulite rocks (C.), the whole series having been subjected subsequently to still later shearing.

West side of Derryclare Lake, Connemara.

This metamorphosed sedimentary series has been extensively invaded by a complex of basic and acid igneous materials, and shows great alteration both by contact with the igneous intrusions, and the later earth stresses that probably accompanied, and evidently succeeded, those intrusions. In many places the limestone, where it has been invaded and enveloped by the acid igneous masses, is converted into a whitish saccharoid marble with garnets developed in it, exactly like the similarly circumstanced limestones of Donegal and Galway, or into a serpentinous rock when the igneous masses of contact are basic.

Examples of the former class of metamorphism occurs in the vicinity of Lough Talt, which lies in a north-west cross glen dividing the Slieve Gamph from the Ox Mountain portion of the range, also at one or two places to the north-west of Castlebar, while along the north lower slope of Croagh Patrick Hill the serpentinous variety is developed, as well as to the north of Castlebar, and elsewhere at many points in Connemara. To the north of Castlebar, and between

Fig. 2.



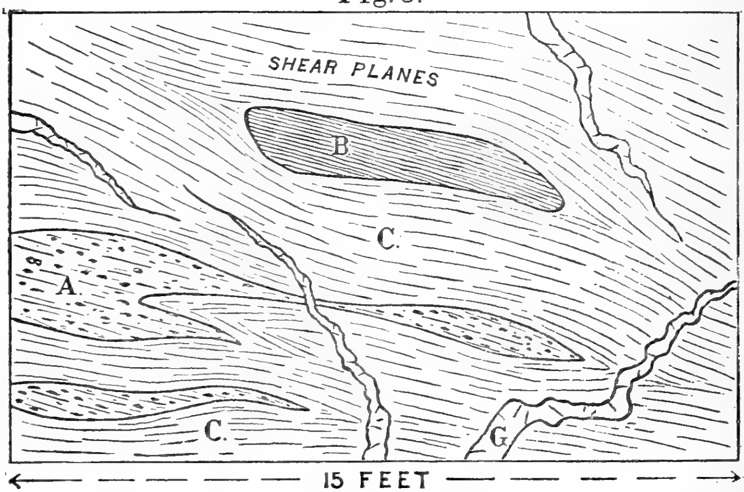
Inclusions of early sheared basic rock (B.) in later sheared acid granulite (C.).
N. of Ballydawley Lake, 4 miles S. of Sligo.

it and Westport, the lowest pebbly grits are in strong evidence, and show the passage stages and conditions from an original conglomeratic grit or sandstone into a quartzite; the metamorphism may be due, however, to dynamic metamorphism, rather than to actual contact with igneous masses. The quartz pebbles in this quartzose grit or conglomerate can be seen to have been crushed and drawn out in a remarkable manner, sometimes into riband-like forms, and even the drawn out pebbles, puckered and contorted by subsequent movement, and folding in the rock mass.

Interbedded with those pebbly grits, there are black shales, which but for the amount of deformation, through movement in the rock mass that they have undergone, are closely similar to Ordovician shales, from which fossils of Llandeilo types have been obtained.

Of the two varieties of igneous intrusions, the basic is the earlier, abundant and conclusive evidence existing at many points to prove this fact (fig. 1). After the basic came an acid intrusion which affected both the basic igneous and the sedimentary rocks to a considerable extent, large masses of both these (basic rocks and sediments) in a highly mineralized condition being included in the

Fig. 3.



(C.) Acid granulite enveloping sediments (A.) and early basic igneous rocks (B.), with later uncrushed granite (G.).

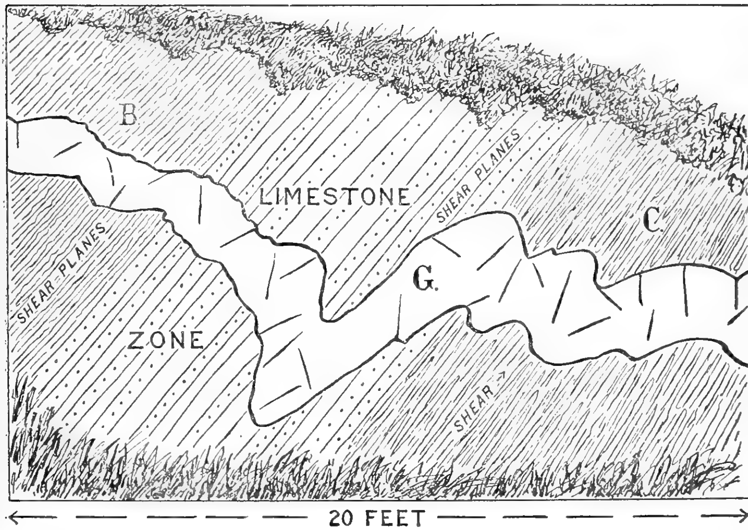
Near Maam Cross, Connemara.

granulitic or second igneous intrusion (fig. 2). Subsequent to the period of this acid intrusion, intense earth stresses took place, which resulted in a milling out, shearing, and banding of all three varieties of rock, thus forming those banded gneissose rocks and sheared or bedded-like rock-masses as they now exist, and which were considered by some authorities to be metamorphosed early Palæozoic sediments, and by others to belong to a more ancient or Archæan period.

Subsequent to the intrusion of the basic rock, and prior to the first acid one, a certain amount of movement in the rock-masses took place, as is shown by the sheared and banded condition of the inclusions of the earlier rock in the acid granulites (fig. 3). A still later intrusion of granitic material took place, the masses and veins of which only occasionally show signs of deformation from earth-stresses (fig. 4).

Regarding the probable age of the two earlier intrusions of basic and acid materials, they are at least pre-Old Red Sandstone, as the

Fig. 4.



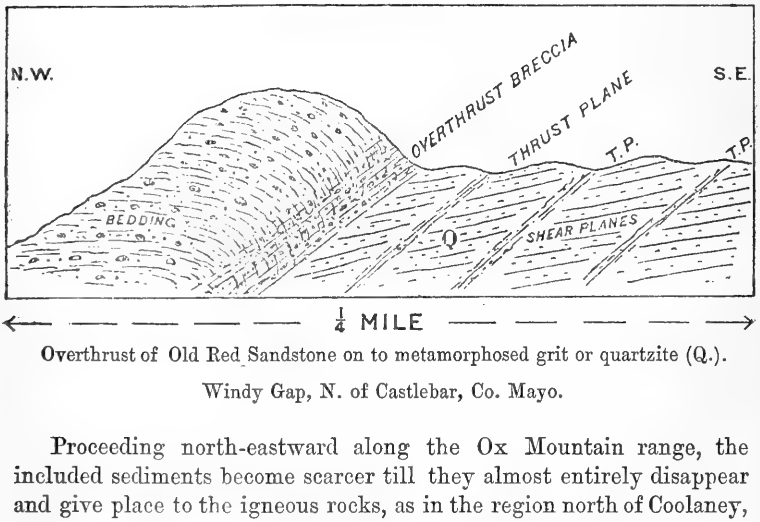
Early basic igneous rock (B.) and later acid granulites (C.) invading the sedimentary limestone zone, all three groups having been subsequently sheared together, and later uncrushed granite vein (G.).

Five miles E. of Clifden, Connemara.

massive conglomerates of this latter formation are largely composed of the detritus of all the varieties of igneous rocks and the associated sediments into which they intrude. Besides, they are seen to rest truly unconformably on them at many places. Therefore, if it be acknowledged that the altered sedimentary rocks are of Ordovician and early Silurian age, it is most likely that the period of this igneous complex belongs to early Devonian time. In my opinion they are the equivalents of, and belong to the same period as, the granites and associated earlier basic igneous rocks of Leinster, which are admittedly of Devonian age.

The relations of the Old Red Sandstone and metamorphic series can be seen in the neighbourhood of Windy Gap, to the north of Castlebar. Here also can be noticed the effects of the post-Old Red Sandstone movement, or overthrusting of the later Old Red Sandstone on to the older metamorphosed rocks, and the formation between the two series, at this place, of a pseudo-conglomerate or zone of fault and crush breccia, 40 feet and more in thickness, the breccia being made up of the broken-up materials of both series, re-cemented into a compact rock mass (fig. 5).

Fig. 5.



Overthrust of Old Red Sandstone on to metamorphosed grit or quartzite (Q.).

Windy Gap, N. of Castlebar, Co. Mayo.

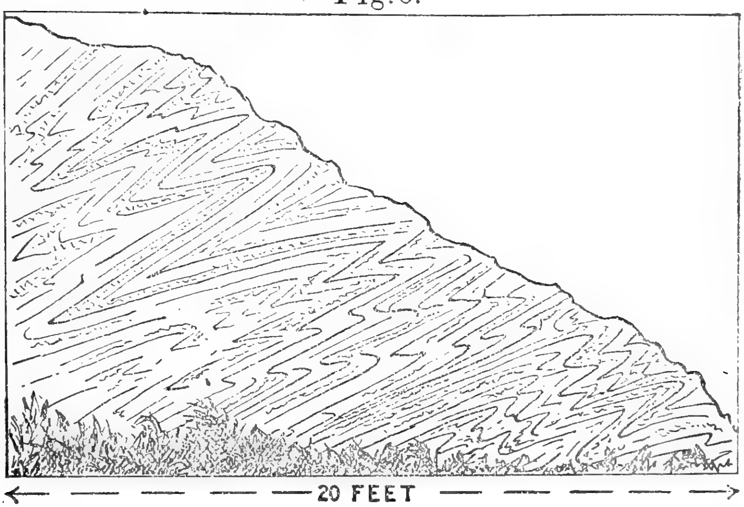
Proceeding north-eastward along the Ox Mountain range, the included sediments become scarcer till they almost entirely disappear and give place to the igneous rocks, as in the region north of Coolaney, south of Lough Gill, and west and north of Manorhamilton. As previously mentioned, the simulation of bedding seen in those rocks to the south of Sligo and elsewhere is not due to sedimentation or deposition, as originally supposed, but, on the contrary, is entirely due to movement and shearing of the rock masses (fig. 6).

It may be mentioned that a small ridge of similar deformed rocks crops out from beneath the Carboniferous strata a few miles to the north-west of Sligo, in the Rosses peninsula.

The general characters of the Ox Mountain rocks are again repeated in south Donegal, in the region to the north of Pettigo, and about Lough Derg. The intrusive rocks of this area have been described as Archæan on the late editions of the Geological Survey Maps of that district. At one time I believed them to belong to this group; but I now consider them to be contemporaneous with the rocks of the Ox Mountain chain, *i.e.* early Devonian.

Continuing north and north-east into Donegal and Tyrone, and on to Londonderry, we have repetitions of the Ox Mountain series, both in the character and the conditions of the rocks, *i. e.* quartzite, "Boulder Bed," limestone zone, black schist or slate, and the lowest pebbly grit, and with the basic and acid intrusions in the same order of sequence.

Fig. 6.



Contorted and crumpled shear structure in complex of basic and acid igneous rocks, simulating bedding.
Four miles W. of Coolaney, Co. Sligo.

In Fanad area, Donegal, to the north of Knockalla Mountain, we find the metamorphosed sediments (quartzite) overthrust on to the Old Red Sandstone, with a zone of crust or overthrust breccia along the line of movement, the direction of the overthrust being to the north-west, here again proving the occurrence of great earth-stress in post-Old Red Sandstone times.

As in the case north of Castlebar, the intrusions of igneous rocks were prior to the folding and shearing, and both sediments and igneous rocks were folded and sheared out together before the disposition of the Old Red Sandstone, as is shown by the contained stones of the former in the latter.

Throughout Donegal, Tyrone, and Londonderry similar conditions and varieties of rocks are found to exist, namely, a lower pebbly grit series, with their black shale or schist beds, probably of Llandeilo age, then a passage upwards into black shales or slates greatly deformed by movement, and sometimes pyritous, above them the limestone zone, probably of Bala age. On top of the limestone that remarkable and important deposit, the "Boulder Bed," is always found to exist. This "Boulder Bed" has been identified all over Donegal, Mayo, and Galway in varying thickness, and from its general appearance and characteristics it is probably an older Palæozoic Glacial Boulder Clay Deposit which marks a possible break between the Ordovician and Silurian series. The boulders in it are almost entirely of an unfoliated granite, unlike any granitic rock at present seen at the surface in Ireland. They are angular and sub-angular, and occasionally rounded in form, and but thinly distributed in a fine-grained matrix; occasionally blocks measuring 3½ feet across can be seen, as in the Fanad area, Donegal.

The limestone, where seen, always underlies the "Boulder Bed," and is occasionally quite pebbly, as at Carndonagh and other places in Donegal, as well as in Counties Galway and Mayo. The known fossiliferous Bala Limestone rocks in the west of Ireland, at Rossroe and Tourmakeady, at Caherconree, in Kerry, and at Portrane, county Dublin, and elsewhere in Ireland, are occasionally found to be pebbly. It appears to me, therefore, to be a point in favour of the contemporaneity of those metamorphosed limestones of the west and north-west, and the Bala Limestone of the west, south, and east, and one well worthy of further consideration.

XII.

THE SYNTHESIS OF GLYCOSIDES: SOME DERIVATIVES OF ARABINOSE.

By HUGH RYAN, M.A., D.Sc., F.R.U.I., and
GEORGE EBRILL, B.A., Catholic University School of Medicine, Dublin.

Read June 22, 1903.

The first experiments recorded in the chemical journals for the synthetical preparation of glycosides were made by Schutzenberger.[1] From triacetylglucose and the sodium or lead derivatives of saligenin he obtained an amorphous compound, which could be hydrolysed by dilute sulphuric acid into glucose and saliretin, but which was not identical with salicin. In a similar manner a substance, which very closely resembled rhamnegin, was obtained from rhamnetin.

By the interaction of the acetochloroglucose discovered by Colley,[2] and the alkali salts of the phenols, Michael[3] obtained helicin, methylarbutin and the glucosides of phenol, eugenol, and guaiacol. Using Michael's method, the glucosides of thymol and α-naphthol were obtained by Drouin,[4] and by a slight modification one of us obtained the glucosides of the three cresols, β-naphthol, and carvacrol, with the galactoside of α-naphthol, and still later the tetracetyl derivatives of the three cresyl glucosides and of β-β-naphthyl glucoside.

By the condensation of helicin in weak alkaline solution with acetic aldehyde, Tiemann and Kees[7] succeeded in obtaining o-cumaric-aldehyde glucoside. Compounds of the aldehydes and ketones with grape-sugar were prepared by Hugo Schiff[8] by the interaction of their components in acetic acid solution.

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[1] Annalen der Chemie und Physik, clx., p. 95.

[2] Ann. Chim. Phys., 1870, iv., 21, p. 363.

[3] Comptes Rendus, lxxxix., p. 355; Amer. Chem. Journ., vi., p. 366.

[4] Bull. Soc. Chim., cxi., 13, p. 5.

[5] Ryan, Journ. Chem. Soc., 1899, p. 1054; Ryan and Mills, Journ Chem. Soc., 1901, p. 704.

[6] Proc. Royal Dublin Soc., 1901, Vol. ix. (n.s.), iv., p. 508.

[7] Berichte, xviii. (1885), pp. 1955, 3481.

[8] Ann. ccxxiv., p. 19.

The substances obtained in this way were very hygroscopic and decomposed even by solution in water.

The most convenient and fruitful method for the synthesis of glycósides was discovered by Emil Fischer.[1] In the first instance, he condensed the sugar with an alcohol or mercaptan, in presence of a large excess of cold, strong hydrochloric acid. The later and more convenient method consisted in heating the sugar and alcohol with a small quantity of hydrochloric acid.

In this way Fischer and his pupils obtained the glucosides of methyl, ethyl, propyl, and benzyl alcohols, of glycol and of glycerine, of dimethyl acetal, of ethyl, amyl, benzyl, ethylene, and trimethylene mercaptans; the galactosides of methyl and ethyl alcohols, of ethyl, benzyl, and ethylene mercaptans; the mannosides of methyl alcohol, of ethyl, and ethylene mercaptans; the fructoside of methyl alcohol; the glucoheptosides of methyl alcohol and ethyl mercaptan; the rhamnosides of methyl and ethyl alcohols, of ethyl, benzyl and ethylene mercaptans; the arabinosides of methyl, ethyl, and benzyl alcohols, of ethyl, benzyl, and trimethylene mercaptans; the xylosides of methyl alcohol and the sorboside of methyl alcohol.

Although the glycosides of the monatomic phenols cannot be obtained by Fischer's method,[2] those derived from the polyatomic phenols resorcine, pyrocatechine, pyrogallol, and phloroglucine with arabinose have been so obtained. In a similar manner the glucosides of resorcine, orcine, and phloroglucine with the galactoside, fructoside, and mannoside of phloroglucine were synthesised.[3]

Another method for synthesising glycosides was discovered by Hill,[4] who found that zymohydrolysis is a reversible operation. He obtained maltose from glucose by the action of maltase; but later experiments by Emmerling[5] seem to show that the disaccharide obtained by Hill's method was isomaltose. Similarly by the action of the kephyr lactase on a mixture of galactose and glucose, Emil Fischer and Armstrong[6] obtained galactosido-glucose (isolactose).

The discovery of a method of obtaining a crystalline mother sub-

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[1] Berichte, xxvi. (1893), pp. 2400, 2928; xxvii. (1894), pp. 674, 2483, 2985; xxviii. (1895), p. 1145.

[2] Emil Fischer and Jennings, Berichte, xxvii., 1894, p. 1358.

[3] Berichte, xxviii., 1895, p. 24.

[4] Journ. Chem. Soc., lxxiii., 1898, p. 634.

[5] Berichte, xxxiv., 1901, p. 600.

[6] Sitz. der K. Akad. der Wissensch., Berlin, 1901, xii., p. 123.

stance (acetobromoglucose) by Kœnigs and Knorr[1] was an important advance in the method of synthesising glycosides. The pure, well-crystallized acetobromoglucose was converted into β-pentacetyl glucose, β-methyl, β-ethyl, β-phenyl, β-β-naphthyl, and β-carvacryl-glucosides.

A still further advance was made by the discovery of Fischer and Armstrong,[2] that anhydrous liquid halogen acids react with α- and β-pentacetyl glucoses to form well-crystallized α- and β-acetochloro and acetobromoglucoses. In this way the acetochlorogalactose, obtained as a syrup by Colley's method,[3] was isolated in the pure condition as a well-crystallized compound, and converted into β-phenyl galactoside. From the α-acetochloroglucose they obtained α-alkyl-glucosides, and from β-acetochloroglucose the corresponding β-glucosides. The failure of Fischer and Armstrong to convert acetohalogen pentoses into phenol derivatives is probably due to the ease with which the α-compound changes into the β-derivative in the presence of dilute alkali.[4]

By the action of phosphorous pentachloride and aluminium chloride on the chloroform solution of α-pentacetyl-glucose and α-pentacetylagalactose, crystallized α-acetochlorohexoses were obtained by Skraup and Kremann.[5] Acetochlorolactose was obtained by Bodart,[6] by the action of hydrochloric acid gas on dry lactose, suspended in cold acetic anhydride, which, with its isomeride, was also obtained by Fischer and Armstrong. The latter chemists also converted the analogous acetochloromaltose into β-methyl-maltoside.

The β-phenyl-maltoside obtained by Fischer and Armstrong[7] from β-acetobromomaltose was hydrolysed by emulsine to maltose and phenol. Its behaviour towards the enzyme is different from that of amygdalin, which is decomposed, on hydrolysis by emulsine into glucose, benzaldehyde, and hydrocyanic acid.

Although halogen derivatives have been most largely employed for the synthesis of glycosides, it is interesting to note that nitro-derivatives have also been successfully used by Kœnigs and Knorr.[8]

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[1] Sitz. Bayr. Akad. der Wissensch., 1900, p. 103.

[2] Sitz. der K. Akad. der Wissensch., Berlin, 1901, xiii., p. 316.

[3] Ryan, Journ. Chem. Soc., 1899, p. 1057; Proc. Roy. Dubl. Soc., vol. ix. (N.S.), p. 506.

[4] Berichte, xxxiv., 1901, p. 2885.

[5] Monatsch. f. Chem., xxii., p. 375.

[6] *V. loc. cit.*

[7] Berichte, xxxv., 1902, p. 3153.

[8] Berichte, xxxiv., 1901, p. 957.

Acetonitroglucose and acetonitrogalactose have been converted into alkyl hexosides. From acetonitromaltose heptacetyl-β-methyl maltoside was similarly obtained.

It has been shown by Ryan and Mills[1] that, by the direct action of acetyl chloride on arabinose, a well-crystallized acetochloroarabinose can be obtained. Chavanne, by the same method, afterwards[2] re-discovered the substance, obtained the corresponding acetobromoarabinose, and converted it into a crystallized tetracetylarabinose.

From acetochloroarabinose, as mother-substance, we have obtained the arabinosides of carvacrol, ortho cresol, β-naphthol, and methyl alcohol. The new glycosides resemble the corresponding phenolic hexosides in their appearance and behaviour.

Preparation of Acetochloroarabinose.

The method of obtaining this compound has been briefly described in a previous paper.[3] In further preparations the method which was found most convenient was to allow acetyl chloride (4 mols.) to act on dry, powdered arabinose (1 mol.) in a small flask (fitted with a calcium chloride tube to prevent the entrance of moisture), until the mixture had solidified to a crystalline magma. Dry chloroform was then added, and the action allowed to go on until complete solution was effected.

The chloroform solution was shaken in a funnel, washed first with water, then with sodium carbonate, separated, passed through a dry filter, dried with anhydrous sodium sulphate, and the chloroform distilled off in vacuo.

The yield from five grams of arabinose was generally seven and a half grams of crystalline acetochloroarabinose, which was sufficiently pure for conversion into phenolic glycosides. The properties of the substance given by Chavanne (*loc. cit.*) are almost identical with those previously given by Ryan and Mills (*loc. cit.*).

The acetochloroarabinose, which is a well-crystallized compound, and comparatively stable in the air, is a more convenient mother-substance for the preparation of glycosides than the impure syrupy acetochloroglucose and acetochlorogalactose previously employed.

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[1] Journ. Chem. Soc., 1901, p. 706.

[2] Comptes Rendus, cxxxiv., 1902, p. 661.

[3] Ryan and Mills, Journ. Chem Soc., 1901, p. 706.

Owing to its stability, it is even more convenient than the crystallized acetobromoglucose of Kœnigs and Knorr; and the method of preparation is simpler than that of Fischer and Armstrong for the acetohalogenhexoses.

Action of Methyl Alcohol on Acetochloroarabinose.

Acetochloroarabinose (1·6 gram) was dissolved in warm methyl alcohol (50 c.c.), and the mixture was allowed to remain at the temperature of the laboratory for four days. Silver carbonate (1·6 gram) was added, and the precipitate filtered. After evaporating the filtrate on the water-bath, the residue was dissolved in a little methyl alcohol, refiltered, and let evaporate spontaneously in a vacuum desiccator over calcium chloride. Leaf-like aggregates of crystals separated. They were free from chlorine, and did not reduce Fehling's solution before hydrolysis. After repeated recrystallizations from hot methyl alcohol, the crystals, when dried at 105° C., became soft at 159° C., and melted at 166–168° C.

Methyl arabinoside obtained by Fischer's method becomes soft at 165° C., and melts at 169–176° C. It crystallizes in needles or leaf-like aggregates, and does not reduce Fehling's solution.[1]

Action of an Alkaline Solution of Carvacrol on Acetochloroarabinose.

Slightly more than equivalent quantities of potash and carvacrol, dissolved in absolute alcohol, were added to a solution of acetochloroarabinose (7 grams) in absolute alcohol. The mixture was allowed to remain at the temperature of the laboratory for a few days. A white solid separated, and the solution smelt of acetic ester. The filtrate from the potassium chloride was evaporated on the water-bath, and the residue dissolved in water. The aqueous solution was evaporated a few times with addition of water, until the odour of carvacrol had disappeared.

The residue crystallized on cooling. The reaction had proceeded thus:—

$$CH_2\,OAc\,\overbrace{CH\,(CHOAc)_2\,\underset{\substack{|\\ Cl}}{CH}}^{O} + C_6H_3CH_3C_3H_7\,OK + 3C_2H_5OH$$

$$= CH_2OH\,\overbrace{CH\,(CHOH)_2\,\underset{O-C_6H_3\,CH_3\,C_3\,H_7}{CH}}^{O} \qquad + KCl + 3CH_3\,COOC_2\,H_5$$

[1] Berichte, xxvi., 1893, p. 2400.

The carvacryl-arabinoside was recrystallized from boiling water, and dried at 100° C. for analysis:—

$$0{\cdot}1229 \text{ g. sbst.} : 0{\cdot}2869 \text{ g. } CO_2 : 0{\cdot}0897 \text{ g. } H_2O.$$
$$C\ 63{\cdot}66, \quad H\ 8{\cdot}19$$
$$C_{15}H_{22}O_5 \text{ requires } C\ 63{\cdot}78,\ H\ 7{\cdot}87.$$

Carvacryl arabinoside ($C_5H_9O_4 \cdot O \cdot C_6H_3 \cdot CH_3 \cdot C_3H_7$) crystallizes from water in long needles, melting, when dry, at 119–120° C. It dissolves in alcohol, ether, acetone, and chloroform. It is insoluble in carbon bisulphide and toluene, and sparingly soluble in cold water, but readily in hot water. The pure substance does not reduce Fehling's solution. When heated for a short time with dilute sulphuric acid it is hydrolysed to carvacrol and arabinose. Carvacryl arabinoside differs from carvacryl glucoside in its not being more soluble in potash than in water.

Conversion of Acetochloroarabinose into β-naphthyl-arabinoside.

Acetochloroarabinose (3 grams), dissolved in absolute alcohol, was slowly added to a solution of 0·6 gram potassium hydroxide and 1·5 gram β-naphthol, also dissolved in absolute alcohol. The mixture after a few minutes smelt of acetic ester, and quickly became turbid from the separation of a white solid (potassium chloride). After remaining at the temperature of the laboratory for one day it was heated on the water-bath for a short time, and again allowed to remain for three days at the ordinary temperature. The yellow filtrate from the potassium chloride was heated on the water-bath, under the reflux condenser, for half an hour, and the alcohol then distilled off. The cold residue became solid on the addition of a little water. The product was dried on clay, washed with chloroform till colourless, recrystallized from boiling absolute alcohol, and dried at 105° C. for analysis:—

$$0{\cdot}1072 \text{ g. sbst.} : 0{\cdot}2562 \text{ g. } CO_2 \text{ and } 0{\cdot}0562 \text{ g. } H_2O.$$
$$C\ 65{\cdot}18,\ H\ 5{\cdot}82.$$
$$C_{15}H_{16}O_5 \text{ requires } C\ 65{\cdot}21,\ H\ 5{\cdot}8.$$

β-naphthyl arabinoside crystallizes from absolute alcohol in long-branching, grouped needles, which are visible and multicoloured between crossed nicols. It dissolves in cold alcohol and acetic ester. The crystals are scarcely soluble in benzene, chloroform, ether, water, or petroleum ether, but very readily soluble in hot alcohol. They melt, when dry, at 176–177° C. The arabinoside does not reduce Fehling's solution before hydrolysis, but does so readily after hydrolysis by boiling with dilute sulphuric acid for a short time.

Conversion of Acetochloroarabinose into Orthocresyl Arabinoside.

Equimolecular quantities of orthocresol, potassium hydroxide, and acetochloroarabinose were mixed together in alcoholic solution. The copious precipitate which first formed was redissolved on boiling the mixture. After remaining at the ordinary temperature for a few days, the filtrate from the precipitated potassium chloride was allowed to evaporate spontaneously, and the residual oil was dissolved in boiling water. On concentrating to a small bulk, and allowing it to stand for several days, beautiful rosettes, consisting of needle-shaped crystals, were obtained, which were dried on clay and recrystallized from water. When air-dried at 100° C. it melted at 124° C., and gave an analysis: —

0·1548 g. sbst. : 0·3364 g. CO_2, 0·0978 H_2O,
C 59·44, H 7·02,
$C_{12}H_{16}O_5$ requires C 59·95, H 6·7.

Orthocresyl arabinoside is soluble in cold water, and very readily soluble in hot water. It is insoluble in ether and carbon disulphide, scarcely soluble in chloroform or benzene, and easily soluble in alcohol or acetone, from which it separates in beautiful branching needles. The arabinoside does not reduce Fehling's solution before, but readily after, hydrolysis by hot, dilute sulphuric acid. The hydrolysed solution smelt of cresol.

Nomenclature employed.

It has been customary, up to the present, to call a substance which can be hydrolysed by an enzyme or a dilute acid to two or more bodies, one of which is a reducing sugar—a *glucoside.* The oldest and best-known members of the series are derivatives of glucose, and, in these cases, the term is a correct one. When, however, similar derivatives were obtained from another hexose, such as galactose, they should, strictly speaking, have been termed *galactosides.*

In most instances, this system has been adopted; but a difficulty is still felt in finding a suitable name for the whole series.

The term *hexoside* has been applied by me to all such derivatives of the hexoses (glucose, galactose, fructose, mannose, &c.). Analogous derivatives of the pentoses, tetroses, &c., may be called *pentosides*, *tetrosides*, &c. In general, any such derivative of a polyose may be called a *polyoside*. Although the latter term is probably the best for the whole series, I have, in the present paper, used the word *glycoside*, suggested for the same purpose by van Rijn.

XIII.

A LIST OF IRISH HEPATICÆ.

By DAVID McARDLE.

(REPORT FROM THE FAUNA AND FLORA COMMITTEE.)

Read June 22, 1903. Published January 28, 1904.

Introduction.

This paper is an attempt to give a full and reliable list of the Hepaticæ of Ireland, as they are known at the present time. It is intended to form Part II. of "Cybele Hibernica," and is based on exactly the same lines. Since the late Dr. D. Moore's death in 1879, I have continued to study the subject which he first taught me, knowing that his valuable Report on Irish Hepaticæ, which he read before the Royal Irish Academy in 1876, was preliminary to a more exhaustive work. With financial help from the Fauna and Flora Committee of the Academy, I have been enabled to make research in many counties. The results I have from time to time laid before the Academy, and for their help I offer my best thanks.

The Irish Hepaticæ have been studied with great success by the earlier botanists, notably by Dr. Taylor, of Kenmare, in Kerry, who published the result of his researches in Part II. of Mackay's "Flora Hibernica," in which seventy-five species are enumerated under the genus *Jungermania*, besides *Marchantiaceæ* and *Anthocerotaceæ*, which include eight species, making eighty-three in all.

Miss Hutchins, of Bantry, about the same period was collecting and studying Hepaticæ in Co. Cork, with rare discriminating power. Most of the plants she gathered were sent to Sir William Hooker; and one has only to turn over the pages of Hooker's grand work on the British *Jungermaniæ* to find her name more or less connected with the discovery of every rare Irish plant.

Dr. Thomas Power's "Contributions towards the Fauna and Flora of Cork," published in 1844, includes fifty species.

The late Mr. Isaac Carroll contributed largely to our knowledge of these plants in Co. Cork and elsewhere. In 1863, the late Dr. Carrington, of Manchester, published his "Gleanings among the

Irish Cryptogams"; 110 species are enumerated, and many varieties collected by him when on a visit to Ireland of eleven weeks' duration, which he spent in Kerry and Cork. He also includes in his list some stations for rare Hepaticæ, discovered by Dr. D. Moore; and some species growing in the neighbourhood of Cork by Mr. I. Carroll, and Mr. W. Wilson, of Warrington; about the same time Mr. Mitten made interesting discoveries in Co. Kerry, notably on Brandon.

In 1873, at the invitation of Dr. D. Moore, the late Professor Lindberg, of the University of Helsingfors, paid a visit to this country, and spent the months of June and July collecting Liverworts, in company with Dr. Moore, in Co. Kerry. Brandon, and a large part of the Dingle peninsula, and Killarney, got a close examination. They also collected in many parts of Co. Wicklow and Co. Dublin. The result of their trip was a collection of eighty-seven species of Hepaticæ, an account of which Professor Lindberg published in the "Acta Societatis Scientiarum Fennicæ," vol. x., under the heading, "Hepaticæ in Hibernia, mense Julii, 1873, lectæ" This was an important contribution, and included several new species.

In the northern counties, the subject has been by no means neglected, but has occupied the attention of keen observers since the days of John Templeton, A.L.S., of Belfast, one of the most acute naturalists of his time. Mr. Samuel Alexander Stewart, of the same city, has studied the subject with his characteristic care. The results of his work are published in the "Flora of the N.-E. of Ireland," and in various Reports. In 1885, in company with Mr. Holt, of Manchester, he visited Killarney, in search of Mosses and Hepaticæ. The result of their trip was the discovery of several species of Hepaticæ new to science. He has also been ably assisted by the Rev. C. H. Waddell, of Saintfield, Co. Down, and the Rev. Canon Lett, of Loughbrickland, Co. Down. The Report of the latter, which was read before the R. I. Academy in 1889, included the Mosses, Hepaticæ, and Lichens of the Mourne Mountain district. Sixty-four species of Hepaticæ are enumerated, an important list of plants collected on a wide area, which includes roughly 560 square miles. The Rev. C. H. Waddell published a valuable paper in the "Journal of Botany," 1893, on the distribution of *Lejeunea* in Ireland.

Dr. D. Moore's Report on Irish Hepaticæ in 1876 included all previous papers and work by collectors in Ireland up to that date. As to his own investigations he writes: "The Irish habitats may be relied upon, as I have collected nearly every one of the plants with my own hands at some time or other during the last forty years, having for this purpose travelled over a very large portion of Ireland, from east to west, and from north to south, and from sea-level to the tops of the highest mountains. The chief merits of this Report may indeed be considered to consist in its giving as full an account as I am able to render of the Irish Hepaticæ, and of their geographical distribution in Ireland; 137 species of them are enumerated." It will be seen from the following list that I have endeavoured to follow closely in the footsteps of this great bryologist, and have availed myself of every advantage offered to further the object. I enumerate 172 species and sixty-three varieties; some of the latter have been raised to the rank of species by authors, and they are all more or less of botanical value. To Mr. W. H. Pearson, of Manchester, and Mr. M. B. Slater, of Malton, Yorkshire, I offer my best thanks for their help in matters of doubt when investigating critical species.

Physical Features.

The physical features of Ireland are favourable for the growth of Hepaticæ. A large area is occupied by peat bogs both lowland and mountain; and large lakes lie in the central plain, with smaller and more numerous ones towards the west—as in Connemara, West Mayo, and Kerry. In the north-east, Lough Neagh covers an area of 153 square miles, and is the largest fresh-water surface in the British Islands. The Shannon is the largest river; it flows for 214 miles, and creates in its course Lough Ree and Lough Derg. The eastern part of the central plain is drained by the Rivers Boyne and Liffey, the south-eastern part by the Rivers Suir, Barrow, and Nore; while the waters of the north-eastern part are collected into Lough Neagh, chiefly by the Blackwater, and from thence discharged into the sea by the Lower Bann. The rivers outside the central plain are short; the principal ones are the Erne, flowing north-west; the Foyle and Bann to the north; the Slaney to the south-east; and the Bandon, Lee, and Blackwater flowing through Co. Cork. The bays and marine loughs are numerous and deep, penetrating inland for a considerable distance, as Lough Swilly on the north coast, Bantry Bay in the south-west, &c.

The principal mountain ranges are near the coast. The highest Irish mountain is Carrantuohill, 3414 feet, which is part of Magillicuddy's Reeks in Kerry; while westward across the Iveragh and Dingle Peninsulas lies Brandon, which rises to 3127 feet, and is the highest in the Dingle range; on the east coast ranges we have Lugnaquilla in Co. Wicklow, which reaches to 3039 feet; and the Galtees in Co. Tipperary rise to 3015 feet. In the counties of Mayo, Waterford, and Wexford, some mountains are over 2600 feet. Northwards, the extensive Ben Bulben range in Sligo rises to 2100 feet; Errigal, 2466 feet, and Muckish, 2197 feet in Co. Donegal; there are extensive ranges in Antrim and Derry; and Slieve Donard in Co. Down rises to 2796 feet.

Climate.

The moist, mild atmosphere of the south-west and south is now accounted for by the broad area covered by the south-west winds over the Atlantic Ocean (which drive the vapour-laden clouds which are condensed by the Kerry Mountains), and also by the influence of the Gulf Stream.

The mean annual temperature is about 50° Fahrenheit. The rainfall is remarkable, as may be seen from the following table for ten years. It will be observed that the increase from east to west is striking.

RAINFALL IN INCHES FOR THE TEN YEARS—1892–1901.

Counties.	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901
Co. Kerry.										
Valentia Telegraph Station,	56·06	46·36	58·30	48·88	53·39	62·22	50·26	61·56	58·72	51·54
Mangerton Mountain,	114·30	—	90·50	74·00	77·75	113·00	88·50	—	118·80	—
Killarney, Woodlawn,	57·02	41·88	63·34	53·47	48·84	63·42	54·58	58·92	65·96	47·36
Co. Sligo.										
Collooney, Markree Observatory,	41·83	36·20	44·33	38·42	42·27	46·08	40·38	43·73	45·26	44·87
Co. Galway.										
Kylemore House,	81·15	69·42	89·61	70·91	76·90	88·58	81·28	76·33	75·53	67·38
Co. Armagh.										
Observatory,	32·44	24·28	33·06	30·54	31·21	35·07	31·76	32·50	36·45	32·11
Co. Down.										
Donaghadee, Meteoric Council,	30·97	24·19	31·33	31·43	29·88	34·13	30·54	32·80	37·77	29·60
Co. Donegal.										
Carrablagh,	47·14	46·57	43·60	44·70	45·79	44·14	49·43	50·45	47·39	40·37
Co. Wicklow.										
Fassaroe, Bray,	38·50	26·25	44·12	40·23	37·72	44·01	37·88	42·43	45·24	40·00
Co. Dublin.										
Glen-na-Smoel Waterworks,	47·87	28·93	42·53	48·02	43·72	52·32	50·36	41·53	64·69	42·55
Glasnevin, Royal Botanic Gardens,	29·23	23·75	30·40	35·00	29·33	32·92	31·33	30·51	37·55	28·08

Peculiarities of the Irish Hepatic Floras.

It is in the moist, warm, sheltered glens of the high mountain ranges near the coast that some of the rarest species flourish. A few of them are alpine, as *Scapania nimbosa* and *S. ornithopodioides*, Cesias, &c. The curious *Clasmatocolea cuneifolia* often descends, as do other alpines or sub-alpines, to low elevations, washed down by mountain torrents, so that in few instances can we recall species that are exclusively alpine in habitat. About the Killarney basin the luxuriance and beauty of some of the tropical species, such as *Dumortiera irrigua*, are remarkable. This is accounted for by its sheltered position, and the continual moist, genial atmosphere the plants enjoy most months of the year. Similar luxuriance has been observed in many of the glens in the Dingle peninsula, where 129 of the total 172 species of the Irish Hepatic flora are known to grow.

It is remarkable that several of these plants have never been found in fruit, and still continue to grow and increase, as in the case of *Plagiochila tridenticulata*, the female plant of which has not been seen. The same may be said of *Clasmatocolea cuneifolia*; neither male nor female fruit has been found, and yet it flourishes. Of *Porella pinnata*, sterile plants only are found in Ireland, and, I believe, in Europe. *Adelanthus decipiens* furnishes another example; the male plant was once found many years ago at Killarney by the late Dr. Carrington; but the female has never been seen on Irish or British soil. The rare and beautiful *Scapania ornithopodioides*, of which fertile specimens are unknown, luxuriates on Brandon, in Kerry, and has been known to grow there for over one hundred years.

Later research proves that Hepatics can propagate themselves not only by spores, but by adventitious budding, gemmæ being produced on the leaf-margins, or almost on any part of the plant, stem and perianth included. Dr. Spruce records an instance of *Jungermania juniperina* (= *Herberta adunca*) with branchlets growing out of the leaves, which would in time become independent plants (see "Phytologist," vol. ii., 1845, p. 85). My own investigations for a number of years, on this subject of their asexual mode of propagation and dispersal, prove that they readily propagate by budding, and with more certainty of growth, as the gemmæ are often furnished with root-hairs before they become detached from the parent plant. (See McArdle, "On Adventitious Branching in Liverworts," "Irish Naturalist," vol. iv., p. 81, plate 3, 1895).

Alpine or Sub-Alpine Hepaticæ.

Anthelia julacea, *Mastigophora Woodsii*, *Scapania ornithopodioides*, *S. nimbosa*, *S. uliginosa*, *Mylia Taylori*, *Plagiochila spinulosa*, *P. punctata*, *P. tridenticulata*, *Jungermania cordifolia*, *J. alpestris*, *J. lycopodioides* var. *Floerkii*, *J. minuta*, *Nardia compressa*, *Marsupella sphacelata*, *M. Funckii*, *Cesia coralloides*, *C. obtusa*, *Fossombronia pusilla*, *F. cristata*, *F. cæspitiformis*.

Tropical Types.

Jubula Hutchinsiæ (Pacific Islands), *Lejeunea hamatifolia* (Gold-bearing districts, Kynsna, South Africa), *Pleurozia cochleariformis* (E. Indies, Sandwich Islands) *Herberta adunca* (W. Indies, Africa, Java), *Mastigophora Woodsii* (Himalayas), *Lepidozia cupressina* (W. Indies), *Cephalozia connivens* (S. Africa), *C. curvifolia* (Mexico, S. Africa), *C. divaricata* (Asia), *Prionolobus Turneri* (California and Africa), *Adelanthus decipiens* (Cuba), *Scapania ornithopodioides* (Sandwich Islands, E. Indies), *S. nemorosa* (Java), *Lophocolea bidentata* (W. Indies), *Jungermania minuta* (Africa, Mexico), *Blasia pusilla* (N. Asia), *Aneura pinguis* (Cuba), *Metzgeria pubescens* (Simla, Himalayas), *M. furcata* (Africa), *M. conjugata* (Africa), *M. hamata* (Asia, N. Zealand), *Marchantia polymorpha* (Japan, Java), *Conocephalus conicus* (Asia, Japan), *Reboulia hemisphærica* (Asia, Java, N. Zealand), *Preissia commututa* (Asia, Japan), *Lunularia cruciata* (Africa, Queensland), *Dumortiera irrigua* (W. Indies), *Sphærocarpus terrestris* (N. Africa).

Tropical South American Types.

Lejeunea flava, *L. hamatifolia*, *Herberta adunca*, *Jubula Hutchinsiæ*, *Lepidozia cupressina*, *Cephalozia* (*Odontoschisma*) *denudata*, *Adelanthus decipiens*, *Scapania nemorosa*, *Clasmatocolea cuneifolia*, *Nardia hyalina*, *Blyttia Lyellii*, *Aneura palmata*, *Metzgeria furcata*, *M. hamata*, *Targionia hypophylla*.

North American Types.

We have ninety-three species, among them *Lejeunea serpyllifolia*, *L. calcarea*, *Porella Thuja*, *P. platyphylla*, *P. pinnata*, *Trichocolea tomentella*, *Lepidozia reptans*, *Bazzania tricrenata*, *B. triangularis*, *B. trilobata*, *Mylia Taylori*, *Fossombronia pusilla*, *F. angulosa*, *F. cristata*, *Jungermania gracilis*, *J. cordifolia*, *Harpanthus scutatus*, *Marsupella sphacelata*, *Pellia calycina*, *Metzgeria pubescens*, *Riccia glauca*, *Anthoceros lævis*, *A. punctatus*.

BRITISH TYPES.

Lejeunea Mackaii, *L. microscopica*, *Frullania germana*, *Radula voluta*, *R. aquilegia*, *Lepidozia Pearsoni*, *Cephalozia pallida*, *Scapania nimbosa* (Scotland and Ireland), *Lophocolea spicata*, *Acrobolbus Wilsoni*, *Scalia Hookeri*, *Pallavicinia hibernica*, *Aneura sinuata*, *Riccia glaucescens*.

IRISH TYPES.

Lejeunea Holtii, *L. diversiloba*, *Radula Holtii*, *Bazzania Pearsoni*, *Cephalozia hibernica*, *Plagiochila ambagiosa*, *P. exigua*.

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distans, . . .	1	–	–	–	–	–	–	–	–	–	–	–	476
rivularis, . . .	–	–	–	4	–	–	–	–	–	–	–	–	476
robusta, . . .	–	–	–	4	–	–	–	–	–	–	–	–	476
Marsupella emarginata, . .	1	2	3	4	5	6	7	8	9	10	11	12	476
minor, . . .	1	–	–	4	–	–	–	8	–	10	11	12	477
picea, . . .	1	–	–	–	–	–	–	–	–	–	–	–	477
major, . . .	1	–	–	–	–	–	–	–	–	–	–	–	477
sphacelata, . . .	1	–	–	4	–	–	–	8	–	–	–	12	478
Funckii, ...	–	–	–	–	–	–	–	8	–	10	–	12	478
Cesia coralloides, . . .	1	2	–	4	–	–	–	–	–	–	–	–	478
obtusa, ...	–	–	–	–	–	–	–	8	–	–	–	12	479
crenulata, . . .	1	2	–	4	5	–	–	–	–	–	–	12	479
Acrobolbus Wilsoni, . .	1	–	–	–	–	–	–	8	–	–	–	–	480
Saccogyna viticulosa, . .	1	2	3	4	5	6	7	8	9	10	11	12	480
Scalia Hookeri, . . .	1	–	–	–	5	–	–	–	–	–	–	–	481
Fossombronia pusilla, . .	1	–	–	–	–	–	–	–	–	–	11	12	481
ochrospora, . . .	1	–	–	–	–	–	–	–	–	–	–	–	482
cristata, ...	–	–	–	–	–	–	–	–	–	–	–	12	482
angulosa, . . .	1	–	–	–	–	–	–	–	–	–	–	–	482

	1	2	3	4	5	6	7	8	9	10	11	12	PAGE
Fossombronia pusilla—*cont.*													
Dumortieri, . . .	1	–	–	–	–	–	–	–	–	–	–	–	483
cæspitiformis, . . .	–	–	–	–	–	–	–	–	–	–	11	–	483
Petalophyllum Ralfsii, . .	1	–	–	–	5	–	–	–	–	–	–	–	483
Pallavicinia Lyellii, . .	1	–	–	4	5	–	–	–	–	–	–	–	483
hibernica, . . .	–	–	–	4	–	–	–	–	–	–	–	–	484
leptodesma, . .	–	–	–	–	5	–	–	–	–	–	–	12	484
Blasia pusilla, . . .	1	2	–	4	5	–	–	8	–	10	11	12	484
Pellia epiphylla, . . .	1	2	3	4	5	6	7	8	9	10	11	12	485
calycina, ...	1	–	3	4	5	6	7	–	9	–	11	12	485
Neesiana, . . .	1	–	–	–	–	–	–	–	–	–	–	–	486
Aneura palmata, . . .	1	–	–	4	–	–	–	8	–	10	–	–	486
multifida, . . .	1	2	3	4	5	6	7	8	9	10	11	12	487
ambrosioides, . . .	1	–	–	–	–	–	–	–	–	–	–	–	487
latifrons, ...	1	–	3	4	5	6	7	8	–	–	–	–	487
sinuata, ...	1	2	–	4	–	–	–	–	–	10	–	12	488
pinguis, ...	1	2	3	4	5	6	7	8	–	10	11	12	489
denticulata, . .	1	–	–	–	–	–	–	–	–	–	–	–	489
Metzgeria pubescens, . .	–	–	–	–	–	–	–	–	–	–	–	12	490
furcata, ...	1	2	3	4	5	6	7	8	9	10	11	12	490
æruginosa, . .	1	–	3	4	5	–	–	–	9	10	11	12	490
prolifera, . . .	–	–	–	–	5	–	–	–	–	–	–	–	490
conjugata, . . .	1	2	3	4	5	6	7	8	–	10	11	12	491
prolifera, . . .	–	–	–	–	–	6	–	–	–	–	–	–	491
hamata, ...	1	–	–	–	–	–	–	8	–	–	–	–	492
Marchantia polymorpha, . .	1	–	–	4	5	6	–	8	–	–	11	12	492
Conocephalus conicus, . .	1	2	3	4	5	6	7	8	9	10	11	12	493
Reboulia hemisphærica, . .	1	–	–	–	5	6	–	8	–	–	11	12	493
Preissia commutata, . .	1	–	–	–	5	–	–	8	–	–	11	12	494
Lunularia cruciata, . . .	1	–	–	4	5	–	7	–	–	10	11	12	494
Dumortiera irrigua, . .	1	–	–	4	–	–	–	–	–	–	–	–	495
Targionia hypophylla, . .	1	–	–	–	–	–	–	–	–	–	–	12	496
Sphærocarpus terrestris, . .	–	–	–	–	–	–	–	–	–	–	–	12	496
Riccia glauca, . . .	1	–	–	4	5	–	–	–	–	–	11	12	497
crystallina, . . .	–	–	–	..	–	–	–	–	–	–	–	12	497
sorocarpa, . . .	1	–	–	–	–	–	–	–	–	–	–	–	497
glaucescens, . . .	–	–	–	–	–	–	–	–	–	–	11	12	498
Ricciella fluitans . . .	–	–	–	–	5	6	–	–	9	10	–	12	498
Ricciocarpus natans, . .	–	–	–	–	5	6	–	–	–	–	–	–	498
Anthoceros lævis, . . .	1	–	–	–	–	–	–	–	–	–	–	–	499
punctatus, . . .	1	2	–	4	5	–	–	8	–	–	11	12	499

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National Museum, Kildare-street, Dublin.

Botanical Department, Trinity College, Dublin.

Abbreviations used for Authorities other than those cited in the foregoing List.

Brenan,	...	Rev. S. A. Brenan, B.A., Cushendun.
Carrington,	..	Dr. Benjamin Carrington, Eccles, Manchester.
Carroll,	..	Isaac Carroll, Cork.
F. W. M.,	..	Frederick William Moore, A.L.S., Glasnevin Botanic Gardens.
Greene,	..	Dr. G. E. J. Greene, F.L.S., &c., Ferns, Co. Wexford.
Holt,	..	G. A. Holt, Manchester.
Hooker,	..	Sir William Jackson Hooker, London.
Hunt,	..	G. Hunt, Manchester.
Hunter,	..	J. Hunter, Holywood, near Belfast.
Hutchins,	..	Miss Hutchins, Bantry, Co. Cork.
Lett,	..	Rev. Canon H. W. Lett, M.A., Loughbrickland, Co. Down.
Lindberg,	..	Professor Sextus Otto Lindberg, Helsingfors University.
McA.,	..	David McArdle, Glasnevin Botanic Gardens.
Moore,	..	Dr. David Moore, Glasnevin Botanic Gardens.
Pearson,	..	W. H. Pearson, Manchester.
Praeger,	..	Robert Lloyd Praeger, National Library, Dublin.
Russell,	..	Rev. Canon Charles Russell, D.D., Geashill, King's Co.
Scully,	..	Dr. Reginald Scully, Dublin.
Stewart,	..	Samuel Alexander Stewart, F.B.S.E., Belfast.
Templeton,	..	John Templeton, A.L.S., Cranmore, Belfast.
Taylor,	..	Dr. Thomas Taylor, Kenmare.
Waddell,	..	Rev. C. H. Waddell, B.D., Saintfield, Co. Down.
Wade,	..	Dr. Walter Wade, Dublin.

The Twelve Botanical Districts of "Cybele Hibernica."

I. South Atlantic.—Kerry and South Cork; 3143 square miles.
II. Blackwater.—North Cork, Waterford, South Tipperary; 3181 square miles.
III. Barrow.—Kilkenny, Carlow, Queen's County; 1805 square miles.
IV. Leinster Coast.—Wexford and Wicklow; 1677 square miles.
V. Liffey and Boyne.—Kildare, Dublin, Louth, Meath; 2230 square miles.
VI. Lower Shannon.—Limerick, Clare, East Galway; 3989 square miles.
VII. Upper Shannon.—North Tipperary, King's Co., Westmeath, Longford; 2700 square miles.
VIII. North Atlantic.—West Galway, West Mayo; 2146 square miles.
IX. North Connaught.—East Mayo, Sligo, Leitrim, and Roscommon; 3086 square miles.
X. Erne.—Cavan, Armagh, Fermanagh, Monaghan, Tyrone; 3733 square miles.
XI. Donegal.—Donegal, and Derry west of the Foyle; 1890 square miles.
XII. Ulster Coast.—Down, Antrim, and Derry; 2862 square miles.

Class HEPATICÆ.

Order I. JUNGERMANIACEÆ.

Tribe I. **JUBULEÆ**.

Genus I. **Frullania** Raddi.

1. **Frullania Tamarisci** Linn., Dumort.

Jungermania Tamarisci Linn., Sp. Pl., 1 ed., vol. ii., p. 1134. Hook., Brit. Jung., tab. 6. Dumort., Recueil Jung., p. 13. Moore, Irish Hepat., p. 610. Pearson, Hepat. Brit. Isles, p. 24, plate I.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On the trunks of trees in large spreading patches, on rocks and wall-tops, from sea level to the tops of the highest mountains.

var. *atrovirens* Carrington.

Hab.—On rocks which are frequently inundated.

Eagle's Nest and Cromaglown, Killarney: Carrington 1863. Glena, Killarney, 1873: Lindberg 1875. Torc Waterfall, Sept. 1897: McA. & Lett. Ross I., 1899 (McA. & Lett): McA. 1900. Loughanscaul near Dingle, rare, Sept. 1898 (Lett & McA.): McA. 1901.

var. *cornubica* Carrington.

Hab.—On stones.

Fairhead, Co. Antrim (Lett): Stewart 1888.

var. *robusta* Lindberg.

Hab.—On rocks and on the bark of trees.

Glena and Cromaglown at Killarney, Connor hill near Dingle, and Lough Bray, Co. Wicklow, 1873: Lindberg 1875; McA. 1890.

2. **Frullania microphylla** Gottsche, Pearson.

Frullania Tamarisci Linn., var. *microphylla* Gottsche ex Carrington in Trans. Bot. Soc. Edinb., vol. vii., p. 457, 1863. *Frullania microphylla* Gott., Pears. in Journ. of Bot., 1894. Exsicc. Gottsche & Rabenh., Hepat. Eur., nos. 209 & 636. Carr. & Pears., Hepat. Brit., fasc. 2, no. 137. Pearson, Hepat. Brit. Isles, p. 26, plate 2.

Districts I. II. — — — — — VIII. — — XI. —.

Hab.—On smooth rocks and on the bark of trees, in shallow patches, closely attached, mostly near the coast.

I. Old Weir Bridge, Killarney: Carrington 1863; Moore 1876. Ross I., Killarney, 1899 (Lett & McA.): McA. 1900. Torc Waterfall, Killarney, 1898: McA. & Lett 1899. Anascaul and Connor Hill: McA. 1894. On the west side of Brandon near the summit, and Maghanabo glen near Castlegregory, April 1897: F. W. M. & McA. On smooth rocks on the shores of Lough Duff near Connor Hill, May 1899 (Lett & McA.): McA. 1901. Glengariff, 1861 (Carrington and G. E. Hunt): Pearson 1902.

II. On rocks, Bay Lough, Knockmeildown Mountains, Co. Tipperary, June 1902: McA.

VIII. Woods at Pontoon on Lough Conn and on Nephin, May 1901: Lett & McA. Achill and Bangore, Sept. 1901: Lett. On Alder near Ballinlough, Co. Mayo, Sept. 1901: McA.

XI. Rathmullan Wood, July 1902: Hunter. Gartan Lake and Cratleagh Wood, Sept. 1902: McA. On rocks, River Trillick, Buncrana, March 1903: Hunter. On *Hypnum cupressiforme*, Errigal, June 1903: McA.

3. **Frullania fragilifolia** Taylor.

Frullania fragilifolia Tayl. in Ann. and Mag. of Nat. Hist., p. 172, 1843, and Trans. Bot. Soc. Edinb., vol. ii., p. 45, 1846. Moore, Irish Hepat., p. 609. Pearson, Hepat. Brit. Isles, p. 29, plate 3.

Districts I. — — IV. — — — — — — XI. XII.

Hab.— On shaded rocks and on the bark of moss-covered trunks of trees.

I. Killarney: Moore 1876. Muckross demesne and near Dean Bridge: Carrington. On the bark of *Betula*, Killarney, 1873: Lindberg 1875. Torc Waterfall, on rocks and the bark of trees, 1897: McA. & Lett 1899. Ross I., 1899 (Lett & McA.): McA. 1900. On mural rocks, Dunkerron, 1829 (Taylor): Carrington 1863. Burnham Wood between Dingle and Ventry: McA. 1901. On boulders, Bantry Bay and Glengariff: Carrington.

IV. On the trunks of Alder with *Plagiothecium Borrerianum*, Lough Bray, Co. Wicklow, 1887: McA. 1890.

XI. Cratleagh wood near Milford, rare, Sept. 1902: McA.

XII. On granite rocks, Cove Mtn., Co. Down: Lett 1890. "The Craigs," Rasharkin, Co. Antrim (Lett & Waddell); Glenariff (Lett): Stewart 1895.

4. **Frullania germana** Taylor.

'*Jungermania germana* Tayl. in Trans. Bot. Soc. Edinb., vol. ii. p. 45, 1846. *Frullania Tamarisci*, var. *germana* Carr., Trans. Bot. Soc. Edinb., vol. viii. 1863. *Frullania germana* Tayl., Moore, Irish Hepat., p. 610. Pearson, Hepat. Brit. Isles, p. 31, plate 4.

Districts I. — — IV. — VI. — VIII. — X. XI. XII.

Hab.—On rocks and on the trunks of trees.

I. Dunkerron, 1832: Taylor. Killarney: Moore 1876. Glena and O'Sullivan's Cascade, 1873: Lindberg 1875; and (Holt & Stewart): Pearson 1902. On rocks at Torc Waterfall, rare, Sept. 1897: McA. & Lett 1899. Ross I., 1899 (Lett & McA.): McA. 1900. Connor Hill near Dingle, 1873: Lindberg 1875. Burnham Wood near Ventry, May 1894: McA. 1901. On the west side of Brandon, Sept. 1897; Anascaul and Mt. Eagle, 1898; rocks between Emalough and Inch, May 1899: Lett & McA. Lough Duff in the Brandon Valley, 1899 (Lett & McA.): McA. 1901. Old walls about Castletown Berehaven: McA. 1894.

IV. Lough Bray, Co. Wicklow: Moore 1876.

VI. Carn Seefin, Co. Clare: McA. 1895*a*.

VIII. On the slopes of the Devil's Mother, and on Slievemore, Achill, Sept. 1901: Lett.

X. Slieve Glah, Ballyhaise woods, and Farnham woods, Co. Cavan, 1893; McA. 1898.

XI. Glenalla hill, Rathmelton and Rathmelton Wood, July 1902: Hunter. Cratleagh Wood, on rocks by Columbkil Lake, Bunlin Waterfall on trees, Sept. 1902; Lough Eask woods, June 1903: McA.

XII. Rathlin Island, Co. Antrim: Stewart 1888.

5. **Frullania dilatata** Linn., Dumort.

Jungermania dilatata Linn., Sp. Pl., p. 1600. Hook., Brit. Jung., tab. 3. *Frullania dilatata*, Dum., Recueil Jung., p. 13. Moore, Irish Hepat., p. 609. Pearson, Hepat. Brit. Isles, p. 33, plate 5.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On the trunks of trees and on rocks.

var. *flabellata* Spruce.

Hab.—On the trunks of trees in shallow tufts, closely attached, spreading in neat strata. Hickson's Wood near Anascaul, Co. Kerry, very rare, 1898 (Lett & McA.): McA. 1901.

var. *prolifera* McArdle.

Hab.—On moist rocks, side of a stream near the Baily Lighthouse, Howth, Co. Dublin, 1896: McA. 1897.

Note.—This form shows adventitious budding, the leaf-margins and the stems being covered with leafy shoots, which become independent plants.

Genus II. **Jubula** Dumort.

Jubula Hutchinsiæ Hook., Dumort.

Jungermania Hutchinsiæ Hook., Brit. Jung., tab. 1. *Frullania Hutchinsiæ*, Nees, Europ. Leberm., iii., p. 240. Moore, Irish Hepat., p. 608. *Jubula Hutchinsiæ* Dum., Comm. Bot., p. 212. Pearson, Hepat. Brit. Isles, p. 36, plate 6.

Districts I. — — IV. — — — VIII. — — — XII.

Hab.—On shaded wet rocks near streams, often found within reach of the spray of waterfalls.

I. Glengariff (Miss Hutchins): Hooker 1816; and Moore 1876. Ballinhassig Glen, and near Kinsale (I. Carroll): Moore 1876. Cromaglown (Moore), Torc Cascade, Killarney, 1873: Lindberg 1875. In the same station on the fronds of *Dumortiera irrigua*, Sept. 1898: Lett & McA. Caves, Dingle Bay (Moore): Carrington 1863. Maghanabo Glen near Castlegregory, 1875: McA. Loughanscaul, west side of Brandon, and shores of Lough Doon in the Dingle Peninsula, 1897–8 (Lett & McA.): McA. 1901.

IV. Altadore Glen, Co. Wicklow: McA. 1889.

VIII. Rocks by the lake at Letterfrack, 1874: Moore. On the slopes of the Devil's Mother, Co. Mayo, Sept. 1901: Lett.

XII. Rocks on the coast south of Newcastle, Co. Down (Miss Thompson): Waddell, Irish Nat., vol. iv., 1895, p. 190. Tollymore Park, and by the Spinkwee River: Waddell 1892. Waterworks on Rostrevor Mtn. (Waddell): Stewart 1888.

var. *integrifolia*, Nees ab Essenbeck, Syn. Hepat., p. 426: var. *β*.

N. ab E., Hepat. Java, l.c. Moore, Irish Hepat., p. 609 (under *Frullania*), with excellent figure, plate 45.

Hab.—On wet rocks, and on the larger Hepaticæ. Connor Hill 1873 (Lindberg & Moore): Lindberg 1875; Moore 1876. Mountain stream in the Maghanabo Glen near Castlegregory, on the fronds of *Dumortiera irrigua*, fertile, 1875 (McA.): Moore 1876. Torc

Waterfall, Killarney, 1889: Scully 1890. On rocks, Loughanscaul near Dingle, Sept. 1898: Lett.

Genus III. **Lejeunea** Libert.

1. **Lejeunea Mackaii** Hook., Sprengel.

Jungermania Mackaii Hook., Brit. Jung., tab. 53. *Phragmicoma Mackaii* Dumort., Comm. Bot., p. 112. *Lejeunea Mackaii*, Spreng., Syst. Veg., iv., p. 233. Moore, Irish Hepat., p. 616. Pearson, Hepat. Brit. Isles, p. 40, plate 7.

Districts I. — — IV. V. VI. — VIII. — — — XII.

Hab.—Mostly on limestone rocks, often in large shallow patches, and on decayed wood.

I. Ballylicky near Bantry, 1812 (Miss Hutchins): Hooker 1816. Near Cork, frequent: Moore 1876. Muckross, Killarney: Carrington 1863; and (Moore): Lindberg 1875. Ross I., 1893: McA.; plentiful 1899 (Lett & McA.): McA. 1900. Torc Waterfall, Sept. 1899: Lett and McA. Loughanscaul, rare, Sept. 1898 (Lett & McA.): McA. 1901.

IV. Dargle, Co. Wicklow, 1812 (Mackay): Hooker 1816. On rocks in the same station (Scully & McA.): McA. 1889.

V. Woodlands near Dublin: Moore. Omeath Waterfall, Co. Louth (Waddell): Lett 1890.

VI. At Kilmurvy on the Aran Islands, rare: McA. 1895 *a*. Clonbrock, Co. Galway: McA. 1895 *b*.

VIII. On rocks by a small lake near Letterfrack, Co. Galway, 1874: Moore.

XII. On old yew trees, Tollymore Park, Co. Down (Waddell): Lett 1890. Gobbins Cliffs, Co. Antrim: Waddell 1893. Limestone rocks, Redhall Glen, 1809 (Templeton); Glenariff (Lett): Stewart 1895.

2. **Lejeunea serpyllifolia** Dicks., Libert.

Jungermania serpyllifolia Dicks., Pl. Crypt. Brit., fasc. 4. *Lejeunea serpyllifolia* Libert. in Ann. Gen. Sch. Phys., vi., p. 374. Moore, Irish Hepat., p. 614. Pearson, Hepat. Brit. Isles, p. 45, plate 10.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—In damp shaded places, on the trunks of trees, on rocks and stones in rivulets, and on damp banks.

var. *planiuscula* Lindberg.

Hab.—On rocks among Mosses. O'Sullivan's Cascade, Killarney, 1873: Lindberg 1875. In same station: Scully 1890. Connor Hill near Dingle, 1873: Lindberg 1875.

var. *cavifolia* Ehrhart, Lindberg.

Hab.—On rocks and damp banks.

Killarney: Carrington 1863; Moore 1876. Glena and Torc Cascade, among *Hypnum eugyrium*, 1873: Lindberg 1875. On a turfy bank among rocks, between Emalough and Inch, Co. Kerry, May 1899 (Lett & McA.): McA. 1901.

var. *heterophylla* Carrington.

Hab.—On wet rocks.

O'Sullivan's Cascade and Torc Waterfall: Carrington 1863; Moore 1876. Ross I., 1899 (Lett & McA.): McA. 1900. Frequent in the Dingle Peninsula: McA. 1901. Altadore Glen, Co. Wicklow: McA. 1889. Glenariff, Co. Antrim; Spinkwee River, Co. Down: Waddell 1892. Lough Eask woods and Barnesmore Gap, June 1903: McA.

var. *prolifera* McArdle.

Hab.—On decayed bark.

Hickson's Wood near Anascaul, Co. Kerry, May 1894: McA. 1901, and McA. 1895 *b*.

3. **Lejeunea patens** Lindberg.

Lejeunea patens Lindberg in Acta Soc. Fenn., vol. x., p. 482, 1875. Moore, Irish Hepat., p. 615, plate 49, 1876. Pearson, Hepat. Brit. Isles, p. 47, plate 11.

Districts I. — III. IV. V. VI. — VIII. IX. — XI. XII.

Hab.—On damp rocks, on the bark of moss-covered trees, and on the larger Mosses and Hepaticæ.

I. Killarney: W. Wilson. Glena and Torc Cascade, 1861: Carrington; and Sept. 1897: McA. & Lett 1899. O'Sullivan's Cascade, among *Thamnium alopecurum*, and on Connor Hill, 1873: Lindberg 1875. Between Dingle & Ventry, 1873: Lindberg & Moore. On the west side of Brandon, and on Mt. Eagle, 1881: F. W. M. & McA. Coumanare Lakes, Sept. 1898; Derrymore Glen near Tralee, May 1899: Lett & McA. Frequent in the Dingle Peninsula: McA. 1901. Dunboy Wood, Castletown Berehaven: McA. 1894.

III. Cappard, Queen's Co., 1891 (Russell): McA. 1892 *a*. Wood near Goresbridge, Co. Carlow: McA. 1896 *a*.

IV. Altadore Glen, Co. Wicklow: McA. 1889.

V. Carlingford Mtn., Co. Louth, very rare (Waddell): Lett 1890.

VI. Carn Seefin, Co. Clare: McA. 1895*a*.

VIII. Gentian Hill near Galway: McA. 1895 *a*. Co. Galway, 1891: Dr. E. J. McWeeney. Nephin, May 1901: Lett & McA. Slopes of the Devil's Mother, Bangore, Slievemore on Achill, Sept. 1901: Lett. Pontoon near Foxford, May 1901: Lett & McA.

IX. Ben Bulben: Moore; and July 1880: McA. Glenade, Co. Leitrim, 1875: Moore.

XI. Cratleagh Wood near Milford, very rare, Sept. 1902: McA. Dunree River near Buncrana, June 1903: Hunter.

XII. Glenariff: Waddell 1893. Sallagh Braes (Lett): Stewart 1895. Tollymore Park: Waddell 1893. Black Stairs on Slieve Donard: Waddell.

var. *erecta*. McArdle, I. Nat., vol. iii., p. 139, 1894.

Hab.—On damp peat among rocks.

Ross. I., Killarney, 1893: McA. Connor Hill near Dingle, rare, June 1894: McA.

var. *cochleata*, Spruce (species).

Spruce, Hepat. Amaz. et And., Trans. Bot. Soc. Edinb., vol. xv., p. 273, 1885.

Hab.—On wet rocks, decayed wood, and on the larger Mosses and Hepatics.

Ben Bulben, Co. Sligo, and Glenfarm demesne, Co. Leitrim, 1871: Moore. Kylemore, Co. Galway, 1874: Moore; McA. 1880; and 1891: McWeeney. Woodenbridge, Co. Wicklow, fertile, 1895: McA. Glenariff, Co. Antrim: Waddell. Black Stairs on Slieve Donard, Co. Down, and Slish Wood, Co. Sligo: Waddell 1892. O'Sullivan's Cascade, Killarney, 1893: McA.

Note.—The specimens collected in these localities compare favourably with plants collected by Dr. Spruce on Mount Tanguragua, S. America, and probably the var. *cochleata* should be the type, and *L. patens* the variety.

4. **Lejeunea flava** Swartz, Nees.

Lejeunea flava Swz., Prodr. Fl. Ind. Occ., p. 144, 1788. Nees, Nat. Eur. Leberm., iii., p. 277, 1839. *Lejeunea serpyllifolia* var. *thymifolia* Carrington, Irish Crypt. 1863. *Lejeunea Moorei* Lindberg, Hepat. Hib., p. 487, 1875. Moore, Irish Hepat., p. 615. Pearson, Hepat. Brit. Isles, p. 49, plate 12.

Districts I. — III. IV. V. VI. — VIII. — — XI. XII.

Hab.—On damp moss-covered rocks, on decayed wood, and on the larger Hepatics.

I. Cromaglown and Glena, 1873: Lindberg 1875. At the Hunting Tower, Cromaglown, 1862: Moore; and 1875: McA. O'Sullivan's Cascade (Moore; G. A. Holt; M. B. Slater): Pearson 1902. On decayed wood and on the fronds of *Metzgeria*, Torc Waterfall, very scarce, 1897: McA. & Lett 1899. Ross I., 1893: McA.; and 1899, rare (Lett & McA.): McA. 1900. Brandon, April, 1897: F. W. M. & McA. Among *Hypnum*, Lough Nalachan on Brandon, 1899; and Mt. Eagle Lake, Sept., 1898: Lett & McA. Hickson's Wood near Anascaul, 1894: McA. In the Dingle Peninsula: McA. 1901. Dunboy Wood, Co. Cork, typical: McA. 1894.

III. Goresbridge, Co. Carlow: McA. 1896 *a*.

IV. Altadore Glen and Luggielaw: McA. 1889. Dargle, Co. Wicklow: McA. & Scully. Wood by the Slaney River near Enniscorthy, and Killoughrim Oak Forest, Co. Wexford, typical, rare, 1899: McA.

V. Howth demesne, Co. Dublin, April, 1895: McA. 1897.

VI. Carn Seefin, Co. Clare: McA. 1895 *a*.

VIII. Near Letterfrack, Co. Galway, 1891: McWeeney. Pontoon, Co. Mayo, May, 1901: Lett & McA.

XI. Very fine in wood by the seashore, Rathmullan, and at Macamish Point, July 1902: Hunter. Cratleigh Wood and wood at Mulroy Bay, Sept. 1902: McA. Barnesmore Gap, very scarce, June 1903: McA.

XII. Glenariff, Co. Antrim, and Tollymore Park, Co. Down: Waddell 1893.

5. **Lejeunea Holtii** Spruce.

Lejunea Holtii Spruce, Journ. Bot., vol. xxv., p. 33, plate 272. 1887. McA. & Lett, Hepat. of Torc Waterfall, Killarney, Proc. R. I. Acad., 3rd ser., vol. v., no. 2, 1899. McArdle, Report on the Hepat. of the Dingle Peninsula, Proc. R. I. Acad., 3rd ser., vol. vi., no. 3, 1901. Pearson, Hepat. Brit. Isles, p. 51, plate 13, 1902.

Districts I. — — — — — — — — — — —.

Hab.—On wet rocks in shaded places, among Mosses and on the larger Hepatics, on the bare wet rocks in neat strata.

I. Torc Waterfall, Killarney, June 1885 (Holt): Spruce 1887*a*. On *Trichocolea* and *Metzgeria*, also mixed with *Lejeunea Mackaii*, on bare rocks within the spray of Torc Waterfall, Sept. 1897: McA. & Lett 1899. In the crevices of rocks among *Fissidens taxifolius*, Loughanscaul near Dingle, May 1894: McA. Rocks near the lake on Mt. Eagle, and shores of Barnanaghea Lough near Dingle, Sept. 1898: Lett & McA. Lough Nalachan on Brandon, May 1899 (Lett & McA.): McA. 1901.

6. **Lejeunea ovata** Taylor.

Jungermania serpyllifolia var. *ovata* Hook., Brit. Jung., tab. 42. *Lejeunea ovata* Taylor MS., G. L. N., Syn. Hepat., p. 376. Moore, Irish Hepat., p. 612. Pearson, Hepat. Brit. Isles, p. 42, plate 8.

Districts I. — — — — VI. — VIII. — — XI. XII.

Hab.—On moss-covered trunks of trees, and on the larger Hepaticæ and Mosses.

I. Killarney: Carrington. Torc Waterfall: Taylor; and Sept. 1897: McA. & Lett. Cromaglown abundant, and through the Killarney district: Moore. Among *Rhacomitrium* on Connor Hill near Dingle, 1873 (Lindberg and Moore): Lindberg 1875; and 1881, F. W. M. & McA. On the N.E. side of Brandon, 1875: McA. Frequent in the Dingle Peninsula: McA. 1901. Bantry: Taylor. Dunboy Wood and near Pulleen Cove, Co. Cork: McA. 1894.

VI. Carn Seefin, Co. Clare, plentiful: McA. 1895 *a*.

VIII. Nephin, May 1901: Lett & McA. Bangore, slopes of Devil's Mother, and on Slievemore, Achill, Sept. 1901: Lett.

XI. On *Frullania Tamarisci* on Goat Island, Lough Eask, plentiful, June 1903: McA.

XII. Near Belfast (Dickie): Moore 1876. Slieve Donard: Lett 1890. On the stem of Holly at the Black Stairs on Slieve Donard, Co. Down (Waddell): Lett 1890. Glenariff, Co. Antrim: Waddell 1893.

7. **Lejeunea hamatifolia** Hook., Dumort.

Jungermania hamatifolia Hook., Brit. Jung., tab. 54. *Lejeunea hamatifolia* Dum., Comm., p. 111, 1822. Moore, Irish Hepat., p. 611. Pearson, Hepat. Brit. Isles, p. 43, plate 9.

Districts I. — III. IV. V. VI. — VIII. IX. — XI. XII.

Hab.—On the trunks of trees and on bare moist rocks, and on the larger Hepatics, such as *Frullania*.

I. Killarney Woods, plentiful: Moore. On bare rocks, Connor Hill near Dingle, with *Lejeunea calyptrifolia*, July 1873 (Lindberg and Moore): Lindberg 1875. In same locality, very fine, with perianths, Sept. 1898: Lett & McA. Mt. Eagle, July 1881: F. W. M. & McA. Loughanscaul, on *Radula Carringtonii*, Sept. 1898: Lett & McA. Brandon, June 1900: Lett & McA. Frequent in the Dingle Peninsula: McA. 1901. Rocks near Ballybunnion: Stewart 1890.

III. Brittas demesne, Queen's Co., 1891 (Russell): McA. 1892 *a.*

IV. Powerscourt, Co. Wicklow: Moore.

V. Woodlands, Co. Dublin (Taylor): Moore 1876. Close to the waterfall in Omeath Glen, Co. Louth, rare: Lett 1890.

VI. Gleninagh, Co. Clare: McA. 1895 *a.* Tycooley Wood, Clonbrock, Co. Galway: McA. 1896 *b.*

VIII. Pontoon near Foxford, May 1901: Lett & McA. Bangore, slopes of Devil's Mother, and Doolough, Co. Mayo, Sept. 1901: Lett. Kylemore, 1874: Moore.

IX. Glenfarm demesne, Co. Leitrim, 1875: Moore.

XI. Woods by River Trillick, Buncrana, March 1903: Hunter. Goat Island, Lough Eask, June 1903: McA.

XII. Glendun, 1836: Moore, and Glenarm and Colin Glen, Co. Antrim, 1837: Moore. Glenariff, Co. Antrim, 1889 (Waddell): Stewart 1895. Near the waterfall at the Black Stairs on Slieve Donard: Lett 1890. Tollymore Park, Co. Down: Waddell 1893.

8. **Lejeunea calcarea** Libert.

Lejeunea calcarea Libert, in Bory de St. Vinc., Ann. des Sc. Nat., vol. vi., p. 373, no. 1, tab. 96, fig. 1, 1820. *Jungermania hamatifolia* var. *echinata* Hook., Brit. Jung., 1816. *Lejeunea echinata* Taylor MS., G. L. N., Syn. Hepat., p. 345, 1844. Moore, Irish Hepat., p. 612. Pearson, Hepat. Brit. Isles, p. 58, plate 16.

Districts I. — — — V. — — — — — — XII.

Hab.—On limestone rocks and on Mosses.

I. Muckross demesne, on *Thamnium alopecurum*, 1863 (Carrington): Moore 1876. In the same place, and on the same moss, 1873: Lindberg 1875. Ross I.: Scully 1890. Limestone rocks near Tralee, 1875: Moore. On rocks, Mt. Eagle, July 1881: F. W. M. & McA. Connor Hill near Dingle, 1897: Lett & McA.

V. Limestone rocks at Woodlands, Co. Dublin (Taylor): Hooker 1816. Omeath, Co. Louth: Lett 1890; Waddell 1893.

XII. Wall at the base of bridge over the Shimna River, Tollymore Park, Co. Down, very rare (Waddell): Stewart 1888. Glenariff, Co. Antrim, 1893 (Lett and Waddell): Stewart 1895.

9. **Lejeunea Rossettiana** Massalongo.

Lejeunea Rossettiana Massal., Nuovo Giorn. Bot. Ital., vol. xxi., p. 487, 1889. Pearson in Journ. Bot., vol. xxvii., p. 352, tab. 292, 1889. Pearson, Hepat. Brit. Isles, p. 60, plate 17. McA., Hepaticæ of

Ross Island, Killarney, Irish Naturalist, vol. ix., p. 23, plate 1, figs. 1–6, February, 1900.

Districts I. — — — V. — — — — — — — —.

Hab.—On limestone rocks and among Mosses, often mixed with *L. calcarea.*

I. Muckross demesne, May 1861 : Carrington. Ross I., Killarney, 1889: Scully 1890. On decayed stems of *Erica*, and on damp peat in the same place, very rare, May 1899 : Lett & McA.

V. At Woodlands near Dublin, 1830 : Taylor.

10. **Lejeunea minutissima** Smith.

Lejunea minutissima Smith, Eng. Bot., tab. 1633. Hook., Brit. Jung., tab. 52, excepting fig. 5, which is probably *L. ulicina. Jungermania inconspicua* Raddi, in Atti Soc. Mod., 1818. Moore, Irish Hepat., p. 613 (under *Lejeunea*). *Lejeunea minutissima* Sm., Pearson, Hepat. Brit. Isles, p. 61, plate 18.

Districts I. — III. — — — — VIII. — X. — XII.

Hab.—On the trunks of trees and on decayed wood, and on the larger Mosses and Hepatics.

I. Kenmare : Taylor. On Ash trees, Muckross demesne : Carrington 1863. Near Muckross Hotel on Beech, among *Zygodontium*, and on rocks at Glena on *Lejeunea Mackaii*, 1873 : Lindberg 1875. Ross I., 1893 : McA. 1900. Torc Waterfall, on *Metzgeria*, and on bark of trees, Sept. 1897 : Lett & McA. Brandon : Moore. Connor Hill, 1873 : Lindberg 1875. Burnham Wood near Ventry, May 1894 : McA. 1901. Hickson's Wood near Anascaul, Sept. 1898 : Lett & McA. Co. Cork (I. Carroll) : Carrington 1863.

III. Brittas demesne, Queen's Co., 1891 : Russell & McA.

VIII. Slievemore, Achill, Co. Mayo, Sept. 1901 : Lett.

X. On trees among *Metzgeria*, Farnham demesne, and very fine on *Frullania*; and at Killakeen, Co. Cavan, on *Hypnum cupressiforme* : McA. 1898.

XII. Gillhall, Co. Down (Waddell), Colin Glen near Belfast (Moore) : Stewart 1888.

11. **Lejeunea microscopica** Taylor.

Jungermania microscopica Taylor, in Mackay's Fl. Hib., part ii., p. 59. Taylor, in Hooker's Journal of Botany, vol. iv., p. 97, with excellent figure, tab. 29. *Lejeunea microscopica* Moore, Irish Hepat., p. 613. Pearson, Hepat. Brit. Isles, p. 63, plate 19.

Districts I. — — — — VI. — VIII. — — — XII.

Hab.—On the bark of trees, decayed wood, Filmy Ferns, Mosses, and Hepatics.

I. Wood at Gortagaree, near Killarney, on *Hypnum loreum*, 1836 (Taylor): Moore 1876. Cromaglown, 1849: Taylor and W. Wilson. Torc Cascade with *Lophocolea bidentata*: Carrington 1863; and Sept. 1897: McA. & Lett 1899. Killarney, common up to 1500 feet on Slieve Mish: Scully 1890. O'Sullivan's Cascade 1873: Lindberg 1875. Ross I., on Hymenophyllum, Nov. 1893: McA. 1900. Glen on Brandon: Moore. Very fine on the N.E. side of Brandon on *Diplophyllum albicans*, June 1900: Lett & McA. On *Frullania*, Connor Hill, 1873: Lindberg 1875; and Sept. 1877: McA. Loughanscaul, Sept. 1898 (Lett & McA.): McA. 1901.

VI. Carn Seefin, Co. Clare, on *Plagiochila spinulosa*: McA. 1895 *a*.

VIII. On the bark of Alder and on *Frullania Tamarisci*, fertile, Pontoon near Foxford, and on Nephin, May 1901: Lett & McA. On Devil's Mother, and on Slievemore, Achill, Sept. 1901: Lett.

XII. Glenariff, Co. Antrim, July 1889 (Waddell): Stewart 1895.

12. **Lejeunea diversiloba** Spruce.

Lejeunea diversiloba Spruce, Journ. of Bot., vol. xxv., p. 38, 1887. *Lejeunea minutissima* var. *major* Carrington, Trans. Bot. Soc. Edinb., vol. viii., p. 468, tab. 17, fig. 1. *Lejeunea diversiloba* Pearson, Hepat. Brit. Isles, p. 56, plate 15.

Districts I. — — — — — — — — — — —.

Hab.—On moist rocks and on the trunks of trees among *Metzgeria*, &c., and on Mosses.

I. Torc Waterfall, 1842: Spruce; and 1885 (Holt): Spruce 1887*a*. Very rare here, Sept. 1897: McA. & Lett. Torc Waterfall, Glena and Eagle's Nest, Killarney: Carrington 1863. On damp rocks among *Metzgeria conjugata*, Connor Hill near Dingle, July 1881: F. W. M. & McA.; and Sept. 1898: Lett & McA. Loughanscaul near Dingle, Coumanare Lakes and Barnanaghea Lough near Anascaul, Sept. 1898; and at Lough Nalachan on Brandon, rare, 1899: Lett & McA.

13. **Lejeunea ulicina** Taylor.

Jungermania ulicina Taylor, in Trans. Bot. Soc. Edinb., vol. i., p. 115, 1841. *Lejeunea ulicina* Taylor, in G. L. N., Syn. Hepat., p. 387. Pearson, Hepat. Brit. Isles, p. 54, plate 14.

Districts I. II. III. IV. V. — VII. VIII. IX. — XI. XII.

Hab.—On the bark of trees and on mosses.

I. Abundant in the Killarney woods: Moore 1876. Loughanscaul near Dingle among *Hypnum* on damp rocks, Sept. 1898 : Lett & McA. Rare in the Dingle Peninsula : McA. 1901. About Cork, frequent (Carroll) : Carrington 1863.

II. In woods, Scarriff, Galtees, cum. per., plentiful; and Glengarra Wood, Galtees, Co. Tipperary, June 1902 : McA.

III. Cappard, Queen's Co., 1891 : Russell.

IV. Luggielaw and Powerscourt, Co. Wicklow : Moore. Killoughrim Oak Forest, Co. Wexford, May 1899 : McA.

V. Woodlands near Dublin : Moore.

VII. Lake at Brittas, King's Co., 1892 : McA.

VIII. Kylemore Castle demesne, 1874 : Moore. On the bark of Alder at Pontoon, and on Nephin, May 1901 : Lett & McA.

IX. Glenfarm demesne, Co. Leitrim : Moore 1876.

XI. Lough Eask Woods, on *Frullania Tamarisci*, June 1903 : McA.

XII. Gillhall and Castlewellan, Co. Down : Waddell 1893. Colin Glen near Belfast : Moore.

14. **Lejeunea calyptrifolia** Hook., Dumort.

Jungermania calyptrifolia Hook., Brit. Jung., tab. 43. Eng. Bot., tab. 2538. *Lejeunea calyptrifolia* Dum., Comm., p. 111. *Colura calyptrifolia* Dum., Recueil, p. 12. *Lejeunea calyptrifolia* Moore, Irish Hepat., p. 611. Pearson, Hepat. Brit. Isles, p. 64, plate 20.

Districts I. — — — V. — — VIII. — — — XII.

Hab.—In minute yellowish-green tufts on the bark of trees, on bare moist rocks, on the stems of *Ulex* near the ground, and on *Frullania.*

I. Glengariff, Co. Cork (Miss Hutchins) : Hooker 1816. On rocks, Upper Lake, Killarney, 1873 (Lindberg & Moore) : Moore 1876. Near Dunkerron, 1836 : Taylor. Torc Mountain on the stems of *Pinus* : Wilson & Carrington. O'Sullivan's Cascade, 1893 : McA. Near the Hunting Tower, Killarney : Scully 1890. Connor Hill, on bare moist rocks by the "Doctor's Well," 1873 : Lindberg & Moore ; also July 1881 : F. W. M. & McA. ; and Sept. 1897–8 (Lett & McA.) : McA. 1901. In Hickson's Wood near Anascaul, on the stems of *Abies* and *Pinus*, fertile : McA. 1894, and I. Nat., vol. iv., p. 73, 1895. Loughanscaul, on *Frullania*, Sept. 1897 : Lett & McA. Barnanaghea near Lispoll, on *Diplophyllum albicans* and *L. ovata*, June 1899 (Lett & McA.) : McA. 1901.

V. Luttrellstown, Co. Dublin (Templeton MSS.) : Waddell 1893.

VIII. Co. Mayo, Sept. 1901 : Lett.

XII. Slieve Donard, Co. Down, very rare : Waddell in Brit. Assoc. Guide to Belfast, 1902.

Tribe 2. JUNGERMANIEÆ.

Sub-tribe 1. RADULEÆ.

Genus IV. Radula Dumort.

1. Radula voluta Taylor.

Radula voluta Taylor, G. L. N., Syn. Hepat., p. 253. *Radula xalapensis* N. M., Lindberg, Hepat. Hib., 1875. Moore, Irish Hepat., p. 616. *Radula voluta* Tayl., Pearson, Hepat. Brit. Isles, p. 67, plate 21.

Districts I — — — — — — VIII. — X. — —.

Hab.—On moist rocks and on the trunks of trees.

I. Dunkerron: Taylor. On boulders below Torc Waterfall (Spruce): Carrington 1863. Very fine there and plentiful, forming large yellowish patches, Sept. 1897: McA. & Lett 1899. Rocks below the Eagle's Nest, Cromaglown (G. E. Hunt), near Derrycunighy Cascade and Gortagree (Moore), O'Sullivan's Cascade and Glena, 1873: Lindberg 1875. Glena (Stewart & Holt): Pearson 1902. Derrynane and Mangerton, and to 2500 ft. on the Reeks: Scully 1890. Burnham Wood near Ventry, 1894: McA. Mount Eagle Lake on rocks, rare, Sept. 1897: Lett and McA.

VIII. Pontoon near Foxford, May 1901: Lett & McA.

X. Shores of Lough Cultra, Co. Cavan, 1893: McA. 1898.

2. Radula Holtii Spruce.

Radula Holtii Spruce, in Journ. of Bot., vol. xxv., p. 209, 1887. McArdle & Lett, Hepaticæ of Torc Waterfall, Proc. R. I. Acad., 3rd ser., vol. vii., no. 2, 1899, p. 323, plate 9. Pearson, Hepat. Brit. Isles, p. 72, plate 24.

Districts I. — — — — — — VIII. — — — —.

Hab.—On moist shaded rocks and epiphytic on *Dumortiera irrigua*, *Jubula Hutchinsiæ*, and *Lejeunea Mackaii*.

I. Torc Waterfall, Killarney, June 1885 (Holt): Spruce 1887 *a.* Within the spray of same waterfall, associated with the same plants and *Radula Carringtonii*, very rare, Sept. 1897: McA. & Lett.

VIII. Bengorm north of Killery Bay, Sept. 1901: Lett.

3. Radula aquilegia Taylor.

Jungermania aquilegia Tayl., in Trans. Bot. Soc. Edinb., vol. ii., p. 117, 1846. *Radula aquilegia* Taylor, G. L. N., Syn. Hepat., p. 260. *Jungermania complanata* var. *minor* Hook., Brit. Jung., t. 81, fig. 17.

Radula aquilegia Tayl., Moore, Irish Hepat., p. 617. Pearson, Hepat. Brit. Isles, p. 74, plate 25.

Districts I. II. — — — — — VIII. — — — XII.

Hab.—On damp rocks and on the trunks of trees which are often submerged, and on the larger Hepatics such as *Frullania Tamarisci.*

I. Not rare in the Killarney district: Moore 1876; and Carrington, cum. per. Glena, male plants, 1873: Lindberg 1875. Knockavohill (Taylor): Pearson 1902. Near Waterville, Mangerton, Slieve Mish to 1500 ft.: Scully 1890. Coomashana Lake, Dingle: Carrington 1863. Connor Hill, 1877: McA. On the west side of Brandon, April 1897: F. W. M. & McA. Mount Eagle 1898: Lett & McA. Anascaul, on *Frullania Tamarisci*: McA. 1894; and 1898: Lett & McA. Burnham Wood near Ventry, and Lough Nalachan, 1899: Lett & McA. Derrymore Glen near Tralee, May 1899: Lett & McA. Near Bantry (Miss Hutchins): Hooker 1816.

II. On rocks, Galtees, Co. Tipperary, July 1902: Lett.

VIII. Bangore, slopes of the Devil's Mother, and on Slievemore, Achill, Sept. 1901: Lett.

XII. On wet rushes in the chasm below the waterfall at the Black Stairs on Slieve Donard (Waddell): Lett 1890.

4. **Radula Carringtonii** Jack.

Radula Carringtonii Jack., in "Flora," vol. lxiv., p. 385, 1881. *Radula aquilegia* Taylor var. *major* Carrington, in Trans. Bot. Soc. Edinb., vol. vii., p. 455, 1863. Lindberg, Hepat. Hib., p. 491. *Radula Carringtonii* Jack., Pearson, Hepat. Brit. Isles, p. 76, plate 26. McArdle & Lett, Hepat. Torc Waterfall, Proc. R. I. Acad., vol. v., no. 2, plate 8, 1899.

District I. — — — — — — VIII. — — — —.

Hab.—On damp shaded rocks, on the trunk of trees, and on the larger Hepatics.

I. Torc Woods, Cromaglown, Glena, Tomes Woods, Killarney, June 1861: Carrington. Rocks near Torc Cascade, male plant, April, 1892: G. E. Hunt. On damp rocks with *Metzgeria conjugata* and *Lejunea Mackaii*, 1899: McA. & Lett 1899; and June 1885, male plants: Stewart & Holt. O'Sullivan's Cascade, Glena, and Cromaglown, Killarney, 1873: Lindberg 1875 (under *R. aquilegia* var. *major*). Anascaul near Dingle: McA. 1894; and May 1898, fertile: Lett & McA. Mt. Eagle, May 1898: Lett and McA. Brandon near the summit, on north-east side, 1900: Lett & McA. Lough

Nalachan on Brandon, and on the rocky shores of Lough Duff in the Brandon Valley, 1899 (Lett & McA.): McA. 1901.

VIII. Bangore and Devil's Mother, Co. Mayo, Sept. 1901: Lett.

5. **Radula complanata** Linn., Dumort.

Jungermania complanata Linn., Sp. Pl., 1599, 1753. Hook., Brit. Jung., tab. 81. *Radula complanata* Dum., Comm., p. 112. Moore, Irish Hepat., p. 617. Pearson, Hepat. Brit. Isles, p. 78, plate 27.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On the trunks of trees and on rocks.

var. *minor* McArdle (non Hook.).

A very minute and fragile plant of a light yellow colour, leaves more convex, found fertile among *Metzgeria* on Ross I., Killarney, 1899: Lett & McA. On Slieve Glah, and in Killakeen Woods, Co. Cavan, Oct. 1893: McA. 1898.

Sub-tribe 2. **PORELLEÆ**.

Genus V. **Porella** Dillenius.

1. **Porella lævigata** Schrad., Lindb.

Jungermania lævigata Schrader, Sammlung, ii., no. 104, p. 6, 1797. Hook., Brit. Jung., tab. 35. *Madotheca lævigata* Dumort., Comm., p. 111, 1822. *Porella lævigata* Lindberg, Musc. Scand., p. 3, 1879. Moore, Irish Hepat., p. 617. Pearson, Hepat. Brit. Isles, p. 80, plate 28.

Districts I. — — IV. — — — — — X. — —.

Hab.—On the trunks of trees near the ground, on stones and rocks which are often submerged.

I. Mountains near Bantry (Miss Hutchins): Hooker 1816. Near Cork (I. Carroll): Moore 1876. O'Sullivan's and Torc Cascades, Killarney, 1873: Lindberg 1875. Upper Lake and Dean Bridge: Carrington 1863. Near Waterville: Scully 1890.

IV. Damp rocks, Lough Bray, Co. Wicklow (Moore): McA. 1890.

X. Rocks below Benburb Castle, Co. Tyrone, 1880: Lett.

var. *integra* Dill., Lindberg.

Glena, Killarney, on inundated stones by the margin of the Lower Lake, 1873 (Lindberg): Moore 1876.

2. **Porella platyphylla** Linn., Lindberg.

Jungermania platyphylla Linn., Sp. Pl., ed. 1, p. 1134. Hook., Brit. Jung., tab. 40. *Madotheca platyphylla* Dumort., Comm., p. 111. *Porella platyphylla* Lindberg, Musc. Scand., p. 3, 1879. Moore, Irish Hepat., p. 618. Pearson, Hepat. Brit. Isles, p. 84, plate 30.

Districts I. — — IV. V. VI. — IX. X. — XII.

Hab.—On rocks and stones, on the trunks of trees, and on moss-covered banks.

I. Killarney, frequent: Carrington 1863. Torc Waterfall, 1897: McA. & Lett 1899. Brandon, 1881: F. W. M. & McA. Mount Eagle Lake, 1898: Lett & McA. Anascaul, 1894, and other places in the Dingle Peninsula: McA. 1901.

IV. On rocks and trees, Co. Wicklow: Moore 1876. On stones at the summit of Dermott McMurrough's Castle, near Ferns, Co. Wexford, 1897: Canon Gibson & McA.

V. On rocks, Beauparc, Co. Meath, Sept. 1893: McA.

VI. Common in South Clare: Stewart 1890. Kilronan, Aran Islands: McA. 1895 *a.*

IX. Ben Bulben, Co. Sligo: McA. 1880. Lough Allen, Co. Leitrim, frequent: Stewart 1885.

X. Killakeen Woods near Cavan, 1893: McA. 1898.

XII. On dry exposed rocks, Co. Antrim, 1834: Moore. On a bank at the railway embankment north of Dromore, Co. Down: Lett 1890.

3. **Porella Thuja** Dicks., Moore.

Jungermania Thuja Dicks., Pl. Crypt. Brit., fasc. 4, p. 19. *Madotheca Thuja* Dumort., Comm., p. 111. Moore, Irish Hepat., p. 618. Pearson, Hepat. Brit. Isles, p. 82, plate 29.

Districts I. — — IV. — — — — — — — XII.

Hab.—On rocks and stones; on the trunks of trees.

I. Near Lough Mangerton, 1885 (Holt & Stewart): Pearson 1902. Lough Fennehy, Dunkerron (Taylor): Moore 1876. Brandon, 1864: Moore; and 1899: Lett & McA. Anascaul, May 1894: McA. Mount Eagle Lake near Dingle, 1898: Lett & McA. Side of Gougane-Barra Lake near Bantry (Miss Hutchins): Hooker 1816.

IV. Lough Bray, Co. Wicklow: Moore; and McA. 1890.

XII. On moist rocks by the side of a waterfall near Carrickfergus, Co. Antrim (Templeton): Hooker 1816. Woodburn and Colin Glens, Co. Antrim: Waddell in Brit. Assoc. Guide to Belfast, 1902.

4. **Porella rivularis** Nees, Lindberg.

Madotheca rivularis Nees, Nat. Eur. Leb., iii., p. 196. *Porella rivularis* Nees, Lindberg, Musc. Scand., p. 3. Pearson, Hepat. Brit. Isles, p. 87, plate 31.

Districts — — — — — — — — — X. — XII.

Hab.—On wet rocks and stones and on trees near water.

X. Castleshane, Co. Monaghan: Waddell.

XII. On trees by the River Lagan at Drumcro, Co. Down (Waddell): Stewart 1888. Saintfield, Co. Down (Waddell): Stewart 1895.

5. **Porella pinnata** Dill., Lindberg.

Jungermania Porella Dicks., Trans. Linn. Soc., vol. iii., p. 230. *Jungermania Cordeana* Hüben., Hepat. Germ., p. 291. *Madotheca Porella* Nees, Nat. Eur. Leb., p. 201. *Porella pinnata* Dill., Lindb., Hepat. Hib., p. 493. Pearson, Hepat. Brit. Isles, p. 89, plate 32.

Districts I. — — — — — — — — — — —.

Hab.—On damp shaded rocks, on stones, and on aquatic mosses.

I. Near Fermoy, Co. Cork (T. Chandlee): Moore 1876. South of Ireland (Taylor & Moore): Pearson 1902. Lough Mangerton (Stewart & Holt): Pearson 1902. Connor Hill, 1873: Lindberg 1875. On wet rocks, Anascaul near Dingle, 1894: McA. Lough Adoon near Clohane on *Cinclidotus*, Sept. 1897: Lett & McA. Lough Nalachan on Brandon, rare, Sept. 1899 (Lett & McA.): McA. 1901.

Genus 6. **Pleurozia** Dumortier.

1. **Pleurozia cochleariformis** Weiss, Dumort.

Jungermania cochleariformis Weiss, Pl. Crypt., p. 123. Hook., Brit. Jung., tab. 68. *Jungermania purpurea* Scop., Fl. Carm. ii., p. 347. *Physiotium cochleariforme* Nees, Nat. Eur. Leb., iii., p. 79. *Pleurozia cochleariformis* Dumort., Syll. Jung. Eur., p. 38. Moore, Irish Hepat., p. 620. Pearson, Hepat. Brit. Isles, p. 91, plate 33.

Districts I. — — IV. V. VI. — VIII. — — XI. XII.

Hab.—On damp bogs among heaths, and on the boggy mountain slopes in quantity.

I. Mountain near Lough Guitane, and Glena: Carrington 1863. Connor Hill, 1873: Lindberg 1875. Mangerton, 1873: Lindberg 1875; and the male plant (Stewart & Holt): Pearson 1902. Common in the Dingle Peninsula: McA. 1901.

IV. Lough Bray, Co. Wicklow, 1887: McA.

V. Dublin mountains, frequent: Moore 1876.

VI. Very fine on bogs near Clonbrock, Co. Galway: McA. 1896 *b*.

VIII. Maam Turc, Connemara, fertile in September: Wade Rar. 1804; and 1874: Moore. Croaghpatrick and Murrisk, Sept. 1901: McA. Pontoon near Foxford, and on Nephin, May 1901: Lett & McA. Slopes of Devil's Mother, Doolough, and on Slievemore, Achill, Sept. 1901: Lett. Gentian Hill near Galway: McA. 1895 *a*.

XI. Errigal and Barnesmore Gap, and plentiful near the White Cliffs, Lough Belshade, June 1903: McA. Bog at Drumfries, foot of Slieve Snacht, and Bulben Mountain, March 1903: Hunter.

XII. Abundant on moist boggy moors through Co. Antrim, 1836: Moore. Rasharkin bog, Co. Antrim (Lett & Waddell): Stewart 1895. Evish Mountain (Lett): Stewart 1895. Rocky Mountain and Hen Mountain, Co. Down, very rare: Lett 1890 (under *Pleurozia purpurea*). Abundant in Co. Derry (Moore): Stewart 1895.

Sub-tribe III. **Ptilideæ.**

Genus VII. **Anthelia** Dumortier.

1. **Anthelia julacea** Linn., Dumort.

Jungermania julacea Linn., Sp. Pl., ii., p. 1601. Hook., Brit. Jung., tab. 2. *Anthelia julacea* Dumort., Recueil, p. 18. Moore, Irish Hepat. p. 636. Pearson, Hepat. British Isles, p. 94, plate 34.

Districts I. — — IV. — — — VIII. — — XI. XII.

Hab.—In the crevices of moist rocks and in large patches on damp peat in alpine and sub-alpine situations.

I. Magillicuddy's Reeks: Moore. Connor hill, 1873: Lindberg 1875. Horse's Glen, Mangerton: Scully 1890. Common in the mountainous parts of the Dingle Peninsula: McA. 1901.

IV. Lugnaquilla: Hart 1886.

VIII. Maam Turc, Co. Galway: Wade Rar. 1804; and Moore 1876. Kylemore, Co. Galway, 1874: Moore.

XI. On rocky bank, River Trillick, Buncrana, March 1902: Hunter. Barnesmore, Lough Belshade, Errigal, Goat Island near Lough Eask, June 1903: McA.

XII. Slieve Donard and Bloody Bridge River, Co. Down (Waddell): Stewart 1888. White River Glen, Slievenabrock, Slievenamaddy, Bloody Burn glen, Hare's Gap, Deer's Meadow, Shanslieve, Co. Down: Lett 1890.

var. *gracilis* Hook.

Hook., Brit. Jung., tab. 2, fig. 3. Moore, Irish Hepat., p. 636, (under var. *minor*).

Brandon: Moore 1876. On the west side of Brandon, April 1897: F. W. M. & McA. Connor Hill (Moore): Carrington 1863.

Genus VIII. **Herberta** Gray & Bennett.

1. **Herberta adunca** Dicks., Gr. & B.

Jungermania adunca Dicks., Pl. Crypt. Brit., fasc. iii., p. 12. *J. juniperina β adunca* Hook., Brit. Jung., tab. 4. *Herberta adunca* Gr. & B., Nat. Arr. Brit. Pl., p. 705, 1821. *Schisma adunca* Dumort., Comm., p. 116, 1822. *Herberta adunca* Gr. & B., Moore, Irish Hepat., p. 635. Pearson, Hepat. Brit. Isles, p. 99, plate 36.

Districts I. — — IV. — — — VIII. IX. — XI. XII.

Hab.—Growing in dense tufts on damp shelving rocks and banks at high elevations.

I. Mountains near Bantry (Miss Hutchins): Hooker 1816. Cromaglown, Killarney, 1845: Spruce. Connor Hill, 1873: Lindberg 1875. Common at high elevations in the Dingle Peninsula: McA. 1901.

IV. Lough Bray, Co. Wicklow (Moore): McA. 1890.

VIII. Slievemore on Achill, and on the slopes of Devil's Mother, Co. Mayo, Sept. 1901: Lett.

IX. Gleniff and Glenade, Co. Leitrim: Moore.

XI. Fanet: Hart 1886.

XII. On the undercliff of Fairhead, Co. Antrim (Templeton in Herb. Belfast Museum): Stewart 1888.

Genus IX. **Mastigophora** Nees.

1. **Mastigophora Woodsii** Hook., Nees.

Jungermania Woodsii Hook., Brit. Jung., tab. 66. *Blepharozia Woodsii* Dumort., Recueil, p. 116. *Mastigophora Woodsii* Nees, Nat. Eur. Leb., iii., p. 95. Moore, Irish Hepat., p. 635. Pearson, Hepat. Brit. Isles, p. 102, plate 37.

Districts I. — — — — — — VIII. — — — —.

Hab.—On damp banks and on shelving rocks in mountainous places.

I. On the ascent to Mangerton, 1809 (J. Woods): Hooker 1816. Moore 1876. Devil's Punch-bowl on Mangerton, 1829: Taylor; and (Stewart and Holt): Pearson 1902. Carantual: Moore. Brandon, Oct. 1829: Taylor and Wilson. In a gorge on the N.E. side near the summit of Brandon, June 1900: Lett & McA. Connor Hill: Moore.

VIII. Slievemore on Achill, Sept. 1901: Lett.

Genus X. **Blepharozia** Dumortier.

1. **Blepharozia ciliaris** Linn., Dumort.

Jungermania ciliaris Hook., Brit. Jung., tab. 65. *Blepharozia ciliaris* Dumort., Recueil, p. 16. *Ptilidium ciliare* Hampe, Prodr. Fl. Herc., 1836. *Blepharozia ciliaris* Dumort., Moore, Irish Hepat., p. 634. Pearson, Hepat. Brit. Isles, p. 104, plate 38.

Districts I. — — — — — — — — — — —.

Hab.—On heaths and among rocks in sub-alpine places.

I. Mangerton, and Ross Bay, Killarney: Carrington 1863. Torc Mountain, 1861: Moore. Brandon, 1829: Taylor.

Genus XI. **Trichocolea** Dumortier, Nees.

1. **Trichocolea tomentella** Ehrhart, Dumort.

Jungermania tomentella Ehr., Beitr., ii., p. 150. Hook., Brit. Jung., tab. 36. *Trichocolea tomentella* Ehrh., Moore, Irish Hepat., p. 634. Pearson, Hepat. Brit. Isles, p. 108, plate 39.

Districts I. — — IV. — — VII. — — — XI. XII.

Hab.—On wet rocks, and damp woods in shaded places.

I. Killarney Woods, abundant: Moore. Cromaglown 1873: Lindberg 1875. Hanging in dense tufts over the rocks within the spray of Torc Waterfall, Killarney, Sept. 1897: Lett & McA. Black Stairs bridge, Kenmare Bay: Scully 1890.

IV. Lough Bray: Moore. Woodenbridge, Sept. 1892: Praeger; Sept. 1894 (Miss Constance Pim): McA. in I. Nat., vol. iii., p. 258, 1894.

VII. Bog near Geashill, King's Co.: McA. 1892 *a*.

XI. Wood by Mulroy Bay, and Cratleigh Wood near Milford, Sept. 1902: McA. Bridge End Glen, 1889, and Linsfoot Glen, Buncrana, March 1903: Hunter. Woods about Lough Eask, June 1903: McA.

XII. Moist shady banks, Co. Antrim, 1836: Moore. Saintfield, Co. Down, 1897: Waddell. By a rivulet in Belvoir Park, Co. Down (Templeton), Glenarm, Co. Antrim (Brenan); Stewart 1895. By the Shimna River in Tollymore Park (Lett), Rostrevor Mountain and Moygannon Glen (Waddell), and the Spinkwee River in Tollymore Park, very rare (Stewart): Lett 1890.

Genus XII. **Blepharostoma** Dumortier.

1. **Blepharostoma trichophyllum** Linn., Dumort.

Jungermania trichophylla Linn., Sp. Pl., p. 1601. Hook., Brit. Jung., tab. 15. *Blepharostoma trichophyllum* Dumort., Recueil, p. 18.

Moore, Irish Hepat., p. 636. Pearson, Hepat. Brit. Isles, p. 112, plate 41.

Districts I. — — IV. V. — — VIII. — — — XII.

Hab.—On turfy heaths, in bogs among *Sphagnum*, and among the larger Hepatics.

I. Near Bantry (Miss Hutchins): Hooker 1816. Cromaglown, Killarney (Carrington): Moore 1876. O'Sullivan's Cascade, 1873: Lindberg 1875. Glencar and Torc Mountains, Killarney: Scully 1890. Brandon, fertile, and Mount Eagle, 1881: F. W. M. & McA. Lough Adoon, Sept. 1897, rare in the Dingle Peninsula: Lett & McA.

IV. Lough Bray, Co. Wicklow, 1877: Moore; and 1890, fertile: McA., I. Nat., vol. ii., p. 172, 1893.

V. Omeath Glen, Co. Louth, very rare: Lett 1890.

VIII. Kylemore, Co. Galway, 1874: Moore. Nephin: Moore 1876; and May 1901: Lett & McA. Slievemore, Achill, Sept. 1901: Lett.

XII. Near Belfast (Templeton): Hooker 1816. Glendun, Co. Antrim, 1836: Moore. Tollymore Park and Slievenabrock, Co. Down (Lett), Colin Glen, sparingly (Stewart and Waddell): Stewart 1888.

Sub-tribe 4. **Trigonantheæ.**

Genus XIII. **Lepidozia** Dum.

1. **Lepidozia cupressina** Swartz.

Jungermania cupressina Swz., Prod. Fl. Ind. Occid., p. 144. *Jungermania reptans* var. *pinnata* Hook., Brit. Jung., tab. 75. *Lepidozia tumidula* Tayl., in G. L. N., Syn. Hepat., p. 206. *Lepidozia cupressina* Pearson, Hepat. Brit. Isles, p. 116, plate 43.

Districts I. — — IV. V. VI. — VIII. — X. XI. —.

Hab.—Growing in dense cushions on the ledges of rocks, and on damp shaded banks.

I. Near Bantry, fertile (Miss Hutchins): Hooker 1816. Killarney woods, abundant: Moore 1876; Carrington 1863. Glena and O'Sullivan's Cascade, Killarney, 1873: Lindberg 1875. Mount Eagle, Coumanare Lakes, and Loughanscaul in the Dingle Peninsula, rare Sept. 1898: Lett & McA.

IV. Lough Bray, Co. Wicklow, plentiful (Turner): Hooker 1816; McA. 1890.

V. Among rocks, Ballykill, and in the Howth Demesne, Co. Dublin, 1895: McA. 1897.

VI. Clare Glen, Glenstall, Co. Limerick: Hart 1886.

VIII. Nephin, plentiful, May 1901: Lett & McA. Devil's Mother and Slievemore, Achill, Sept. 1901: Lett.

X. Shores of Lough Allen, Co. Leitrim: Stewart 1885.

XI. Portlaw Hill, Buncrana, March 1903, and Carrodoan Wood, Lough Swilly, March 1901: Hunter.

2. **Lepidozia reptans** Linn., Dum.

Jungermania reptans Linn., Sp. Pl., 1599, 1753. *Lepidozia reptans* Dum., Recueil, p. 19. Pearson, Hepat. Brit. Isles, p. 119, plate 44.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On banks in woods, on decayed wood, among rocks in damp shaded places; a beautiful and distinct plant.

3. **Lepidozia Pearsoni** Spruce.

Lepidozia Pearsoni Spruce, in Journ. of Bot., vol. xix., p. 34, 1881. *Lepidozia Wulfsbergii* Lindb., Soc. F. & Fl. Fenn., 1882.

District I. — — — — — — — — — — —.

Hab.—On damp banks among rocks with *Sphagnum* and other Mosses.

I. Lough Duff in the Brandon Valley, May 1899 (Lett & McA.): McA. 1901. The only locality at present known in Ireland.

4. **Lepidozia setacea** Web., Mitt.

Jungermania setacea Web., Spic. Pl. Goett., p. 143. Hook., Brit. Jung., tab. 8. *Blepharostoma setacea* Dumort., Recueil, 1835. *Lepidozia setacea* Web., Mitt., Journ. Linn. Soc. v., p. 103. Pearson, Hepat. Brit. Isles,p . 124, plate 46.

Dlstricts I. II. III. IV. V. VI. VII. VIII. — — XI. XII.

Hab.—On turfy bogs, shaded banks, decayed wood, and among the larger Hepaticæ.

I. Bog near Bantry (Miss Hutchins): Hooker 1816. Abundant in the Killarney Woods: Moore and others. Common in the Dingle Peninsula: McA. 1901.

II. Knockmeildown and Galtee Mountains, Co. Tipperary, June 1902: McA.

III. Near Cappard, Queen's Co.: McA. 1892 *a*.

IV. Lough Bray, Co. Wicklow (Turner): Hooker 1816; also 1873: Lindberg 1875; and McA. 1890.

V. Boggy places on the Hill of Howth: McA. 1893 *a*. Anglesey Mountain, Co. Louth: Lett 1890.

VI. Doon bog, Clonbrock, Co. Galway: McA. 1896 *b*. Carn Seefin, Co. Clare, frequent: McA. 1895*a*.

VII. Ard Bog, King's Co., 1890: Russell.

VIII. Nephin, May 1901: Lett & McA. Murrisk and Croagh-patrick, Sept. 1901: McA. Pontoon near Foxford, May 1901: Lett & McA. Slievemore, Achill, Sept. 1901: Lett.

XI. Croghan Mountain, hill above Mintiaghs, Carradoan Wood, Rathmullan, Glenalla Hill, Rathmelton, July 1902: Hunter. Errigal, June 1903: McA.

XII. Rasharkin, Co. Antrim, Sept. 1838: Moore; and (Lett): Stewart 1895. Hen Mountain and Tollymore Park: Lett 1890. By the Yellow River, Co. Down (Waddell), Anahilt bog (Templeton), and Slievenamaddy (Lett): Stewart 1888. North side of Divis Mountain, 1803 (Templeton): Stewart 1888. Glendun, Co. Antrim: Brenan & Lett.

var. *sertularioides* Hubener.

Jungermania sertularioides Mich., Fl. Bor. Am., ii., p. 278. Lough Adoon, Co. Kerry, Sept. 1897: Lett & McA. Murrisk near West-port, Sept. 1901: McA.

5. **Lepidozia trichoclados** C. Müll.

Lepidozia trichoclados C. Müll., in Hedwigia, vol. xxxviii., p. 197, 1899. Macvicar, in Journ. of Botany, vol. xl., p. 157, 1902.

Districts I. — — IV. V. VI. — VIII. IX. — — —.

Hab.—On moist peaty bank, shaded by rocks or trees.

I. Mount Eagle near Dingle, June 1898: Lett & McA. Croma-glown, Killarney, 1877: McA. O'Sullivan's Cascade, Killarney, with *Cephalozia hibernica*, Nov. 1893: McA.

IV. Lough Bray, 1880: McA. 1890. Lugnaquilla, 1896: McA.

V. Ballykill, Howth, Oct. 1891: McA.

VI. Carn Seefin, Co. Clare, July 1895: McA.

VIII. Nephin, and Pontoon on Lough Conn, May 1901: Lett & McA. Kylemore, 1874: McA.

IX. Ben Bulben, Co. Sligo, July 1880: McA.

Genus 14. **Bazzania** Gr. & Bennett.

1. **Bazzania trilobata** Linn., Gr.

Jungermania trilobata Linn., Sp. Pl., 1599. Hook., Brit. Jung., tab. 76. *Mastigobryum trilobatum* Nees, in G. L. N., Syn. Hepat.,

p. 230. *Bazzania trilobata* Gr. & B., Nat. Arr. Brit. Pl., p. 704. Pearson, Hepat. Brit. Isles, p. 128, plate 47.

Districts I. — III. IV. V. — — VIII. — — XI. XII.

Hab.—In damp rocky places, shaded banks, and on decayed wood, often forming dense patches in subalpine situations.

I. On the summit of Magillicuddy's Reeks: Taylor 1836. Killarney Woods, abundant: Moore 1876. Glena and Cromaglown, 1873: Lindberg 1875. Glencar; Scully 1890. Common in the Dingle Peninsula (Lett & McA.): McA. 1901.

III. Near the Bridge at Graigue, Co. Carlow, among rocks: McA. 1896 *a*.

IV. Lough Bray and Seven Churches (Moore): McA. 1890.

V. Killakee Glen, Co. Dublin, 1894: McA.

VIII. Kylemore, 1874: Moore. On Lettery Mountain, Connemara: Wade. Rar. 1804.

XI. Macamish Wood, March 1902: Hunter.

XII. Slemish, Co. Antrim; and Dart, Co. Derry, rare, 1836: Moore. Tollymore Park, Co. Down: Stewart 1888. Thomas Mountain, very rare (Waddell & Lett): Lett 1890.

2. **Bazzania triangularis** Schl., Lindb.

Jungermania triangularis Schleicher, Pl. Crypt. Helv., ii., no. 61. *Jungermania deflexa* Mart., Fl. Crypt. Erlang., p. 125, tab. 3, fig. 8. *Bazzania triangularis* Sch., Lindberg, Hepat. in Hibernia, p. 499, 1875. Pearson, Hepat. Brit. Isles, p. 130, plate 48.

Districts I. — — — — — — VIII. IX. X. — —.

Hab.—On damp shaded banks among rocks, and among the larger Hepaticæ.

I. Torc Mountain and Cromaglown, 1863 (Carrington): Moore 1876. O'Sullivan's Cascade: Moore. Upper Glencar: Scully 1890. Macgillicuddy's Reeks: Hart 1886. Brandon (Moore): Lindberg 1875; and 1895: McA. Connor Hill, 1873: Lindberg 1875. Frequent the Dingle Peninsula: McA. 1901.

VIII. Twelve Bens: Hart 1886. Nephin, May 1901: Lett & McA.

IX. Ben Bulben: Moore.

X. Plentiful on Slievenierin, Co. Leitrim: Stewart 1885.

var. *innovans* Nees, in G. L. N., Syn. Hepat., p. 232.

Carrington & Pearson, Exsicc., no. 124.

On damp peaty banks among rocks, Mount Eagle Lake, Sept. 1898: Lett & McA. Connor Hill, Sept. 1897: Lett & McA.

var. *devexum* Nees, in G. L. N., Syn. Hepat., p. 232.

On damp peaty soil among rocks, Brandon: Moore. Connor Hill: Scully 1890.

3. **Bazzania tricrenata** Wahlenberg.

Jungermania tricrenata Wahlenb., Fl. Carp., p. 364, no. 1207. *Bazzania tricrenata* Pearson, Hepat. Brit. Isles, p. 132, plate 49. McA., Hepat. Dingle Peninsula, p. 306. 1901.

Districts I. — — — — — — VIII. — — — —.

Hab.—On damp banks among rocks.

I. Killarney, June 1885 (Stewart & Holt): Pearson 1902. Brandon with *Pleurozia*, April 1897: F. W. M. & McA. Coumanare Lakes and Barnanaghea Lough, 1898, Lough Duff and Lough Nalachan on Brandon, May 1899: Lett & McA.

VIII. Nephin, and Pontoon near Foxford, May 1901: Lett & McA. Devil's Mother and on Slievemore, Achill, Sept. 1901: Lett.

4. **Bazzania Pearsoni**, Stephani.

Mastigobryum Pearsoni Stephani, Hedwigia, 1893. *Bazzania Pearsoni* Steph., Pearson, Hepat. Brit. Isles, p. 133, plate 50.

Districts I. — — — — — — — — — — —.

Hab.—On banks and rocks.

I. Eagle's Nest, Horse's Glen, and Cromaglown, Killarney, June 1885 (Stewart & Holt): Pearson 1902.

Genus 15. **Kantia** Gr. & B.

1. **Kantia Trichomanis** Linn., Gr. & B.

Mnium Trichomanis, Linn., Sp. Pl., p. 1579. *Jungermania Trichomanis* Dicks., Pl. Crypt. Brit., fasc. iii., t. 8, fig. 5. *Kantia Trichomanis*, Gr. & B., Nat. Arr. Brit. Pl., p. 706. *Kantia Trichomanis* Linn., Pearson, Hepat. Brit. Isles, p. 135, plate 51.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On damp clay banks, and among damp rocks, and on the larger Hepaticæ, common.

2. **Kantia arguta**, Mont. et Nees, Lindberg.

Calypogeia arguta, Montagne et Nees, Nat. Eur. Leb., iii., p. 24. *Cincinalis argutus* Dum., Hepat. Eur., p. 117. *Kantia arguta* Lindb., in Hepat. Hibern., p. 307, 1875. Moore, Irish Hepat., p. 632. Pearson, Hepat. Brit. Isles, p. 139, plate 53.

Districts I. II. III. IV. V. VI. VII. VIII. — — XI. XII.

Hab.—On damp clay banks, and among the larger Mosses and Hepaticæ.

I. Cromaglown, Killarney: Scully 1890. Ross I. ,May 1899 (Lett & McA.): McA. 1900. O'Sullivan's Cascade, Glena, near Ventry, and Connor Hill, 1873: Lindberg 1875. Connor Hill, 1881: F. W. M. & McA. Common through the Dingle Peninsula: McA. 1901. Dunboy Wood and Bere Island: McA. 1894.

II. Woods about Scarriff, Galtee Mountains, June 1902: McA.

III. Bank of a stream on Slieve Bloom, Queen's Co., 1891: McA. 1892 *a*. Graigue, Co. Carlow: McA. 1896 *a*.

IV. Kilbora Wood near Ferns, 1896: Greene. Woods by the Slaney River near Edermine Junction, and near Enniscorthy; banks of the Urrin River near Knockroe, and in Killoughrim Oak Forest near Enniscorthy, May 1899: McA. Luggielaw, Co. Wicklow, on *Nardia compressa*: Moore. Lough Bray, 1878: McA.

V. Killakee glen, Co. Dublin, among *Rhynchostegium Swartzii*, 1890: McA.

VI. Carn Seefin, Co. Clare, 1895: Prof. T. Johnson. Shores of Lough Corrib, Co. Galway: McA. 1895 *a*.

VII. Ard bog, King's Co., 1891: Russell.

VIII. Nephin, and Pontoon near Foxford, May 1901: Lett & McA. Devil's Mother and Achill Island, Sept. 1901: Lett.

XI. Damp clay banks at Mount Charles, and Goat Island near Lough Eask, June 1903: McA.

XII. Mountains above Newcastle and in Ballymaghan Glen: Stewart 1888. Slieve Donard, Hen Mountain, Warrenpoint, Black Stairs on Slieve Donard, Slievenamaddy: Lett 1890. Clonallon, and by the Yellow Water, Co. Down (Waddell): Lett 1890. Holywood Hill, May 1903: Hunter.

Genus 16. **Cephalozia** Dumort.

Sub-genus 1. **Eucephalozia** Spruce.

1. **Cephalozia catenulata** Huben.

Jungermania catenulata Hüben., Hepat. Germ., p. 169. *Jungermania reclusa* Tayl., Lond. Journ. Bot., 1846, p. 278. *Cephalozia catenulata* Hüben., Spruce on *Cephalozia*, p. 33. Pearson, Hepat. Brit. Isles, p. 144, plate 44.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On damp, shaded banks among rocks, and on decayed wood.

I. Cromaglown and other places in the S.W. (Taylor, Moore & Spruce): Spruce 1882. Finnahay River near Kenmare (Spruce & Taylor): Carrington 1863. O'Sullivan's Cascade, 1873: Lindberg 1875. Upper Glencar: Scully 1890. Brandon: Moore. Lough Adoon near Clohane, 1897: Lett & McA. Barnanaghea Lough near Lispoll, and Mount Eagle, 1898: Lett & McA. Derrymore Glen near Tralee, 1899 (Lett & McA.): McA. 1901. Caha Mountain and Dunboy Wood, Co. Cork: McA. 1894.

II. Knockmeildown Mountains, Co. Tipperary, June 1902: McA.

III. Graigue, Co. Carlow: McA. 1896 *a*.

IV. Lough Bray, Co. Wicklow: Moore 1876.

V. On damp banks between rocks with *Kantia Trichomanis*, Baily Lighthouse, Howth: McA. 1893 *a*. Killakee Glen, Co. Dublin: Moore 1876. Kelly's Glen, Co. Dublin, Aug. 1896: McA.

VI. Doon bog, Clonbrock, Co. Galway: McA. 1896 *b*. On peat, Carn Seefin, and Ballyvaughan, Co. Clare, very fine: McA. 1895 *a*.

VII. Ard bog and Killeigh bogs, King's Co., Nov. 1891 (Russell): McA. 1892 *a*.

VIII. Kylemore, Co. Galway, 1874: Moore. Diamond Mountain, 1891: McWeeney. Lachan bay, Co. Mayo: Moore. Nephin, May 1901: Lett & McA. Murrisk, Sept. 1901: McA. Pontoon by Lough Conn, May 1901: Lett & McA. Achill, Sept. 1901: Lett.

IX. Gleniff, Co. Leitrim: Moore.

X. On decayed wood on shores of Lough Cultra, on Slieve Glah, and at Ballyhaise, Co. Cavan, among *Diplophyllum*, 1893: McA. 1898.

XI. Croghan Mountains, Rathmullan, July 1902: Hunter. Gartan Wood and Bunlin Waterfall near Milford, Sept. 1902: McA.

XII. Rocks near the head of Glenbush, Co. Antrim, 1838: Moore (under *C. reclusa* Tayl.). Bog at Ballygenan, Co. Down, plentiful, 1903: Lett & Waddell.

2. **Cephalozia pallida** Spruce.

Cephalozia catenulata var. *pallida* (*C. pallida* nobis in hb.), Spruce on *Cephalozia*, p. 34, 1882. Pearson, Hepat. Brit. Isles, p. 146, plate 45.

Districts I. — — IV. V. — — VIII. — — XI. —.

Hab.—On turfy banks among rocks.

I. Brandon, 1875: McA. Mount Eagle, June 1898; Lough Adoon near Clohane, Sept. 1897; Derrymore Glen near Tralee, 1898: Lett & McA.

IV. Lough Bray, Co. Wicklow, 1879: McA. 1890.

V. On damp peat among *Tetraphis pellucida* at Ballykill, Howth, Febr. 1894: McA. 1897.

VIII. Lachan bay, Co. Mayo (Moore): Pearson 1902. Shores of Lough Conn at Pontoon, May 1901: Lett & McA. Doolough, Co. Mayo, Sept. 1901: Lett.

XI. Carradoan Wood, Rathmullan, July 1902: Hunter.

3. **Cephalozia lunulæfolia** Dumort.

Jungermania lunulæfolia Dum., Syll. Jung., p. 61. *Cephalozia lunulæfolia* Dum., Recueil, p. 18, 1835. *C. media* Lindberg, Medd. af. Soc. pro F. Fl. Fenn., vi., p. 242. *C. multiflora* Spruce on *Ceph.*, p. 37. *C. lunulæfolia* Pearson, Hepat. Brit. Isles, p. 147, plate 46.

Districts I. II. — — V. — VII. VIII. — — XI. —.

Hab.—On damp banks and decayed wood, on bogs among *Sphagnum*.

I. O'Sullivan's Cascade and Glena, Killarney, 1873: Lindberg 1875 (under *C. multiflora*). Glencar: Scully 1890. On the N.E. side of Brandon, June 1900, at Loughanscaul and at Coumanare lakes near Connor Hill, rare, Sept. 1898: Lett & McA.

II. Glengarra Wood, Galtee Mtns., and near Baylough, Knockmeildown Mtns., June 1902: McA.

V. Near the Quarries, Sutton, Co. Dublin: McA. 1893 *a*.

VII. On the Gull bog near Tullamore, King's Co.: McA. 1892 *a*.

VIII. Nephin, May 1901: Lett & McA. Doolough, Sept. 1901: Lett. Achill, Sept. 1901: Lett. Pontoon near Foxford, May 1901: Lett & McA. Westport demesne, Sept. 1901: McA. Floating in bog-holes near Kylemore, Co. Galway, 1869 (Moore): Spruce 1882.

XI. Saltpans Wood, Rathmullan, July 1902: Hunter. Gartan Wood near Milford, Sept. 1902: McA.

4. **Cephalozia bicuspidata** Linn., Dumort.

Jungermania bicuspidata Linn., Sp. Pl., 1589, 1753. Hook., Brit. Jung., tab. 11. *Cephalozia bicuspidata* Dum., Recueil, p. 18. Pearson, Hepat. Brit. Isles, p. 150, plate 47.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On damp banks, bogs, and on decayed wood, from sea-level to high elevations.

var. *major* Carrington.

Nephin, Co. Mayo (Moore): Carrington 1863.

var. *rigidula* Carrington.

Cromaglown, Killarney (Carrington): Moore 1876.

var. *setulosa* Spruce, on Ceph., p. 42.

Caha Mtn., Co. Cork: McA. 1894. Doon bog, Clonbrock, Co. Galway: McA. 1896 *b*. Ard bog, King's Co., 1891 (Russell): McA. 1892 *a*. Killakeen, Co. Cavan, 1893: Mc.A. 1898.

var. *tenuirama* Carrington & Pearson, Exsicc., no. 252.

On a peaty bank between Emalough and Inch, Co. Kerry, April 1898: Lett & McA.

var. (?). A minute reddish plant found among the rocks near the Baily Lighthouse, Howth: McA. 1893. Ireland's Eye, Co. Dublin, 1893: McA. Summit of Slieve Glah, Co. Cavan, 1893 *a*: McA. Connor Hill on the hard ground, 1898: Lett & McA. On the pathway in Killoughrim Oak Forest, Co. Wexford, May 1899: McA.

Always sterile. This may prove to be a distinct species.

5. **Cephalozia Lammersiana** Hüben., Spruce.

Jungermania Lammersiana Hübener, Hepat. Germ., p. 165. *J. bicuspidata* var. *uliginosa* Nees, Eur. Leberm., ii., 253. *J. bicuspidata*, Eng. Bot., vol. xxxii., pl. 2239. *Cephalozia Lammersiana* Hüben., Spruce on Ceph., p. 43. Pearson, Hepat. Brit. Isles, p. 153, plate 48.

Districts I. II. III. IV. V. VI. VII. VIII. — X. XI. XII.

Hab.—Damp boggy places.

I. O'Sullivan's Cascade, Killarney, 1869: Moore; 1880: McA.; and Scully 1890. Bog on Connor Hill: Moore; and Sept. 1898: Lett & McA. Near Brandon Head, Anascaul, Barnanaghea Lough, Mount Eagle, and the bogs about the Coumanare Lakes, in the Dingle Peninsula, 1897–8 (Lett & McA.): McA. 1901. Dunboy Wood, Co. Cork: McA. 1894.

II. Galtees, Co. Tipperary, June 1902: McA.

III. Slieve Bloom, Queen's Co.: McA. 1892 *a*.

IV. Lough Bray, Sept. 1897; Glenmalure, May 1896; and wood by the Slaney River near Enniscorthy, Co. Wexford, May 1899: McA.

V. Killakee Glen, Co. Dublin, 1874: McA. Boggy places on the Hill of Howth: McA. 1893 *a*. Kelly's Glen, Co. Dublin, Aug. 1896: McA.

VI. Carn Seefin, Co. Clare: McA. 1895 *a*.

VII. Ard bog, King's Co., 1891 (Russell): McA. 1892 *a*.

VIII. Kylemore, July 1869 (Moore): McA. 1880 (under *C. bicuspidata* var. *uliginosa*). Doon bog, Clonbrock, Co. Galway: McA. 1896 *b*. Nephin, and Pontoon near Foxford, May 1901: Lett & McA. Doolough, Co. Mayo, Sept. 1901: Lett.

X. Boggy places about Ballyhaise woods and on Slieve Glah, Co. Cavan, October 1893: McA. 1898. Slieve Gullion, Co. Armagh: McA., Ir. Nat., vol. 3, March 1894.

XI. Carradoan Wood, Rathmullan, July 1902: Hunter. Gartan Wood and Cratleagh Woods near Milford, 1902: McA.

XII. Abundant on Slieve Croob: Waddell in Guide to Belfast, 1902.

6. **Cephalozia hibernica** Spruce MS.

Pearson, in Irish Naturalist, vol. iii., p. 245, plate 6, 1894. Pearson, Hepat. Brit. Isles, p. 155, plate 49.

Districts I. — — — — — — — — — — —.

Hab.—On damp banks among Mosses.

I. Among *Plagiothecium Borrerianum*, Killarney, 1865: Moore. Killarney: Scully 1890. O'Sullivan's Cascade, Nov. 1893: McA.

7. **Cephalozia connivens** Dicks.

Jungermania connivens Dickson, Pl. Crypt. Brit., fasc. iv., p. 19, tab. 2, fig. 15. Hook., Brit. Jung., tab. 15. Eng. Bot., tab. 2436. *Cephalozia connivens* Dicks., Spruce on Ceph., p. 46. Moore, Irish Hepat., p. 626. Pearson, Hepat. British Isles, p. 157, plate 50.

Districts I. II. — IV. V. VI. VII. VIII. — X. XI. XII.

Hab.—On wet peaty banks, bogs, and on decayed wood.

I. Mount Eagle, July 1881: F. W. M. & McA. Derrymore Glen near Tralee, May 1899 (Lett & McA.), rare or overlooked: McA. 1901.

II. Galtee Mtns., Co. Tipperary, June 1902: McA.

IV. Lough Bray: McA. 1890. Altadore Glen, Co. Wicklow, 1887: McA.

V. Bog on the Sutton side of Howth, very rare: McA. 1893 *a*.

VI. Bogs about Clonbrock, Co. Galway: McA. 1896 *b*.

VII. Killeigh Bog, King's Co., 1891: Russell. Welsh Island near Geashill: McA. 1892 *a*.

VIII. Marsh in Connemara (Mackay): Hooker 1816. Kylemore, 1891: McWeeney. Pontoon near Foxford and on Nephin, May 1901: Lett & McA.

X. Derrycrow bog, Montiaghs, Co. Armagh, 1885: Lett. Top of Camlough Mtn., very rare: Lett.

XI. On *Sphagnum*, Carradoan Wood, Rathmullan, July 1902: Hunter.

XII. Near Belfast (Templeton): Hooker 1816. Bogs between Swatragh and Kilrea, 1834 (Moore): Stewart 1888. Slievenamaddy, Co. Down (Lett): Stewart 1895; Lett 1890.

8. **Cephalozia curvifolia** Dicks., Dumort.

Jungermania curvifolia Dicks., Pl. Crypt. Brit., fasc. ii., 15, tab. 5. Hook., Brit. Jung., tab. 15, et Suppl., tab. 1, ex parte. *Jungermania Baueri* Mart., Fl. Crypt. Erlang., p. 172, tab. 6, fig. 46. *Cephalozia curvifolia* Dum., Recueil, p. 18. McArdle, Hepat. Howth, p. 115, plate 4, figs. 7 to 13. Pearson, Hepat. Brit. Isles, p. 159, plate 51.

Districts I. — — IV. V. — — VIII. IX. — XI. XII.

Hab.—On decayed wood, damp banks among heather, sheep-paths, &c.

I. On decayed wood by a mountain lake near Bantry (Miss Hutchins): Hooker 1816. Dunboy Wood and banks of the Pulleen River, Castletownbere: McA. 1894. O'Sullivan's Cascade, Killarney, 1873: Lindberg 1875. Glencar and Killarney, frequent: Moore; and Scully 1890. Connor Hill: Moore; and Sept. 1897: Lett & McA. Lough Nalachan on Brandon, 1899; and Mt. Eagle, Sept. 1898: Lett & McA. Rare in the Dingle Peninsula: McA. 1901.

IV. Altadore Glen: McA. 1889. On decayed wood, Lough Bray, 1879 (F. W. M.): McA. 1890. Douce, Co. Wicklow, fertile, 1897: McA.

V. On shallow peat under the branches of *Erica*, Ballykill, and other places on Howth: McA. 1893 *a* (with fig.).

VIII. Kylemore, 1874: Moore. Pontoon near Foxford and on Nephin, May 1901: Lett & McA. Doolough, and Slievemore on Achill, Sept. 1901: Lett.

IX. Glenade, Co. Leitrim: Moore.

XI. Gartan Wood near Milford, Sept. 1902: McA. Very fine on bank at waterfall on Errigal and Goat Island near Lough Eask, June 1903: McA. Ned's Point, Buncrana, March 1902: Hunter.

XII. Crannies of rocks, Mourne Mtns. (Templeton): Hooker 1816. Slieve Bingian, Shanslieve, and Hen Mountain: Waddell in Guide to Belfast, 1902.

9. **Cephalozia Francisci** Hook., Dumort.

Jungermania Francisci, Hook., Brit. Jung., tab. 49. *Cephalozia Francisci* Dum., Recueil, p. 18. Moore, Irish Hepat., p. 624.

McArdle, Hepat. Howth, p. 112, plate 3. Pearson, Hepat. Brit. Isles, p. 163, plate 52.

Districts I. — — — V. — — VIII. — — — XII.

Hab.—Damp peaty banks among rocks.

I. Near Bantry (Miss Hutchins): Hooker 1816.

V. Side of a shallow channel on a small bog near Ballykill plantation, Howth, fertile: McA. 1893 *a*.

VIII. Boggy place among rocks at Pontoon on the shore of Lough Conn, May 1901: Lett & McA.

XII. Kinahalla, June 1893, and Deer's Meadow in the Mourne Mtns., Co. Down, 1886: Lett.

10. **Cephalozia fluitans** Nees, Spruce.

Jungermania fluitans Nees, in Syll. Ratisb. *J. inflata* var. *fluitans* Nees, Eur. Leber. *Cephalozia obtusiloba* Lindb., Bot. Not., 1872. *Cephalozia cladorhizans* Spruce, McArdle, new or rare Irish Hepat., Sci. Proc. R. D. Soc., vol. iii., p. 3, fig. 6, 1880. *Cephalozia fluitans* Nees, Spruce on Ceph., p. 50. Pearson, Hepat. Brit. Isles, p. 165, plate 53.

Districts I. — — — V. — VII. VIII. — X. — XII.

Hab.—On *Sphagnum* in wet bogs, often floating.

I. Amongst *Sphagnum cuspidatum* var. *plumosum* on Knocknageeha bog near Killarney, Jan. 1897: Praeger.

V. Wet bog, Ballykill, Howth: McA. 1893*a*.

VII. Bracklin bog near Killucan, Co. Westmeath, on *Sphagnum rubellum*: McA. 1880.

VIII. Floating in bog-holes near Kylemore with *Cephalozia multiflora* and *C. Lammersii*, 1869 (Moore): McA. 1880.

X. Camlough Mtn., Co. Armagh, 1887: Lett.

XII. Giant's Causeway, 1836 (Moore): Ord. Surv. Collection (under *Jungermania inflata*, aquatic form).

Sub-genus 2. **Odontoschisma** Dumort.

11. **Cephalozia Sphagni** Dicks., Spruce.

Jungermania Sphagni Dicks., Crypt. Brit. Hook., Brit. Jung., tab. 33. *Odontoschisma Sphagni* Dum., Recueil, p. 19. *Cephalozia* (*Odontoschisma*) *Sphagni* Dicks., Spruce on Ceph., p. 60. Pearson, Hepat. Brit. Isles, p. 171, plate 55.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On bogs in dense patches, and more frequently among *Sphagnum*. Probably not so common in the northern counties as elsewhere.

12. **Cephalozia denudata** Nees, Spruce.

Jungermania denudata Nees, in Mart. Crypt. Erlang., p. 14. *J. Sphagni* Hook., Brit. Jung., Suppl., tab. 2. *Cephalozia denudata* Spruce on Ceph. Pearson, Hepat. Brit. Isles, p. 174, plate 56.

Districts I. — — — V. — — VIII. — — XI. —.

Hab.—On decayed wood, more frequent on damp peat on worked-out bogs; and among rocks.

I. Bere Island: McA. 1894. Bog between Emalough and Inch, Co. Kerry, May 1899: Lett & McA. Extremely rare in the Dingle Peninsula: McA. 1901.

V. Plentiful on peat among rocks, fertile, Ballykill, Howth, 1891: McA. 1893*a*.

VIII. Corslieve Mtn. near Bangore, Co. Mayo, 1859: Moore 1876. Pontoon near Foxford, May 1901: Lett & McA.

XI. Near Buncrana, 1903: Hunter.

Sub-genus 3. **Cephaloziella** Spruce.

13. **Cephalozia divaricata** Smith, Dumort.

Jungermania divaricata Sm., Eng. Bot., tab. 719. *Jungermania byssacea* Roth, Trent. Fl. Germ., i., p. 387. Hook., Brit. Jung., tab. 12. *J. Starkii* Herb. Funck, Nees, Nat. Eur. Leb., 11, 225. *Cephalozia divaricata* Sm., Dum., Recueil, 1835. Pearson, Hepat. Brit. Isles, p. 177, plate 57.

Districts I. — — IV. V. VI. VII. VIII. — X. XI. XII.

Hab.—On wet rocks, banks, decayed wood, and on the larger Hepaticæ.

I. Cromaglown, Killarney: Moore. Waterville and Glencar: Scully 1890. Torc Waterfall, Sept. 1898: McA. and Lett 1899. Ross I., 1899 (Lett & McA.): McA. 1900. Brandon: Moore; and 1897: Lett & McA. Hickson's Wood near Anascaul, 1898, and Connor Hill, 1897: Lett & McA. Derrymore Glen and bank between Emalough and Inch, May 1899 (Lett & McA.): McA. 1901. Near Bantry (Miss Hutchins): Hooker 1816 (under *J. byssacea*).

IV. Woodenbridge, Co. Wicklow, 1894: McA. Killoughrim Oak Forest, Co. Wexford, 1899: McA. 1903.

V. Howth, Ireland's Eye and Dalkey Island: McA. 1893*a*.

VI. Carn Seefin, Co. Clare: McA. 1895*a*.

VII. Killeigh and Ard bogs, King's Co., 1891 (Russell): McA. 1892*a*.

VIII. Doon Bog, Clonbrock, Co. Galway: McA. 1896*b*. Pontoon near Foxford and Nephin, May 1901: Lett & McA. Murrisk, Sept. 1901: McA. Slievemore on Achill, and Devil's Mother, Co. Mayo, Sept. 1901: Lett.

X. Lakelet near the top of Camlough Mtn., very rare: Lett 1890. Slieve Glah, Co. Cavan, 1893: McA.

XI. Rathmullan, July 1902: Hunter. Gartan Wood and Columbkil Lake near Milford, Sept. 1902: McA.

XII. About Belfast (Templeton): Hooker 1816. Slemish and Fairhead, Co. Antrim: Moore 1876. Glenarm (Dickie): Moore 1876. Claggan Woods, Co. Antrim, 1834: Moore (under *J. byssacea*). Stones on Slemish: Stewart 1888. Colin Glen (Waddell): Stewart 1888. Hen Mtn. and bog between Hilltown and Rathfriland: Lett 1890. Tollymore Park, Co. Down (Waddell): Stewart 1895.

var. *Starkii* Spruce.

Jungermania Starkii Funck, Nees, Hepat. Eur., ii., p. 223; Syn. Hep., p. 134. *J. Grimsulana* Jack., in G. et R., Hepat. Eur.

Hab.—On rocks and damp banks.

Mt. Eagle and Coumanare Lake, 1898: Lett & McA. Lough Nalachan, Brandon, 1899: Lett & McA. Bere Island: McA. 1894. Ballyvaughan and Carn Seefin, Co. Clare: McA. 1895*a*. Mourne Mtns. and Carlingford Mtn.: Lett 1890. Sallagh Braes, Co. Antrim, 1837: Moore. Baily Lighthouse, Howth, on a damp bank, 1893: McA. 1897. On rocks, Rathmullan, July 1902, and behind Rathmullan Church, Sept. 1902: Hunter.

14. **Cephalozia stellulifera** Tayl. MS.

Jungermania stellulifera Tayl. MS., G. L. N., Syn. Hepat., p. 134. *J. Starkii* var. *procerior* Nees, G. & R., Hepat. Eur., no. 625. *Cephalozia divaricata* Sm. var. *stellulifera* Spruce, on Ceph., 1882. *Cephalozia stellulifera* Pearson, Hepat. Brit. Isles, p. 179, plate 58.

Districts I. — — — — — — VIII. — — — XII.

Hab.—On the ground among damp rocks.

I. Cromaglown, Killarney, June 1889: Scully.

VIII. Pontoon on Lough Conn, May 1901: Lett & McA.

XII. Tollymore Park, Co. Down: Waddell in Guide to Belfast, 1902.

Cephalozia elachista Jack., Lindberg.

Jungermania elachista Jack., in G. & R., Hepat. Eur., no. 574. *Cephalozia elachista* Lindb., Hepat. in Hib., p. 502. Moore, Irish Hepat., p. 625. Pearson, Hepat. Brit. Isles, p. 184, plate 62.

Districts I. — — IV. V. — — — — — — —.

Hab.—On damp peaty banks, and on moist rocks.

I. Brandon 1864 (Moore): Spruce 1882. Connor Hill, Sept. 1875: McA. Coumanare lakes, Sept. 1898: Lett & McA. Very rare in the Dingle district: McA. 1901. Waterville, Upper Glencar, MacGillicuddy's Reeks to 2,500 feet: Scully 1890.

IV. Lough Bray, Co. Wicklow, among *Sphagnum cuspidatum*, 1873: Lindberg 1875; Moore 1876.

V. Among rocks near Sutton, Howth, and cliffs on Ireland's Eye: McA. 1893*a*.

Cephalozia leucantha Spruce.

Cephalozia leucantha Spruce, on Ceph., p. 68. Pearson, Hepat. Brit. Isles, p. 186, plate 63.

Districts I. — — — — — — VIII. — — — —.

Hab.—On decayed wood, and on damp peat among rocks.

I. Mount Eagle, Co. Kerry, near the lake, June, 1898: Lett & McA.

VIII. On the rocky shore of Lough Conn at Pontoon, and on Nephin, May 1901: Lett & McA. Devil's Mother and Slievemore, Achill, Sept. 1901: Lett.

Genus XVII. **Prionolobus** Spruce.

I. **Prionolobus Turneri** Hook., Spruce.

Jungermania Turneri, Hook., Brit. Jung., tab. 29. *Anthelia Turneri* Dum., Recueil, p. 18. *Cephalozia Turneri* Lindberg, in Hepat. in Hib., p. 502. Moore, Irish Hepat., p. 627. *Prionolobus Turneri*, Spruce, Hepat. Amaz. et And., p. 507. Pearson, Hepat. Brit. Isles, p. 190, plate 65.

Districts I. — — — — — — — — — — —.

Hab.—On shady damp banks.

I. Shady bank of a rivulet mountain near Bantry, fertile, March 1811 (Miss Hutchins): Hooker 1816; Moore 1876. On a wet sandy bank at Cromaglown, Killarney, bearing perianths, July 1873; Lindberg 1875; Moore 1876.

Genus XVIII. **Hygrobiella** Spruce.

I. **Hygrobiella laxifolia** Spruce.

Jungermania laxifolia Hook., Brit. Jung., tab. 59. *Gymnocolea laxifolia*, Dum., Recueil, p. 17. *Cephalozia laxifolia*, Lindberg, Musc. Scand., p. 75, 1879. *Hygrobiella laxifolia* Spruce, on Ceph., p. 72. Pearson, Hepat. Brit. Isles, p. 197, plate 67.

Districts I. — — — V. — — VIII. — — — —.

Hab.—In the crevices of wet rocks.

I.—Mountain rivulet near Bantry (Miss Hutchins): Hooker 1816; Moore 1876. Aooreagh River near Sneem (Taylor): Moore 1876. Maghanabo Glen and Brandon: Moore. Connor Hill, 1875: McA. Cromaglown and Mangerton (Carrington): Moore 1876. O'Sullivan's Cascade, and Slieve Mish to 1500 ft.: Scully 1890.

V. Castlekelly Mountains, Co. Dublin (Taylor): Hooker 1816.

VIII. Leenane, Co. Galway, Sept. 1901: Lett.

Genus XVIII. **Adelanthus** Mitten.

I. **Adelanthus decipiens** Hook., Mitt.

Jungermania decipiens Hook., in Eng. Bot., vol. xxxvi., t. 2567; Brit. Jung., tab. 50. *Adelanthus decipiens* Mitt., in Journ. Linn. Soc., vol. iii., p. 264, 1864. Moore, Irish Hepat., p. 658. Pearson, Hepat. Brit. Isles, p. 204, plate 69.

Districts I. — — — — — — VIII. IX. — XI. XII.

Hab.—On damp rocks and on peaty banks.

I. Near Bantry (Miss Hutchins): Hooker 1816. West Cork (Carroll) and Glengariff: Carrington 1863. Killarney: Moore. At the Upper Lake: Scully 1890. Connor Hill, and at the foot of Brandon, 1881: F. W. M. & McA. Lough Duff in the Brandon valley, very fine on rocks between Emalough and Inch, and Derrymore Glen near Tralee, May 1899: Lett & McA.

VIII. Nephin, and Pontoon near Foxford, May 1901: Lett & McA.

IX. Glenade, Co. Leitrim: Moore. Slish Wood, Co. Sligo: Waddell 1893.

XI. Lough Eask Woods, Goat Island, June 1903: McA. Rathmullan Wood, 1903: Hunter.

XII. Moist woods at the head of Glenariff, July 1836: Moore. Sallagh Braes: Waddell in Guide to Belfast, 1902.

Sub-tribe 5. **SCAPANIOIDEÆ.**

Genus 19. **Scapania** Dumort.

I. **Scapania compacta** Roth., Dumort.

Jungermania compacta Roth., Tent. Fl. Germ., iii., p. 375. *Jungermania resupinata* Hook., Brit. Jung., tab. 23. *Scapania compacta* Dum., Recueil, p. 14. Moore, Irish Hepat., p. 637. Pearson, Hepat. Brit. Isles, p. 207, plate 70.

Districts I. — III. IV. V. — — VIII. — X. — XII.

Hab.—Banks among moist rocks, and in the crevices of rocks.

I. Brandon: Moore 1876. Connor Hill, very rare, April 1897: F. W. M. & McA. Near Waterville and Killarney: Scully 1890. Ardrune Hill and Musberagh Mountains, Co. Cork (Carroll): Carrington 1863.

III. Amongst granite rocks, bank of the River Barrow near the bridge, Graigue, Co. Carlow, rare: McA. 1896 *a*.

IV. Rocks between Woodenbridge and Arklow, Co. Wicklow: McA.

V. Anglesey Mountain, Co. Louth: Lett 1890.

VIII. Nephin, May 1901: Lett & McA.

X. Camlough Mountain, Co. Armagh: Lett 1890.

XII. Slievenabrock, Spaltha and Deer's Meadow, Co. Down (Lett and Waddell): Lett 1890. Slieve Donard (J. J. Andrew): Lett 1890. Holywood Hill, 1903: Hunter.

2. **Scapania subalpina** Nees, Dumort.

Jungermania subalpina Nees, in Syn. Hepat. Eur., p. 55. *Scapania subalpina* Dumort., Recueil, p. 14. Moore, Irish Hepat., p. 638. Pearson, Hepat. Brit. Isles, p. 211, plate 72.

Districts I. — — IV. — — — VIII. — — — XII.

Hab.—On rocks in mountain rivulets.

I. Magillicuddy's Reeks and Slieve Mish, to 2500 ft.: Scully 1890. Bank near Inch, and Lough Duff in the Brandon Valley, 1899: Lett & McA.

IV. Lugnaquilla, 1864: Moore; and May 1896: McA. Lough Bray (Moore): McA. 1890.

VIII. Nephin, 1862: Moore.

XII. Mountains near Carnlough, Co. Antrim, 1837: Moore.

var. *undulifolia*, G. L. N., Syn. Hepat., p. 64.

Hab.—On wet rocks, often submerged.

Lugnaquilla, 1864: Moore; and May 1896: McA. Lough Bray (Moore): McA. 1890. Kelly's Glen, Co. Dublin: Moore.

3. **Scapania æquiloba** Schwægr., Dumort.

Jungermania æquiloba, Schwægr., Prodr. Hepat., p. 214. *Scapania æquiloba* Dumort., Recueil, p. 14. *Martinellia æquiloba* Lindb., Hepat. in Hib., p. 521. *Scapania æquiloba,* Moore, Irish Hepat., p. 639. Pearson, Hepat. Brit. Isles, p. 212, plate 73.

Districts I. — III. IV. V. VI. — — IX. — XI. —.

Hab.—On rocks and on rocky banks among Mosses.

I. Mangerton and Ross Bay, Killarney: Carrington. Near the Hunting Tower: Scully 1890. Maghanabo Glen near Clohane, April 1897: F. W. M. & McA. Anascaul, 1898, Lough Duff in the Brandon valley, May 1899: Lett & McA. Caha Mountains, Co. Cork: McA. 1894.

III. On rocks by the River Barrow near the bridge, Graigue, Co. Carlow: McA. 1896*a*.

IV. Douce Mtn., Co. Wicklow, 1897: McA.

V. Ballykill, and in Howth Demesne, 1894: McA. 1897.

VI. Cappanwalla Mountain, Co. Clare: McA. 1895*a*.

IX. Near the head of Gleniff, Co. Leitrim, 1875: Moore. Slieveanierin, Co. Leitrim, rare: Stewart 1885.

XI. Near the lake, Macamish, July 1902: Hunter.

var. *inermis* Gottsche.

Gott. et Rab., Exsicc., 80, 404, 408.

On banks in rocky places, Mount Eagle, Co. Kerry, near the lake, Sept. 1897, and at Loughanascaul, Sept. 1898: Lett & McA.

4. **Scapania aspera** Müller and Bernet.

Scapania aspera M. & B., Henri Bernet, Cat. Hepat. du Sud-Ouest de la Suisse et de la Haute-Savoie. Pearson in Journ. of Bot., vol. xxx., p. 353, plate 329. McArdle, Musci and Hepat. Co. Cavan, p. 613, plate 21. Pearson, Hepat. Brit. Isles, p. 214, plate 74.

Districts I. — III. — V. VI. — VIII. — X. XI. —.

Hab.—On limestone rocks and rocky banks, among Mosses.

I. Torc Waterfall, Killarney, Sept. 1897: Lett & McA.

III. Among rocks, side of the River Barrow, Graigue, Co. Carlow: McA. 1896*a*.

V. On rocks among Mosses in Howth Demesne: McA. 1897.

VI. Ballyvaughan and very fine on Cappanwalla Mtn., Co. Clare: McA. 1895*a*.

VIII. Nephin and Pontoon near Foxford, Co. Mayo, May 1901: Lett & McA. Salthill near Galway: McA. 1895*a*.

X. On rocks, fertile, Ballyhaise Wood, Co. Cavan, 1893: McA.

XI. Behind Rathmullan Church, and near the lake, Macamish, July 1902: Hunter.

5. **Scapania resupinata** Linn., Dumort.

Jungermania resupinata Linn., Sp. Pl., p. 1599, 1753. Eng. Bot., tab. 2437. *Scapania resupinata* Dumort., Recueil, p. 14. *Martinellia gracilis* Lindb., Manip. Musc. Secund., p. 365. *Scapania resupinata* Moore, Irish Hepat., p. 639. Pearson, Hepat. Brit. Isles, p. 217, plate 75.

Districts I. II. III. IV. V. — — VIII. — X. XI. XII.

Hab.—On rocks, banks, and trunks of trees in mountainous places.

I. O'Sullivan's Cascade, Killarney, 1873: Lindberg 1875. Torc Waterfall, 1897: McA. & Lett 1899. Common at Ross I., 1900: Lett & McA. Common through the Dingle Peninsula (Lett & McA.): McA. 1901.

II. Knockmeildown and Galtee Mtns., June 1902: McA.

III. Rocks by the River Barrow, Graigue, Co. Carlow: McA. 1896*a*.

IV. Wood by the Slaney River, and Killoughrim Oak Forest near Enniscorthy, May 1899: McA. Near Ferns, Oct. 1896 (Greene): McA. 1903. Lough Bray, 1873: Lindberg 1875; Moore 1876; and 1889: Scully & McA. Lugnaquilla, 1896, and Douce, Co. Wicklow, May 1897: McA.

V. Kelly's Glen, Co. Dublin: Moore 1876. Anglesey Mtn., Co. Louth: Lett 1890. Howth, April 1895: McA. 1897.

VIII. Devil's Mother, Doolough, and Slievemore on Achill, Sept. 1901: Lett. Croaghpatrick, about Murrisk, by the Moyire River, and in Westport demesne, Sept. 1901: McA. Nephin, and Pontoon near Foxford, May 1901: Lett & McA.

X. Camlough Mtn., Co. Armagh: Lett 1890. Ballyhaise, Co. Cavan, 1898: McA.

XI. Muckish: Moore 1876. Rathmullan Wood, Macamish, Croghan Mtn., Carradoan Wood, Glenalla Hill, Rathmelton, July 1902:

Hunter. Columbkil Lake, on rocks near Milford, Gartan Wood, Sept. 1902; Errigal, and Lough Eask woods, 1903: McA.

XII. Thomas Mtn., the Ballagh, and Slieve Donard: Lett 1890. Eagle Mtn., very rare (Waddell): Lett 1890. Cave Hill and Colin Glen (Stewart); Sallagh Braes (Lett); Ballybarrigan Glen, Co. Derry (Moore): Stewart 1888. Fairhead and Glendun (Templeton): Stewart 1895.

6. **Scapania nemorosa** Linn., Dumort.

Jungermania nemorosa Linn., Sp. Pl., 3rd ed., p. 1598. *Martinellia nemorosa* Gr. & B., Nat. Arr. Brit. Pl., i., p. 692. *Scapania nemorosa* Dum., Recueil, p. 14. Moore, Irish Hepat., p. 640. Pearson, Hepat. Brit. Isles, p. 222, plate 78.

Districts I. II. III. IV. V. VI — VIII. — X. XI. XII.

Hab.—On damp shaded banks among rocks, on the trunks of trees, &c.

I. Killarney: Moore; Carrington; McA. Cromaglown and Torc Waterfall, 1873: Lindberg 1875 (under *Martinellia*). Torc Waterfall, 1897: Lett & McA. Magillicuddy's Reeks at 2500 ft.: Scully 1890. Frequent in the Dingle Peninsula (Lett & McA.): McA. 1901. Mountains near Bantry (Miss Hutchins): Hooker 1816. Dunboy Wood: McA. 1894.

II. Woods at Scarriff in Galtee Mtns., and among rocks, Knockmeildown Mtns., Co. Tipperary, June 1902: McA.

III. Rocks by the River Barrow at Graigue, Co. Carlow: McA. 1896 *a*.

IV. Killoughrim Oak Forest, Co. Wexford, 1899: McA. 1903. Glenmalure, May 1896: McA.

V. Anglesey Mtn., Co. Louth: Lett 1890. Howth: McA. 1893 *a*. Kelly's Glen, Co. Dublin, Aug. 1896: McA.

VI. Carn Seefin and Ballyvaughan, Co. Clare: McA. 1895 *a*.

VIII. Woods about Kylemore, 1874: Moore; and 1891: McWeeney. Near the Cottage, Ballinahinch, Connemara: Wade Rar. 1804. Pontoon near Foxford, May 1901: Lett & McA. Slievemore on Achill, Sept. 1901: Lett.

X. Ballyhaise Woods, Co. Cavan, 1893: McA. Strabane Glen, Co. Tyrone, 1882: Lett.

XI. Saltpans Wood, Rathmullan, and very fine on hill above Mintiaghs, July 1902: Hunter. Cratleagh Wood and Gartan Wood, near Milford, Sept. 1902: McA.

XII. Cranmore, Co. Antrim (Templeton), Sallagh Braes (Lett):

Stewart 1888. Glendun: Lett & Brenan. Co. Antrim, abundant, 1838: Moore. Near Lignapieste, Co. Derry, 1834 (Moore): Stewart 1888. Rostrevor Wood and Tollymore Park, Co. Down, very rare (Waddell), Slieve Donard (Lett): Stewart 1888. Saintfield, Co. Down (Waddell): Stewart 1895. Purdysburn and Castlereagh Glen, 1803 (Templeton): Stewart 1888.

var. *purpurea* Hook.

Jungermania purpurea Hook., Eng. Bot., tab. 1023.

Hab.—Among rocks in wet boggy places.

Frequent in the Dingle Peninsula: McA. 1901. Lough Bray: McA. 1890. Croaghpatrick, Sept. 1891: McA. Nephin, and Pontoon near Foxford, May 1901: Lett & McA. Devil's Mother, and Slievemore on Achill, Sept. 1901: Lett. Co. Antrim, 1838: Moore. Carlingford Mtn., Co. Louth, 1894: McA. Rathmullan Wood, Co. Donegal, July 1902: Hunter.

7. **Scapania nimbosa** Taylor.

Scapania nimbosa Tayl., in Lehm., Pugill. Plant., viii., 1844. Trans. Bot. Soc. Edinb., ii., p. 115. Carrington, Brit. Hepat., part ii., plate 7, fig. 21. McArdle, Hepat. Dingle Peninsula, p. 311, plate 2, figs. 1, 2. 3. Pearson, Hepat. Brit. Isles, p. 220, plate 77.

Districts I. — — — — — — — — — — —.

Hab.—On moist rocky ledges among Mosses, &c.

I. Near the summit of Brandon, Co. Kerry, 1813: Taylor. On the same mountain more recently, 18——?: Mitten.

8. **Scapania ornithopodioides** Dill., Withering.

Jungermania ornithopodioides Withering, Bot. Arrang., vol. ii., p. 695, no. 14, 1776. *Jungermania planifolia* Hook., Brit. Jung., t. 67, 1816. *Scapania planifolia* Hook., Dum., Recueil, p. 14, 1835. McArdle, Hepat. Dingle Peninsula, p. 311, plate 2, figs. 4–9, 1901. Pearson, Hepat. Brit. Isles, p. 219, plate 76.

Districts I. — — — — — — VIII. — — — —.

Hab.—On damp rocky banks, and on shelving rocks among Mosses and large Hepaticæ.

I. Brandon 1873: Taylor and William Wilson. In the same station more recently, 18—?: Mitten. In a rocky gorge on the N.E. side of Brandon at 2800 ft. on shelving rocks among *Mastigophora Woodsii*, &c., June, 1900: Lett & McA.

VIII. On Slievemore, Achill, Sept. 1901: Lett.

9. **Scapania undulata** Linn., Dumort.

Jungermania undulata Linn., Sp. Pl., 1598. Hook., Brit. Jung., tab. 22. *Scapania undulata* Dum., Recueil, p. 14. Pearson, Hepat. Brit. Isles, p. 224, plate 79.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On wet banks and rocks, and on stones in streams. Common.

var. *purpurascens* Hüben., Hepat. Germ.

Moore, Irish Hepat., p. 638. G. L. N., Syn. Hepat., p. 66. *Scapania purpurascens* Pearson, Hepat. Brit. Isles, p. 225, plate 90.

Hab.—On wet rocks, and among Mosses in mountainous places.

Common in Co. Kerry. Well distributed among the mountains in the Dingle Peninsula: McA. 1901. Frequent in the mountains of the northern counties: Lett 1890, Stewart, and others. Rathmullan, Co. Donegal: Hart 1886. Goat Island near Lough Eask, Co. Donegal, June 1901: McA. Lough Bray, Co. Wicklow, 1873: Lindberg 1875 (under *Martinellia*); and McA. 1890. Bog at Ballykill, Howth, Co. Dublin: McA. 1893 *a*. Stream at Knockroe, Co. Wexford, 1899: McA. 1903.

var. *speciosa* N. ab E., Hepat. Eur., i., p. 185.

G. L. N., Syn. Hepat., p. 66. Moore, Irish Hepat., p. 638.

Hab.—On wet rocks in mountainous places.

Lugnaquilla: Moore. Nephin, May 1901: Lett & McA. Bangore and Devil's Mother, Co. Mayo, Sept. 1901: Lett. Pontoon near Foxford, May 1901: Lett & McA. Knockroe, Co. Wexford, May 1899: McA. 1903.

var. *isoloba* Nees, Syn. Hepat., p. 66.

N. ab E., Hepat. Eur., iii., p. 421. *Scapania isoloba* Dumort., Hepat. Eur., p. 33.

Hab.—Floating in mountain streams.

Stream on the Clogreen side of Brandon: Moore; and Sept. 1897: Lett & McA. Lough Doon on Connor Hill: McA. 1894. Coumanare Lakes, 1898 (Lett & McA.): McA. 1901.

var. *major* Carrington, N. ab E.

Jungermania resupinata, Eng. Bot., tab. 243. *Scapania undulata* var. *major* G. L. N., Syn. Hepat., p. 65.

Hab.—On wet rocks.

Cromaglown, Killarney, and Connor Hill, Co. Kerry; Maam Turc, Co. Galway; Lough Bray, Co. Wicklow (Moore): Carrington 1863. Pontoon near Foxford, May 1901: Lett & McA.

var. *laxifolia* Dumort.

Scapania resupinata var. *laxifolia* Dumort., Hepat. Eur., p. 34.

Hab.—On heathy banks.

Cromaglown, Killarney, 1899: Lett. Connor Hill, 1894: McA. Muckish, Co. Donegal: Moore 1876. Shanslieve, Co. Down, 1898: Lett.

var. *dentata* N. ab E.

Hab.—On wet rocks.

Pontoon near Foxford, May 1901: Lett & McA. Gartan Wood near Milford, Sept. 1902: McA. Galtee Mtns., Co. Tipperary, June 1902: McA.

10. **Scapania intermedia** Husnot.

Scapania intermedia Husnot., Hepat. Gall., plate 3, fig. 23, 1875. *S. nemorosa* var. *intermedia* Husnot, Hepat. Gall., p. 22, 1876. Pearson, Hepat. British Isles, p. 227, plate 91.

Districts — II. — — — — — — — — XI. XII.

Hab.—On moist shaded rocks.

II. On sandstone rocks south of Lough Muskry, Galtees, July 1902: Lett.

XI. Glen Columbkil, Milford, 1902: McA.

XII. Colin Glen, Co. Antrim, July 1887: Waddell, Journ. Bot., vol. xli., p. 286, 1903.

11. **Scapania irrigua** Nees, Dumort.

Jungermania irrigua Nees, Nat. Eur. Leb., i., p. 193. *Scapania irrigua* Dum., Recueil, p. 13. Moore, Irish Hepat., p. 639. Pearson, Hepat. Brit. Isles, p. 230, plate 92.

Districts I. — — IV. — — — VIII. IX. — — XII.

Hab.—Marshy banks among rocks.

I. Cromaglown, Killarney: Moore. Knockavohill, Co. Kerry (Taylor): Moore 1876.

IV. Lough Bray: Moore; and 1889 (F. W. M.): McA. 1890.

VIII. Nephin, May 1901: Lett & McA.

IX. Benbulben: Moore.

XII. Moist bank, Holywood, Febr. 1902: Hunter.

12. **Scapania uliginosa** Swartz, Dumort.

Jungermania uliginosa Sw., in Lindb., Syn. Hepat., p. 59. *Scapania uliginosa* Dumort., Recueil, p. 14. Moore, Irish Hepat., p. 639. Pearson, Hepat. Brit. Isles, p. 231, plate 93.

Districts I. — — IV. V. — — VIII. — — — XII.

Hab.—In swampy places, on wet rocks, &c., in mountainous districts.

I. Knockavohill, Co. Kerry: Taylor. Near the Hunting Tower, Cromaglown, 1875: Moore. Near Waterville: Scully 1890. Connor Hill, 1873: Moore; and 1894: McA. Brandon, Sept. 1898–1900: Lett & McA. Loughanscaul, 1894: McA. Rare in the Dingle Peninsula: McA. 1901.

IV. Lough Bray: Moore. On old wood at Lough Bray, April 1879: F. W. M. & McA. Banks of a stream, Knockroe, Co. Wexford, May 1899: McA. 1903.

V. Anglesey Mtn., Co. Louth, rare (Waddell): Lett 1890.

VIII. Pontoon near Foxford and on Nephin, May 1901: Lett & McA.

XII. Bog between Hilltown and Rathfriland, and in the Brown Bog near Loughbrickland: Lett 1890.

13. **Scapania curta** Mart., Dumort.

Jungermania curta, Mart., Fl. Crypt. Germ., i., p. 148, tab. 4, fig. 24. *J. nemorosa* var. *denudata*, Hook., Brit. Jung., tab. 21, fig. 17–19. *Scapania curta* Dumort., Recueil, p. 14. Moore, Irish Hepat., p. 641. Pearson, Hepat. Brit. Isles, p. 235, plate 95.

Districts I. — — IV. — — — VIII. IX. X. XI. XII.

Hab.—On moist banks among rocks, decayed wood, and among the larger Hepaticæ.

I. Cromaglown, 1873 (Moore): Lindberg 1875. On the east side of Brandon and at Lough Adoon near Clohane, 1897; Barnanaghea Lough near Lispoll and Connor Hill, 1898; Lough Duff in the Brandon Valley, 1899: Lett & McA.

IV. Lough Bray, on the stems of *Ulex*, 1879: McA. 1890.

VIII. Ballinakill Harbour near Letterfrack, 1874: Moore. Pontoon near Foxford, May 1901: Lett & McA. Devil's Mother, Doolough, and Slievemore on Achill, Sept. 1901: Lett.

IX. Gleniff, Co. Leitrim: Moore. Benbulben range: Moore 1876.

X. Slieve Glah, Co. Cavan, rare: McA. 1898.

XI. Bunlin Waterfall near Milford, Sept. 1902: McA.

XII. Sallagh Braes and Slemish, Co. Antrim: Moore 1876 Benevenagh, Co. Derry, 1900: Lett & Waddell.

14. **Scapania umbrosa** Schrader, Dumort.

Jungermania convexa Scopoli, Flora Carniolica, 2nd Ed., p. 349. *J. umbrosa* Schrad., Syst. Samml. Krypt. Gew., ii., p. 5. Hook., Brit. Jung., tab. 24. *Scapania umbrosa* Dum., Recueil, p. 14. Moore, Irish Hepat., p. 641. Pearson, Hepat. Brit. Isles, p. 236, plate 95.

Districts I. — — IV. V. — — VIII. — X. XI. XII.

Hab.—On moist rocks and on decayed wood.

I. Frequent in the Killarney woods: Moore. O'Sullivan's Cascade, 1873: Lindberg 1875. Carantual (Miss Hutchins): Carrington 1863. Magillicuddy's Reeks at 2500 feet: Scully 1890. Brandon, 1873: Moore. Connor Hill, 1874: McA. Rocks near Mt. Eagle Lake and Coumanare Lakes, 1898; Derrymore Glen near Tralee, 1899; Lett & McA.

IV. Lough Bray, Co. Wicklow, 1873 (Moore): Lindberg 1875; 1887–89: McA. 1890. Boulacross Mtns., Co. Wicklow (Taylor & Mackay): Hooker 1816. Mountain near Powerscourt Waterfall (Mackay): Hooker 1816.

V. Killakee Glen, Co. Dublin: Moore 1878. On rocks near Dublin, 1836 (Taylor): Moore 1876. Kelly's Glen, Co. Dublin, Aug. 1896: McA.

VIII. Kylemore, 1874: Moore. Murrisk, Co. Mayo, Sept. 1901: McA. Nephin, May, 1901: Lett & McA. Devil's Mother, Doolough, Slievemore on Achill, Sept. 1901: Lett.

X. Slieve Gullion, Co. Armagh, 1894: McA.

XI. Carradoan Wood, Rathmullan, and near the lake, Macamish, July 1902: Hunter. Gartan Wood and Cratleagh Wood near Milford, Sept. 1902: McA.

XII. Glenarm, Co. Antrim, Sept. 1836: Moore. Hen Mountain, Co. Down (Lett): Stewart 1895.

Genus 20. **Diplophyllum** Dumort.

1. **Diplophyllum albicans** Linn., Dumort.

Jungermania albicans Linn., Sp. Pl., p. 1599. Hook., Brit. Jung., tab. 25. *Diplophyllum albicans* Dum., Recueil, p. 14. Moore, Irish Hepat., p. 642. Pearson, Hepat. Brit. Isles, p. 238, plate 97.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—Moist banks in woods, and by roadsides, old walls, and rocks, and on the trunks of trees, from sea-level to high elevations

2. **Diplophyllum obtusifolium** Hook., Dumort.

Jungermania obtusifolia Hook., Brit. Jung., tab. 26. *Diplophyllum obtusifolium* Dum., Recueil, p. 16. Moore, Irish Hepat., p. 642. Pearson, Hepat. Brit. Isles, p. 241, plate 99.

Districts I. — — — V. — — — — — — —.

Hab.—On moist clay banks in shaded places.

I. Near Dunkerron, Co. Kerry, 1836 : Taylor. Near Bantry, 1812 (Miss Hutchins) : Hooker 1816. Dunscome's Wood near Cork, 1829 (W. Wilson) : Moore 1876.

V. Glendhu, Co. Dublin, 1890 : McA.

3. **Diplophyllum Dicksoni** Hook., Dumort.

Jungermania Dicksoni Hook., Brit. Jung., tab. 48. *Diplophyllum Dicksoni* Dum., Recueil, p. 16. Moore, Irish Hepat., p. 649 (under *Jungermania* (*Sphenolobum*) *Dicksoni*). Pearson, Hepat. British Isles, p. 243, plate 100.

Districts I. — — IV. V. — — VIII. IX. — — XII.

Hab.—In the crevices of rocks, on moist banks, and among the large Mosses and Hepaticæ.

I. On the north side of Connor Hill growing among Mosses, 1873 : Moore. Lough Nalachan on Brandon, May 1899 : Lett & McA.

IV. Lough Bray, very scarce : Moore.

V. Mountains near Dublin (Taylor) : Hooker 1816.

VIII. Pontoon near Foxford, very rare, and on Nephin, May 1901 : Lett & McA. Slievemore, Achill, Sept. 1901 : Lett.

IX. Gleniff, Co. Leitrim, single stems : Moore.

XII. Shanslieve, Mourne Mountains, 1898 (Lett) : Pearson 1902.

Extremely rare in all these localities.

Sub-tribe 6. **EPIGONEANTHEÆ**.

Genus 21. **Lophocolea** Dumort.

1. **Lophocolea bidentata** Linn., Dum.

Jungermania bidentata Linn., Sp. Pl., p. 1508. Hook., Brit. Jung., tab. 30. *Lophocolea bidentata* Dum., Recueil, p. 17. *Lophocolea bidentata* Moore, Irish Hepat., p. 628. Pearson, Hepat. Brit. Isles, p. 247, plate 101.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On moist shady banks, among rocks, in woods, on plains, from sea-level to the tops of the highest mountains.

var. *Hookeriana* Nees.

Lophocolea Hookeriana Nees, Nat. Eur. Leb., ii., p. 336.

Hab.—On moist shaded rocks.

Nephin, Co. Mayo, May 1901: Lett & McA.

2. **Lophocolea cuspidata** Limpr.

Lophocolea bidentata var. *cuspidata* Nees, Nat. Eur. Leb., ii., p. 327. *Lophocolea cuspidata* Limpricht, in Cohn, Krypt. Fl. Schles., p. 303. Pearson, Hepat. Brit. Isles, p. 249, plate 102.

Districts I. II. — — — — — VIII. — — XI. —.

Hab.—On the trunks of trees among Mosses, and on decayed wood, banks, &c. Probably widely distributed, but confounded with the preceding species.

I. On dead trees, Killarney (Carrington): Moore 1876. Glena and Cromaglown, Killarney, 1873: Lindberg 1875.

II. Glengarra Wood and Scarriff Woods, Galtees, June 1902: McA.

VIII. Pontoon near Foxford, May 1901: Lett & McA.

XI. Gartan Wood, and wood by Mulroy Bay near Milford, Sept. 1902; Lough Eask Woods and Barnesmore Gap, June 1903: McA.

3. **Lophocolea heterophylla** Schrad., Dumort.

Jungermania heterophylla Schrad., Diar. Bot., p. 66. Hook., Brit. Jung., tab. 31. *Lophocolea heterophylla* Dum., Recueil, p. 17. Moore, Irish Hepat., p. 628. Pearson, Hepat. Brit. Isles, p. 250, plate 103.

Districts I. II. — IV. V. — — VIII. — X. XI. XII.

Hab.—On the trunks of trees near the base; more frequently on decayed wood.

I. Torc Mountain, Killarney: Carrington 1863. Fermoy (Carroll): Moore 1876.

II. Wood at Scarriff, Galtees, rare, June 1902: McA.

IV. Altadore Glen, Co. Wicklow, 1887–8: McA. 1889.

V. Ballykill, 1893, and in Howth Demesne, 1895: McA. 1897.

VIII. Near Cong, Co. Galway: Moore.

X. On decayed wood, shores of Lough Cultra, Co. Cavan, 1893: McA. 1898.

XI. Gartan Wood near Milford, rare, Sept. 1902: McA. Buncrana, March 1903: Hunter.

XII. On decayed wood, Holywood, March 1903: Hunter.

4. **Lophocolea spicata** Taylor.

Lophocolea spicata Tayl., in G. L. N., Syn., Hepat., 167. Moore, Irish Hepat., p. 629. Pearson, Hepat. Brit. Isles, p. 252, plate 104.

Districts I. — III. IV. — — — — — — — —.

Hab.—On damp shaded rocks and among the larger Hepatics and Mosses.

I. Dunkerron, Co. Kerry (Taylor): Moore 1876. On rocks below Torc Waterfall: Carrington; fertile there, 1897: Lett & McA. By the side of the Upper Lake, Killarney, fertile, June 1869: Moore. O'Sullivan's Cascade, Glena, and Torc Cascade, 1873: Lindberg 1875. Glencar and Mangerton: Scully 1890. Connor Hill, July 1881: F. W. M. & McA. Near Brandon Head, Loughanscaul, near Dingle, and Mount Eagle, 1898: Lett & McA. Near Bantry (Miss Hutchins): Moore 1876. Glensiskin, Co. Cork (T. Chandlee): Moore 1876; and (the female plant) (I. Carroll): Carrington 1863. Dunboy Wood, Co. Cork: McA. 1894.

III. Wood near Goresbridge, Co. Carlow, very scarce: McA. 1896 *a*.

IV. Altadore Glen, 1873 (Moore): McA. 1889.

Genus 22. **Clasmatocolea** Spruce.

1. **Clasmatocolea cuneifolia** Hook., Spruce.

Clasmatocolea cuneifolia Spruce, Hepat. Amaz. et And., p. 440. *Jungermania* (*Aplozia*) *cuneifolia* Moore, Irish Hepat., p. 646. *J. cuneifolia* Hook., Brit. Jung., tab. 64. Eng. Bot., Suppl., tab. 2700. Pearson, Hepat. Brit. Isles, p. 254, plate 105 (under *Clasmatocolea*).

Districts I. — — — — — — VIII. — — — —

Hab.—On damp peat among rocks, on *Frullania*, and on the trunks of trees.

I. Torc Mtn. (Carrington): Moore 1876. On the stems of trees, creeping over *Frullania Tamarisci*, between the police-barrack and Upper Lake, Killarney: Moore. Waterville, Glena, and Upper Lake, Killarney: Scully 1890. O'Sullivan's Cascade, 1894: McA. Connor Hill, 1899: McA.; and 1898: Lett & McA. Brandon 1877: McA. 1880; and 1881 (F. W. M. & McA.): McA. 1901. Loughanscaul near Dingle, 1898: Lett & McA. Lough Duff in the Brandon valley, very fine on damp rocks, on *Frullania Tamarisci*, June 1900: Lett & McA.

VIII. On the slopes of Devil's Mother and on Slievemore, Achill, Sept. 1901: Lett.

Genus 23. **Chiloscyphus** Dumort.

1. **Chiloscyphus polyanthus** Linn., Dum.

Jungermania polyanthus Linn., Sp. Pl., no. 1597. Hook., Brit. Jung., tab. 62. *Chiloscyphus polyanthus* Dum., Syll. Jung. Eur., p. 67, tab. 1, fig. 9. Moore, Irish Hepat., p. 630. Pearson, Hepat. Brit. Isles, p. 256, plate 106.

Districts I. — III. IV. V. — — VIII. — — XI. XII.

Hab.—Damp shaded places on rocks, and among stones.

I. Killarney: Moore. O'Sullivan's Cascade, 1873: Lindberg 1875. Common in the Dingle Peninsula: McA. 1901.

III. Stream on Slieve Bloom, Queen's Co.: McA. 1892 *a*.

IV. On wet rocks, Co. Wicklow: Moore 1876.

V. Kelly's Glen, Co. Dublin (Moore): Carrington 1863. Howth, rare, April 1895: McA. Anglesey Mtn., Co. Louth: Lett. Omeath Waterfall, Co. Louth, very rare (Waddell): Lett 1890.

VIII. Bangore, Co. Mayo (Moore): Carrington 1863. Nephin, May 1901: Lett & McA.

XI. Gartan Wood, fertile, Sept. 1902; Lough Eask Woods and Barnesmore Gap, June 1903: McA.

XII. Rostrevor Mtn. (Waddell), Glenmackan, Co. Down: Stewart 1888. Rocky Mtn. near Hilltown: Lett 1890. Aghaderg Glebe and Ballyvarley bog (Lett): Stewart 1895. Rocks in the River Bann, Corbett, Co. Down, 1895: Lett. Colin Glen, Carr's Glen, and Rathlin Island, Co. Antrim: Stewart 1888. Slemish (Templeton), Glendun (Brenan & Lett): Stewart 1895. On the Derry side of the Faughan River below Claddy (Moore): Stewart 1888. Glenariff, Co. Antrim, 1836: Moore. Holywood, Febr. 1903: Hunter. Annahilt, Co. Down, June 1901: Waddell.

var. *pallescens* Lindenberg.

Jungermania pallescens Schrad., Syst. Samml. Krypt. Gew., ii., p. 7. *Chiloscyphus pallescens* Dumort., Syll. Jung., p. 67.

Hab.—On wet banks and on rocks, often submerged.

Mountain streams, Killarney (Carrington): Moore 1876. Connor Hill, 1894: McA. Fermoy (T. Chandlee): Moore 1876.

var. *rivularis* Nees.

Hab.—Wet places on rocks and stones, often in mountain streams.

Frequent about Killarney: Carrington 1863. In caves, Connor

Hill: Lindberg 1875. Stream on the west side of Brandon, April 1897: F. W. M. & McA. Mt. Eagle Lake and Coumanare Lakes near Connor Hill, Sept. 1898: Lett & McA. In a spring near Clough, Co. Antrim (Lett): Stewart 1888.

Genus 24. **Harpanthus** Nees.

1. **Harpanthus scutatus** W. et M., Spruce.

Jungermania scutatus Web. et Mohr., Bot. Taschenb., p. 408. Tayl. in Fl. Hib., part ii., p. 64. Moore, Irish Hepat., p. 631 (under *Harpanthus*). Carrington, Brit. Hepat., p. 49, plate 7, fig. 52. Dumort., Hepat. Europ., p. 67. *Harpanthus scutatus* Pearson, Hepat. Brit. Isles, p. 259, plate 107.

Districts I.— — IV. — — — VIII. — — XI. —.

Hab.—On moist banks, rocks, and stones, and on decayed wood.

I. Galway River, Killarney, fertile, August 1829 (W. Wilson): Carrington 1874. Torc Waterfall, Killarney: Taylor 1836. Cromaglown and Glena: Moore. O'Sullivan's Cascade, 1873 (female, sterile): Lindberg 1875; Scully 1890. Tomies Mtn.: Carrington 1863. Cromaglown (Stewart & Holt): Pearson 1902. Gap of Dunloe, June 1900: Lett. Mount Eagle, 1881: F. W. M. & McA. Connor Hill, 1877: McA. Rare in the Dingle Peninsula: McA. 1901. Near Bantry, 1812 (Miss Hutchins): Moore 1876.

IV. Lough Bray, Co. Wicklow: Taylor; Moore 1876; McA. 1890.

VIII. Nephin, May 1901: Lett & McA. Slievemore, Achill, Sept. 1901: Lett.

XI. By the River Leenan near Ramelton, Dec. 1878: Hart 1886. On rocks, Columbkil Lake near Milford, Sept. 1902: McA.

Genus 25. **Mylia** Gray & Bennett.

1. **Mylia Taylori** Hook., Gr. & B.

Jungermania Taylori, Hook., Brit. Jung., tab. 57. *Mylia Taylori* Gr. & B., Nat. Arrang. Brit. Pl., i., p. 695. Moore, Irish Hepat., p. 645. Pearson, Hepat. Brit. Isles, p. 264, plate 109.

Districts I. — — IV. V. — — VIII. — X. XI. XII.

Hab.—On open heaths, boggy places, and moist rocks, in large patches.

I. Killarney, Devil's Punch Bowl, Mangerton, Brandon: Moore. Connor Hill, 1873: Lindberg 1875. Common in the Dingle Peninsula: McA. 1901. Near Bantry (Miss Hutchins): Hooker 1816.

IV. Tonlagee, Co. Wicklow (Taylor): Hooker 1816. On wet banks, Lough Bray: Moore 1878; McA. 1889.

V. Omeath Glen and Anglesey Mtn., Co. Louth: Lett 1890.

VIII. Murrisk, and on the slopes of Croaghpatrick, Sept. 1901: McA. Nephin, May 1901: Lett & McA. Bangore, and on Slievemore, Achill, Sept. 1901: Lett.

X. Camlough Mtn., Co. Armagh, 1887: Lett.

XI. Lough Belshade, Errigal, June 1903: McA.

XII. Glenandra, and near Lignapieste, Co. Derry, 1835: Moore. Top of Divis, Co. Antrim (Templeton): Stewart 1888. Moist mountain near Orra, parish of Loughguile, Co. Antrim, 1838: Moore. Shanslieve and Deer's Meadow (Waddell), Slieve Donard: Stewart 1888. White River, Spinkwee River, Moygannon Glen: Stewart 1888; Lett 1890. Shanslieve: Lett 1890.

2. **Mylia anomala** Hook., Gray & Bennett.

Jungermania anomala Hook., Brit. Jung., tab. 34. *J. Taylori* var. *anomala* Nees, Nat. Eur. Leb., ii., p. 455. *Mylia anomala* Moore, Irish Hepat., p. 646. Pearson, Hepat. Brit. Isles, p. 267, plate 110.

Districts I. — — IV. — — — — — X. — XII.

Hab.—On damp heaths on mountains, often creeping among *Sphagnum*.

I. Lough Guitane, among *Sphagnum*: Carrington. Connor Hill, 1873: Lindberg 1875. On the ascent of Brandon from Cloghane, July 1881: F. W. M. & McA. Near Bantry (Miss Hutchins): Hooker 1816.

IV. Lough Bray, Co. Wicklow, 1889 (F. W. M.): McA. 1890.

X. Camlough Mtn., very rare (Lett & Waddell): Lett 1890.

XII. Divis, Co. Antrim, and Annahilt Bog (now extinct), Co. Down (Templeton): Hooker 1816.

Genus 26. **Pedinophyllum** Lindberg.

1. **Pedinophyllum interruptum** Nees, Lindb.

Jungermania interrupta Nees, Nat. Eur. Leb., i., p. 165. *Jungermania Dumortieri* Lib., Pl. Crypt. Ard., iv., no. 311. *Pedinophyllum pyrenaicum* Lindb., Hepat. in Hib., p. 505. *Plagiochila interrupta* var. *pyrenaica* Carr., Brit. Hepat., plate 3, figs. 2-9. *Pedinophyllum pyrenaicum* Moore, Irish Hepat., p. 629. *P. interruptum* Pearson, Hepat, Brit. Isles, p. 269, plate 161.

Districts I. — — — — VI. — VIII. IX. — — XII.

Hab.—On shady rocks and banks.

I. Burnham Wood near Ventry, 1898, rare (Lett & McA.): McA 1901 (under *Plagiochila*).

VI. Ballyvaughan, Co. Clare : McA. 1895 *a.*

VIII. Bangore, Co. Mayo, Sept. 1901 : Lett.

IX. Through the Benbulben range, 1871 ; Gleniff, Co. Leitrim, 1875 : Moore.

XII. Roadside wall, Rostrevor Quay (Lett) : Stewart 1895 (under *Leptoscyphus*).

Genus 27. **Plagiochila** Dumort.

1. **Plagiochila asplenioides** Linn., Dum.

Jungermania asplenioides Linn., Sp. Pl., p. 1597. Hook., Brit. Jung., tab. 13. Eng. Bot., tab. 1061. *Plagiochila asplenioides* Dum., Recueil, p. 14. Moore, Irish Hepat., p. 643. Pearson, Hepat. Brit. Isles, p. 274, plate 113.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—Banks and rocks in woods ; on the moss-covered trunks of trees.

var. *minor* Lindenberg, Plagiochila, p. 111.

Carr., Brit. Hepat., part. iii., p. 56.

Killarney woods, plentiful : Moore. Ross Bay : Carrington 1863 Ross I., 1899 (Lett & McA.) : McA. 1900. Torc Waterfall, rare, 1897 : Lett & McA. Frequent in the Dingle Peninsula : McA. 1901. On rocks, Graigue, Co. Carlow : McA. 1896 *a.* On *Frullania*, shores of Lough Conn at Pontoon, May 1901 : Lett & McA.

var. *devexa* Carr., Brit. Hepat., part iii., p. 56.

On rocks, Dingle Bay, and at Ross Bay, Killarney, July, 1861 : Carrington. On shaded banks close to the lake, Ross I., 1893 : McA. 1900. On damp rocks, Torc Waterfall, Sept. 1897 : Lett & McA.

var. *humilis* Lindenberg, Plagiochila, p. 111.

Carr., Brit. Hepat., part iii., p. 56.

On damp rocks, Derrymore Glen near Tralee, May 1899 : Lett & McA. Damp bank, Ross I., Killarney, 1893 : McA. 1900. Cargin Wood between Scarva and Tanderagee, Co. Armagh, July 1899 : Lett.

2. **Plagiochila ambagiosa** Mitten.

Plagiochila ambagiosa Mitten, Trans. Linn. Soc., vol. iii., p. 193, 1891. Steph., Bull. Herb. Boissier, vol. v., p. 83, 1897. Pearson, Hepat. Brit. Isles, p. 275, plate 115.

Districts I. — — — — — — — — — — —

Hab.—In damp rocky places.

I. Bantry: Miss Hutchins.

"Mr. Mitten detected this fine species in a collection made many years ago by the late Miss Hutchins in the south of Ireland. It is abundantly distinct from either *P. punctata* Tayl., or *P. spinulosa* Dicks., to which it is most nearly allied": Pearson 1902. My search for this fine *Plagiochila* has not met with success, though I am well acquainted with the plant, having studied a specimen sent to me by Mr. Mitten.

3. **Plagiochila spinulosa** Dicks., Dumort.

Jungermania spinulosa Dicks., Pl. Crypt. Brit., fasc. ii., p. 14. Hook., Brit. Jung., tab. 14. *Plagiochila spinulosa*, Dum., Recueil, p. 5. Moore, Irish Hepat., p. 643. Pearson, Hepat. Brit. Isles, p. 276, plate 116.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—In woods, on moist banks, and on rocks.

var. *flagellifera* Carr., Brit. Hepat., p. 60.

Moore, Irish Hepat., p. 644.

Glengariff, Sept. 1869, and Cromaglown, Killarney: Carrington. Shores of Lough Duff in the Brandon valley, and at Derrymore Glen near Tralee, rare, 1899: Lett & McA.

var. *inermis* Carr., Brit. Hepat., p. 60.

On moist rocks, Torc Waterfall, Sept. 1897: McA. & Lett 1899. Coumanare Lakes near Dingle, 1898: and on bank near Inch, 1899: Lett & McA. On rocks in the Brandon Valley, June 1900 (Lett & McA.): McA. 1901.

4. **Plagiochila punctata** Tayl.

Plagiochila punctata Tayl., Hepat. Antarct., in Lond. Journ. Bot., p. 371, 1844. G. L. N., Syn. Hepat., Suppl., p. 626. *Plagiochila spinulosa* var. *punctata* Carr., Brit. Hepat., part iii., p. 60. Carr., Irish Crypt., p. 19, tab. 2, fig. 3, 1863. *Plagiochila punctata* Moore, Irish Hepat., p. 644. Pearson, Hepat., Brit. Isles, p. 278, plate 117.

Districts I. — III. IV. — — — VIII. — — XI. XII.

Hab.—On shady banks and on rocks.

I. Killarney woods (Moore): Carrington 1863. O'Sullivan's Cascade, Glena, and Cromaglown: Lindberg 1875. Glena and Blackwater Bridge, Kenmare River: Scully 1890. On rocks, Torc Waterfall, 1897: McA. & Lett 1899. Common in the Dingle Peninsula: McA. 1901. Caha Mtn., Co. Cork: McA. 1894.

III. Graigue, Co. Carlow: McA. 1896 *a*.

IV. Altadore Glen and Seven Churches, Co. Wicklow: Moore.

VIII. Croaghpatrick and bank by the Moyire River, Co. Mayo, Sept. 1901: McA. Nephin, May 1901: Lett & McA. Bangore, Devil's Mother, and Slievemore on Achill, Sept. 1901: Lett.

XI. Rathmullen Wood and Saltpans Wood, Rathmullan, July 1902: Hunter. Cratleagh Wood and wood by Mulroy Bay near Milford, Sept. 1902; Goat Island, Lough Eask, June 1903: McA.

XII. Colin Glen and Loughmourne, Co. Antrim, very rare (Lett): Stewart 1888.

5. **Plagiochila tridenticulata** Tayl., Dumort.

Jungermania spinulosa var. *tridenticulata* Hook., Brit. Jung., p. 9, tab. 14, figs. 9–10. *Plagiochila tridenticulata* Dum., Recueil, p. 15. Tayl., in G. L. N., Syn. Hepat., p. 26. Moore, Irish Hepat., p. 644. Pearson, Hepat. Brit. Isles, p. 280, plate 118.

Districts I. — — — — — — VIII. — — XI. XII.

Hab.—On damp peat, rocks, and on the larger Hepaticæ.

I. Cromaglown, Killarney: Taylor 1836; Carrington 1863. Glena: Scully 1890. Torc Waterfall, Sept. 1897: McA. & Lett 1899. Brandon and Connor Hill, 1873: Moore & Lindberg. On *Frullania Tamarisci* on Brandon, July 1881: F. W. M. & McA. On *Radula aquilegia*, Loughanscaul, 1898: Lett & McA. Mt. Eagle, 1898: Lett & McA. Near Bantry (Miss Hutchins, Mackay): Taylor 1836. Glengariff: Carrington.

VIII. Devil's Mother, Slievemore on Achill, and Bangore, Co. Mayo, Sept. 1901: Lett.

XI. By the Leenan River near Ramelton: Hart 1886.

XII. Drumnasole, Co. Antrim (Brenan): Stewart 1895.

6. **Plagiochila exigua** Tayl.

Jungermania exigua Tayl., in Trans. Bot. Soc. Edinb., i., p. 179, 1843. *Plagiochila exigua* Tayl., in Lond. Journ. Bot., vol. v., p. 264. Moore, Irish Hepat., p. 645. Pearson, Hepat. Brit. Isles, p. 282, plate 119.

Districts I. — — — — — — VIII. — — — —.

Hab.—On the trunks of trees near the ground, and on *Frullania* and *Radula*.

I. Knockavohila, Dunkerron, and Torc Mtn. on *Frullania Tamarisci*, 1840: Taylor. Cromaglown, Killarney, 1865: Moore. O'Sullivan's Cascade and Glena, 1875: Moore. Mount Eagle near the lake, and Loughanscaul, 1898; Lough Duff in the Brandon Valley, 1899:

Lett & McA. Glengariff, Sept. 1869: Carrington 1874. Adrigole near Glengariff, Rev. C. H. Binstead: Pearson 1902.

VIII. Slievemore, Achill, Sept. 1901 : Lett.

Genus 28. **Jungermania** Linn.

Sub-genus 1. **Aplozia** Dumort.

1. **Jungermania cordifolia** Hooker.

Hook., Brit. Jung., tab. 32. *Jungermania tersa* Nees, Nat. Eur. Leb., i., p. 329. *Aplozia cordifolia* Dum., Hepat. Eur., p. 59. Moore, Irish Hepat., p. 647. *Jungermania cordifolia* Pearson, Hepat. Brit. Isles, p. 290, plate 122.

District I. — — — — — — — — — — XII.

Hab.—On moist banks and on rocks in mountain streams.

I. On Mangerton in the stream from the Punch Bowl: Taylor 1836. Coomashana Lake: Carrington 1863; Moore 1876. Near the Hunting Tower, Killarney: Scully 1890. Brandon, 1864: Moore. Maghanabo Glen, 1875 (McA.): Moore 1876. By the stream which flows from Lough Doon into the Brandon valley, 1881: F. W. M. & McA. Loughanscaul and Barnanaghea Lough near Anascaul, Sept. 1898: Lett & McA.

XII. Cushendun, Co. Antrim, 1836: Moore. On Sawell, Co. Derry, at 1600 feet, 1838 (Moore): Stewart 1888.

2. **Jungermania pumila** Withering.

With., Brit. Flora, ed. 3, p. 866. Hook., Brit. Jung., tab. 17. *Aplozia pumila* Dumort., Hepat. Europ., p. 59. *Jungermania pumila* Dumort., Moore, Irish Hepat., p. 647. Pearson, Hepat. Brit. Isles, p. 292, plate 123.

Districts I. — — IV. — — — VIII. IX. X. XI. XII.

Hab.—On rocks and banks of streams.

I. Glen near the Hunting Tower, Killarney: Carrington 1863; Moore 1876. Torc Waterfall, 1873: Lindberg 1875. Near Waterville and Blackwater Bridge: Scully 1890. Brandon: Moore. Loughanscaul, 1894: McA. Margin of Mt. Eagle Lake, Sept. 1898; bank between Emalough and Inch, and in Derrymore Glen near Tralee, 1899: Lett & McA. Mtn. near Bantry, Miss Hutchins: Hooker 1816.

IV. Lough Bray: Moore 1878. Dargle (Stokes & Taylor): Hooker 1816.

VIII. On the shore of Lough Conn at Pontoon, and on Nephin, May 1901: Lett & McA. Doolough, Co. Mayo, Sept. 1901: Lett.

IX. Glenade, Co. Leitrim: Moore 1876.

X. On wet rocks, Ballyhaise Wood, Co. Cavan, 1893: McA. 1898.

XI. Seashore on rocks, Macamish, July 1902: Hunter. Barnesmore Gap, Goat Island, Lough Eask Woods, June 1903: McA.

XII. Near Belfast (Templeton): Hooker 1816. Glendun, Co. Antrim (Brenan), Slievenanee (Lett): Stewart 1895. Hen Mtn., Co. Down (Waddell): Lett 1890.

3. **Jungermania riparia** Taylor.

Tayl., in Ann. and Mag. Nat. Hist., Aug. 1843. Spruce, in Phyt., March, 1843. *Apolozia riparia* Dum., Hepat. Europ., p. 65. Moore, Irish Hepat., p. 648. *Jungermania riparia* Pearson, Hepat. Brit. Isles, p. 294, plate 124.

Districts I. — — IV. — VI. — — IX. — XI. XII.

Hab.—In damp places, sides of streams, and on wet rocks.

I. Co. Kerry (Taylor): Moore 1876. Torc Waterfall: Carrington. Brandon: Moore. Wet rocks on Connor Hill, 1873: Lindberg 1875. Maghanabo Glen, 1875: McA. Loughanscaul near Dingle, Sept. 1898: Lett & McA. Rare in the Dingle Peninsula: McA. 1901. Enniscona, Co. Cork (I. Carroll): Moore 1876.

IV. Lough Bray: Moore 1876; McA. 1890. Woodenbridge, Co. Wicklow: Moore.

VI. Moist bank near Kilronan, Aran Isles: McA. 1895 *a*.

IX. Benbulben: Moore.

XI. Saltpans Wood, Rathmullan, July 1902: Hunter.

XII. Glens in Co. Antrim, 1836: Moore (under *J. pumila*). Rathlin Island, rare: Stewart 1888. Colin Glen near Belfast (Waddell); Drumnasole and Glendun (Brenan); Glenariff and Rasharkin Bog (Lett): Stewart 1895. Cove Mountain: Lett 1890. Moygannon Glen and Tollymore Park, Co. Down, very rare (Waddell): Lett 1890.

4. **Jungermania sphærocarpa** Hooker.

Hook., Brit. Jung., tab. 74. *Jungermania Goulardii* Husn., Hepat. Gall., no. 68, et Hepaticol. Gall., p. 29. *Aplozia sphærocarpa* Dum., Hepat. Eur., p. 71. Moore, Irish Hepat., p. 648. *J. sphærocarpa*, Pearson, Hepat. Brit. Isles, p. 296, plate 125.

Districts I. — — IV. V. — — VIII. IX. X. — XII.

Hab.—On stones near streams, and damp banks.

I. Torc Waterfall: Taylor 1836. Waterville, Glencar, and Mangerton: Scully 1890. Connor Hill, 1875: McA.; and 1897:

Lett & McA. Derrymore Glen near Tralee, rare, May 1899 : Lett & McA. Temple Michael Glen, Co. Cork (I. Carroll): Carrington 1863.

IV. Lough Bray : Moore ; on stones at the margin of the lake: McA. 1890. Dargle River : McA. 1889.

V. Near Dublin (Taylor): Hooker 1816. Kelly's Glen, Co. Dublin : Moore. The Quarries, Sutton, Co. Dublin, rare : McA. 1893 *a*. Omeath, Co. Louth : Lett 1890.

VIII. Nephin, May 1901 : Lett & McA.

IX. Glenade, Co. Leitrim : Moore.

X. Camlough Mountain, Co. Armagh : Lett 1890.

XII. Glenariff and Glenarm, Co. Antrim, rare, July and Sept. 1836 : Moore. Colin Glen, Co. Antrim, 1816 (Templeton), Parkmore (Lett) : Stewart 1895. Carr's Glen : Stewart 1888. Mountain rivulets above Mahera, 1836 (Moore) : Stewart 1888. Pigeon Rock Mountain, and Tollymore Park, Co. Down (Lett) ; Eagle Mountain, Co. Down, rare (Waddell) : Stewart 1888. Slievenamaddy and Hen Mountain : Lett 1890.

var. *lurida* Dumort.

Jungermania lurida Dum., Syll. Jung., p. 50. *J. nana* Nees, Nat. Eur. Leb., i., p. 317. Moore, Irish Hepat., p. 648. *Jungermania sphærocarpa* Hook., var. *lurida*, Pearson, Hepat. Brit. Isles, p. 298, plate 126.

Hab.—On wet rocks and by the sides of streams in mountainous districts.

Glengariff (Miss Hutchins): Moore 1876. Blackwater Bridge, Kenmare : Scully 1890. Connor Hill, rare, 1875 : McA. 1901. Near the Seven Churches, Co. Wicklow : Moore. Lough Bray, fertile, 1879 : McA. Kelly's Glen, Co. Dublin : Moore 1876. Glenasmole, 1875 : McA.

The late Dr. Spruce and Mr. Pearson have concluded that there is no specific difference between *Jungermania sphærocarpa* Hook., and *J. lurida* Dum. = *J. nana* Nees ; and, as the result of careful comparison of a series of specimens of both plants, I feel bound to agree with them. The cell-structure of the two is the same ; var. *lurida* is a smaller plant, darker-coloured, and having a more compressed mode of growth.

5. **Jungermania crenulata** Smith.

Sm., Eng. Bot., tab. 1463. Hook., Brit. Jung., tab. 37. *Aplozia crenulata* Dum., Hepat. Eur., p. 57. *Nardia crenulata* Lindberg, Hepat. in Hibernia, p. 529. McArdle, Hepat. Dingle Peninsula, p. 321. *Jungermania crenulata* Pearson, Hepat. Brit. Isles, p. 300, plate 127.

Districts I. II. III. IV. V. VI. — VIII. — X. XI. XII.

Hab.—On moist banks, bogs, often on hard roads, in damp places.

I. Near Bantry (Miss Hutchins): Hooker 1816. Dunboy, Co. Cork: McA. 1894. Ross Bay, Killarney: Carrington 1863. Waterville and Glencar: Scully 1890. Connor Hill, 1873: Lindberg 1875. Common in the Dingle Peninsula: McA. 1901.

II. Bay Lough, Knockmeildown Mtns., Co. Tipperary, June 1902: McA.

III. Roadside, Slieve Bloom, Queen's County: McA. 1892 *a.*

IV. Powerscourt (W. Stokes): Hooker 1816. Side of the river at the Seven Churches: Moore. Luggielaw, 1873: Lindberg 1875. Woodenbridge, Sept. 1894: McA. By the roadside at Lough Bray, 1889: Scully & McA. Glencullen, Co. Wicklow, 1887: McA. Bank of the Urrin River, near Knockroe, Co. Wexford, May 1899: McA. 1903.

V. Howth: McA. 1893 *a.* Kelly's Glen, Co. Dublin: Moore. Golden River on Carlingford Mountain, Co. Louth: Lett 1890.

VI. Ballyvaughan, Co. Clare, and Gentian Hill near Galway: McA. 1895 *a.*

VIII. Connemara: Moore 1876. Pontoon near Foxford, and on Nephin, May 1901: Lett & McA. Doolough and Achill, Sept. 1901: Lett.

X. Slieve Glah, Co. Cavan, sparingly, 1893: McA. 1898.

XI. Rathmullan, seashore at Macamish Hill, above Mintiaghs, July 1902: Hunter. Gartan Wood, Columbkil Lake, Cratleagh Wood near Milford, Sept. 1902; Goat Island, Lough Eask Woods, Errigal, June 1903: McA.

XII. Warrenpoint, Tollymore Park, Mourne Mountains, frequent (Waddell); Slieve Commedagh (Lett): Stewart 1888. Hen Mountain: Lett 1890. Narrow Water demesne, 1894: McA.

var. *gracillima* Smith.

Jungermania crenulata var., Hook., Brit. Jung., tab. 37. *J. gracillima* Smith, Eng. Bot., tab. 2238. *J. genthiana* Hueben., Hepat. Germ., p. 107. *Aplozia gracillima* Dum., Hepat. Eur., p. 57. *Nardia gracillima* Lindberg, Hepat. in Hib., p. 530, 1875. *Jungermania* (*Aplozia*) *crenulata* var. *gracillima* Moore, Irish Hepat., p. 647. Pearson, Hepat. Brit. Isles, p. 302, plate 128.

Hab.—In shallow patches on moist sandy banks, often on hard damp ground by roadsides.

Ditch bank, Pulleen, Berehaven: McA. 1894. Killarney: Carrington 1863. Waterville and Glencar: Scully 1890. Frequent in the Dingle Peninsula: McA. 1901. Galtee Mtns., Co. Tipperary, June 1902: McA. Killoughrim Oak Forest near Enniscorthy, May 1899: McA. Westaston, Co. Wicklow: Moore 1876. Lough Bray, 1873: Lindberg 1875. By the roadside at Lough Bray, 1889: Scully & McA. Woodenbridge, Co. Wicklow, Sept. 1894: McA. Ditch bank near the Baily Lighthouse, and on hard ground among rocks near Sutton, Co. Dublin: McA. 1893 *a*. Golden River on Carlingford Mtn., Co. Louth, rare: Lett 1890. On the shores of Lough Conn at Pontoon, and on Nephin, May 1901: Lett & McA. Bangore, Co. Mayo, Sept. 1901: Lett. On damp ground, Killakeen, Slieve Glah, and on the shores of Lough Cultra, Co. Cavan, 1893: McA. 1898. Wood by Mulroy Bay, Sept. 1902: McA. On damp peat, Lough Belshade, Errigal, June 1903: McA. Tollymore Park and Slieve Commedagh: Lett 1890. Aghaderg: Lett. Moygannon Glen, Co. Down (Lett): Stewart 1888.

Sub-genus 2. **Gymnocolea** Dumort.

6. **Jungermania inflata** Hudson.

J. inflata Huds., Fl. Angl., p. 511. Hook., Brit. Jung., tab. 38. *Gymnocolea inflata* Dumort., Recueil, p. 17. Moore, Irish Hepat. p. 654. Pearson, Hepat. Brit. Isles, p. 307, plate 131.

Districts I. II. — IV. V. — VII. VIII — X. XI. XII.

Hab.—On bogs and heathy places, on stones by streams.

I. Near Bantry (Miss Hutchins): Moore 1876. Upper Glencar, Co. Kerry: Scully 1890. Bog between Emalough and Inch, Co. Kerry, rare, 1899 (Lett & McA.): McA. 1901.

II. Galtee Mtns., Co. Tipperary, June 1902: McA.

IV. On stones, Powerscourt Waterfall: Taylor 1836. Lough Bray: Moore 1878; fertile there, 1880 (McA. & F. W. M.): McA. 1890.

V. Featherbed Mtn., Co. Dublin: Moore. Finglas Quarries: McA. Common on Howth: McA. 1893 *a*.

VII. Bog near Geashill, King's Co., 1894: Russell.

VIII. Diamond Mtn., Co. Galway, 1891: McWeeney. Croaghpatrick, Sept. 1901: McA. Shores of Lough Conn at Pontoon and on Nephin, May 1901: Lett & McA.

X. Moist bank near the summit of Slieve Glah, Co. Cavan, 1893 : McA. 1898.

XI. On schist rock behind Rathmullan, 1903 : Hunter.

XII. Moist banks, Giant's Causeway, 1836 : Moore. Seashore at Holywood, Febr. 1903 : Hunter.

var. *compacta* Carrington.

On dry rocks, top of the Hill of Howth (Moore) : Carrington 1863.

var. *laxa* Carrington.

Lough Guitane, Dean's Bridge, and Ross Bay, Killarney (Carrington) : Moore 1876. Rathmullan, July 1902 : Hunter. On *Sphagnum*, Holywood Hill, Febr. 1903 : Hunter.

var. *heterostipa* Lindberg.

Lindb. in Arn. and Lindb., Musc. Asiæ Bor., p. 47, 1888. Kaalaas, Leverm. Norge, p. 290, 1893. *Cephalozia heterostipa* Carr. et Spruce, Spruce on Cephalozia, p. 55, 1882.

Hab.—On wet rocks in mountainous districts.

On schist rocks, Rathmullen, Co. Donegal, 1903 : Hunter. New to the Irish cryptogamic flora.

7. **Jungermania turbinata** Raddi.

J. turbinata Raddi, in Act. Soc. Sc. Modena, xviii., p. 29, tab. 111, figs. 2, 3. *J. affinis* Wils., in Hook., Brit. Fl., ii., p. 128. *J. corcyracea* Nees, Nat. Eur. Leb., ii., p. 39. *J. Wilsoniana* Nees, Nat. Eur. Leb., iii., p. 548. *J. affinis* Wils., Moore, Irish Hepat., p. 654. E. *turbinata* Pearson, Hepat. Brit. Isles, p. 309, plate 132.

Districts I. — III. IV. V. VI. VII. — — — XI. XII.

Hab.—On damp shady banks or on damp rocks, in the limestone districts chiefly.

I. Killarney : Carrington 1863. Torc Cascade and Carantual : Moore.

III. Quarry bank near Goresbridge, Co. Carlow : McA. 1896 *a*. Bank by roadside, Slieve Bloom, Queen's Co. : McA. 1892 *a*.

IV. Bank by the Dargle River : McA. 1889.

V. Leixlip, Co. Kildare (*acutiloba*) : McA. 1893 *b*. Woodlands near Dublin, 1830 (W. Wilson) : Taylor 1836. Finglas quarries near

Dublin (McA.): Moore 1876. Kelly's Glen, Co. Dublin, Aug. 1896: McA.

VI. Oak Wood and Doon Bog, Clonbrock, Co. Galway: McA. 1896 *b*.

VII. Bog at Geashill, King's Co., 1890; Emo Park, Portarlington, 1893: Russell.

XI. Clay banks near the quay at Donegal, Mount Charles, Barnesmore Gap, Goat Island near Lough Eask, June 1903: McA. Bundoran, 1894: Professor T. Johnson. (On these specimens, *Sphærospora binominata*, Massee, was growing, an addition to the Irish fungus flora.) On rocks, seashore, Macamish, July 1902: Hunter.

XII. On white limestone, Glenarm: Moore. Colin Glen near Belfast, 1837: Moore; and (Waddell): Stewart 1888. Giant's Causeway, 1836: Moore. Carr's Glen and Springfield Glen: Stewart 1888. White rocks, Portrush, 1893: Russell. Narrow Water demesne, Co. Down, 1894: McA.

Sub-genus 3. **Lophozia** Dumortier.

8. **Jungermania bantriensis** Hooker.

J. bantriensis Hook., Brit. Jung., in note under *J. stipulacea*, no. 41. *J. bidentata* var., Hook., Brit. Jung., Suppl., t. 111. *Jungermania hygrophylla* Spruce, Trans. Bot. Soc. Edinb., ii., 1846. *J. culearis* Wils. MS., in Spruce, Hepat. Pyr., Trans. Bot. Soc. Edinb., iii., p. 20. *J. bantriensis* Hook., Moore, Irish Hepat., p. 649. Pearson, Hepat. Brit. Isles, p. 312, plate 133.

Districts I. — III. IV. — — — — IX. — — XII.

Hab.—In loose patches on rocks and damp banks.

I. Brandon: Moore. Laharn Wood near Bantry (Miss Hutchins): Hooker 1816 (under *J. stipulacea*, tab. 41). Glengariff (Carrington): Moore 1876.

III. Among *Campylopus* in a sandy deposit beside a stream on Slieve Bloom, near Clonaslea, Queen's Co., August 1891: McA. 1892 *a*.

IV. Lough Bray (Taylor): Hooker 1816.

IX. Benbulben: Moore 1876.

XII. Annahilt Bog, Co. Down (Herb. Belfast Mus.); glen on the shore of Belfast Lough (Templeton in Herb. Belfast Mus.); Colin Glen near Belfast: Stewart 1888.

var. *Muelleri* Nees.

Jungermania Muelleri Nees, in Lindenb., Syn. Hepat. Eur., p. 39.

Lophozia Muelleri Dum., Recueil, p. 17. *J. bantriensis* Hook., var. *Muelleri* Nees, Pearson, Hepat. Brit. Isles, p. 314, plate 334.

Hab.—Among damp rocks.

Glenade, Co. Leitrim, May 1875: Moore.

var. *acuta* Lindenberg.

Jungermania acuta Lindenb., Syn. Hepat. Eur., p. 88. *Lophozia acuta* Dumort., Recueil, p. 17. *J. bantriensis* Hook., var. *acuta* Lindenb., Pearson, Hepat. Brit. Isles, p. 316, plate 135.

Hab.—On damp rocks.

Connor Hill, among *Plagiothecium denticulatum*, 1873; Lindberg 1875.

var. *Hornschuchiana* Nees.

Jungermania Hornschuchiana Nees, Europ. Leberm., ii., p. 153. Moore, Irish Hepat., p. 650.

Hab.—Among damp rocks in mountainous places.

Cromaglown, Killarney, and among rocks near Torc Mountain, July 1869: Moore. Stream near Woodenbridge, Co. Wicklow: Moore 1876.

Note.—Dr. Moore states[1] that "this form might be easily passed over for *J. riparia*, both in a fresh and a dried state. It is only when the peculiarly notched subvertical leaves, with their amphigastria (stipules), are examined, that its distinguishing characters are observed. Dr. Lindberg considers *J. Hornschuchiana*, *J. bantriensis*, and *J. Muelleri* to be forms of one species."

9. **Jungermania capitata** Hook.

J. excisa Dicks., Pl. Crypt. Brit., fasc. iii., p. 11. *J. capitata* Hook., Brit. Jung., tab. 80. *J. intermedia* var. *capitata* Nees, Europ. Leberm., ii., p. 125. *J. capitata* Hook., Moore, Irish Hepat., p. 652. Pearson, Hepat. Brit. Isles, p. 322, plate 138.

Districts I. II. — — — — — VIII, IX. — XI. XII.

Hab.—On mountain rocks in damp places, often epiphytic on the larger Hepatics, such as *Frullania.*

I. Near Bantry (Miss Hutchins): Hooker 1816. Bog between Emalough and Inch, Co. Kerry, rare, 1899: Lett & McA.

II. Glengarra Wood, and among *Campylopus fragilis* near Lough Muskry, Galtee Mtns., Co. Tipperary, June 1902: McA.

VIII. Connemara, 1891: McWeeney. Murrisk near Westport,

[1] Report on Irish Hepaticæ, Proc. R. I. A., Ser. 2, vol. 2, Science.

Sept. 1901 : McA. On the slopes of Devil's Mother, Co. Mayo, Sept. 1901 : Lett.

IX. Benbulben, 1880 : McA.

XI. Rathmullan, Saltpans Wood, Rathmelton, July 1902 : Hunter. On *Frullania*, Goat Island, Lough Eask, June 1902 : McA.

XII. On rocks by roadside, Tonaghmore near Saintfield, Co. Down, 1900 : Waddell, Ir. Nat., vol. xii., p. 219, 1903.

11. **Jungermania bicrenata** Schmidel.

J. bicrenata Schmid., Anal., p. 347, t. 64, fig. 1. *Lophozia bicrenata* Dum., Recueil, p. 17. *Jungermania bicrenata* Lindenb., Synop. Hepat., p. 82. Moore, Irish Hepat., p. 652. Pearson, Hepat. Brit. Isles, p. 324, plate 139.

Districts I. II. — IV. V. — — VIII. — — — XII.

Hab.—On exposed rocks on the ground among heaths, and on damp shaded banks.

I. Temple Michael, Co. Cork (I. Carroll) : Moore 1876. Kinnordy, Co. Kerry (Taylor) : Carrington 1863. M'Gillicuddy's Reeks at 2000 feet : Scully 1890.

II. Knockmeildown Mtns., Co. Tipperary, June 1902 : McA.

IV. Lough Bray, Co. Wicklow : Moore 1878 ; McA. 1890.

V. On hard peaty soil, Ballykill, Howth, 1893–4 : McA. 1897. In Howth demesne among rocks, April 1895, very rare : McA. 1897.

VIII. Near Letterfrack and Kylemore, 1874 : Moore. Kylemore, 1891 : McWeeney.

XII. On rocks at roadside between Banbridge and Scarva : Waddell in Guide to Belfast, 1902.

12. **Jungermania ventricosa** Dicks.

J. ventricosa Dicks., Pl. Crypt. Brit., fasc. ii., p. 14. Hook., Brit. Jung., tab. 28. *Lophozia ventricosa* Dum., Recueil, p. 17. *Jungermania ventricosa* Moore, Irish Hepat., p. 652. Pearson, Hepat. Brit. Isles, p. 327, plate 140.

Districts I. II. — IV. V. VI. — VIII. IX. X. XI. XII.

Hab.—On banks and rocks in mountainous places.

I. Near Bantry, fertile in November (Miss Hutchins) : Hooker 1816. Killarney, rare : Carrington 1863. Slieve Mish and Magillicuddy's Reeks : Scully 1890. Connor Hill, 1873 : Lindberg 1875 ; 1880 and 1897 : McA. Brandon : McA. 1880 ; and Sept. 1897 : Lett & McA. Derrymore Glen near Tralee, and on bank between Emalough and Inch, 1899 (Lett & McA.) : McA. 1901.

II. Galtee and Knockmeildown Mtns., Co. Tipperary: Moore 1876; and June 1902: McA.

IV. Co. Wicklow: Taylor 1836. Lough Bray: Moore 1878; Lindberg 1875; McA. 1890. Lugnaquilla, May 1896: McA.

V. Boulacross Mtn., fertile in May: Hooker 1816; Taylor 1836. Near Dublin (Mackay): Hooker 1816. Anglesey Mtn., Co. Louth: Lett 1890. Howth, 1894 and 1895: McA. 1897.

VI. Shore of Lough Corrib, Co. Galway: McA. 1895 *a*.

VIII. Kylemore, 1891: McWeeney. Slopes of Devil's Mother, and Slievemore on Achill, Sept. 1901: Lett. Pontoon near Foxford, and on Nephin, May 1901: Lett & McA. Murrisk near Westport, Sept. 1901: McA.

IX. Benbulben: Moore 1876.

X. Top of Camlough Mtn., and Slieve Gullion, Co. Armagh: Lett 1890. Slieve Glah, Co. Cavan, 1893: McA. 1898.

XI. Saltpans Wood, Rathmullan; Croghan Mtn.; Carradoan Wood, Rathmullan, July 1902: Hunter. Bunlin Waterfall near Milford, Sept. 1902: McA.

XII. Sallagh Braes, Co. Antrim, 1837: Moore. Moygannon Glen and Slieve Martin: Lett 1890. Summit of Slieve Commedagh, and Rostrevor Wood, Co. Down (Waddell): Stewart 1888.

var. *porphyroleuca* Limpr., in Cohn, Krypt. Fl. Schles., i., p. 280.

Jungermania porphyroleuca Nees, Nat. Eur. Leb., ii., p. 78.

Hab.—Growing in patches, in subalpine situations, on damp peat, and on decayed wood.

Lough Bray: McA. 1889. Clermont Mountain and Carlingford, Co. Louth (Waddell), Slieve Gullion: Lett 1890. Pontoon near Foxford, and on Nephin, May 1901: Lett & McA. Among rocks, Columbkil Lake near Milford, Sept. 1902: McA. Ballyvalley near Rostrevor, very rare (Waddell): Stewart 1888.

13. **Jungermania alpestris** Schleich.

J. alpestris Schleicher, Exsicc., cent. ii., no. 59. Web., Prod., p. 81. *Jungermania sudetica* Nees, in Hueben., Hepat. Germ., p. 142. *J. Goepertiana* Hueben., Hepat. Germ., p. 254. *Cephalozia alpestris* Cogn., Hepat. Belg., p. 35. *Jungermania alpestris* Schl., Pearson, Hepat. Brit. Isles, p. 331, plate 142.

Districts I. — III. IV. V. — — — IX. X. — XII.

Hab.—On banks and rocks in mountainous places.

I. Kinnordy, Co. Kerry (Taylor): Carrington 1863. Connor Hill, June 1894: McA. Mount Eagle, Sept. 1898; Derrymore Glen near Tralee, May 1899: Lett & McA. Rare in the Dingle Peninsula: McA. 1901.

III. Among rocks near the River Barrow at Graigue, Co. Carlow, very rare, 1895: McA. 1896 *a.*

IV. Lough Bray, March 1892: McA.

V. Bank at the Rabbit Warren, Howth, 1893, rare: McA. 1897.

IX. Benbulben, 1880: McA.

X. Damp bank, Slieve Glah, Co. Cavan, 1893: McA. 1898.

XII. Glenariff, Co. Antrim, 1836: Moore. Near Saintfield, Co. Down: Waddell in Guide to Belfast, 1902.

14. **Jungermania incisa** Schrader.

J. incisa Schrad., Syst. Samml. Krypt. Gew., ii., p. 5. Hook., Brit. Jung., tab. 10. *Lophozia incisa* Dum., Recueil, p. 17. *J. incisa* Schrad., Moore, Irish Hepat., p. 653. Pearson, Hepat. Brit. Isles, p. 335, plate 144.

Districts I. — III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On bogs and heaths, and among rocks.

I. Near Bantry (Miss Hutchins): Hooker 1816. Near Cooneashana Lake: Carrington 1863; Moore 1876. Slieve Mish and near the Hunting Tower, Killarney: Scully 1890. Bogs about Connor Hill: McA. Coumanare Lakes, Sept. 1898; Derrymore Glen, May 1899; bog between Emalough and Inch, Co. Kerry, 1899: Lett & McA.

III. Slieve Bloom, Queen's Co., 1891: McA. 1892 *a.*

IV. Lough Bray: McA. 1890. Douce Mountain, 1897: McA.

V. Damp peaty banks, Howth: McA. 1893 *a.*

VI. Bogs about Clonbrock, Co. Galway, common: McA. 1896 *b.*

VII. Bog near Geashill, King's Co., 1890: Russell.

VIII. Corslieve and Bangore mountains, Co. Mayo: Moore 1876. Kylemore, and abundant on the top of Mweelrea, 1874: Moore. Nephin, May 1901: Lett & McA. Slievemore, Achill, Sept. 1901: Lett.

IX. Slish Wood, Co. Sligo: Waddell 1892.

X. Derrytagh Bog, Mintiaghs, Co. Armagh, 1882: Lett.

XI. Rathmullan, July 1902: Hunter.

XII. Aughalogan Bog, Parish of Duneane, Co. Antrim, rare, 1838: Moore. Lisbane near Saintfield, and Ballygowan: Waddell in Guide to Belfast, 1902.

15. **Jungermania exsecta** Schmidel.

J. exsecta Schmid., Ic. et Anal., p. 241, tab. 62, fig. 2. Hook., Brit. Jung., tab. 14, et suppl., tab. 1. *Lophozia exsecta* Dum., Recueil, p. 17. *J. exsecta* Schm., Moore, Irish Hepat., p. 651. Pearson, Hepat. Brit. Isles, p. 337, plate 145.

Districts I. — — IV. — VI. — VIII. IX. — — XII.

Hab.—On damp banks, on decayed wood, and among rocks in woods and heaths.

I. Near Bantry (Miss Hutchins) : Hooker 1816. Ballinhassig and Kildowry, Co. Cork (I. Carroll): Carrington 1863. On rotten logs, Cromaglown, Killarney: Carrington 1863. Glencar: Scully 1890. Bank near Mount Eagle Lake, July 1881 : F. W. M. and McA. Rare in the Dingle Peninsula: McA. 1901.

IV. Lough Bray, 1887, female, very rare: McA. 1890.

VI. In the oak wood, on Sheep-pool bog, and Doon bog, Clonbrock, Co. Galway, 1896, very rare : McA. 1896 *b*.

VIII. Slievemore, Achill, Sept. 1901 : Lett.

IX. Gleniff, Co. Leitrim : Moore.

XII. Sallagh Braes, Co. Antrim: Moore. The Warren, Holywood (Templeton) : Herb. Belfast Museum.

16. **Jungermania exsectæformis** Breidler.

J. exsectæformis Breidler, Leberm. Steiermarks, in Mitth. d. naturw. Ver. für Steiermarks, Jahrg. 1893, p. 321.

Districts — — — IV. — VI. — — — — — —

Hab.—On bogs, closely adhering to peat, and on old wood.

IV. On decayed wood, Lough Bray, Co. Wicklow, July 1887: McA.

VI. On peat, Doon bog, Clonbrock, Co. Galway, June 1896: McA. New to the Irish cryptogamic flora.

17. **Jungermania Lyoni** Taylor.

Jungermania quinquedentata Web. et Mohr., Bot. Taschenb., p. 430. Eng. Bot., tab. 2517. *Jungermania Lyoni* Tayl., in Trans. Bot. Soc. Edinb., i., p. 116, tab. 7. Dum., Hepat. Europ., p. 73. Moore, Irish Hepat., p. 651. Pearson, Hepat. Brit. Isles, p. 339, plate 146.

Districts I. — — IV. — — — — — — — XII.

Hab.—On rocky banks among Mosses, in patches interwoven.

I. On rocky banks, Coumanare Lakes, Co. Kerry, 1898: Lett & McA. Very rare in the Dingle Peninsula : McA. 1901.

IV. Glenmalure, Co. Wicklow, among tufts of *Scapania resupinata*, very rare, single stems only found : Moore.

XII. Rostrevor Mountain, Moygannon Glen, and Slieve Donard, Co. Down, rare (Waddell): Stewart 1888; and Lett 1890 (under

J. quinquedentata). Divis (Thompson), Cave Hill, and Sallagh Braes, Co. Antrim: Stewart 1888 (under *J. quinquedentata*).

18. **Jungermania gracilis** Schleicher.

J. gracilis Schleicher, Pl. Crypt. Helv., cent. iii., no. 60. *J. barbata* var. *minor* Hook., Brit. Jung., tab. 70, figs. 18–20. *J. barbata* var. *attenuata* Mart., Fl. Crypt. Erl., p. 177, tab. 6, fig. 50 *c*. *J. attenuata* Lindenb., Hepat. Eur., p. 44, no. 40. McArdle, Proc. R. I. Acad., 3rd ser., vol. iv., no. 1, 1897.

Districts I. II. — — V. — — — — — XI. —.

Hab.—Among rocks in heathy places.

I. Near Bantry, so embedded among Mosses and tufts of *Scapania nemorosa* that only the tops of the shoots appear (Miss Hutchins): Hooker 1816.

II. Baylough, Knockmeildown Mtns., Co. Tipperary, rare, June 1902: McA.

V. Near Dublin (Taylor): Hooker 1816. Among rocks in tufts of *Leucobryum glaucum* and *Tetraphis pellucida* at Ballykill, Howth, plentiful, June 1893, and Febr. 1894, and very fine in Howth demesne, 1895: McA. 1897.

XI. Among *Diplophyllum albicans*, Columbkil Lake near Milford, Sept. 1902: McA.

19. **Jungermania barbata** Schreber.

J. barbata Schreber, Fl. Lip., p. 107. Hook., Brit. Jung., tab. 70, fig. 7–8. *Lophozia barbata* Dum., Recueil, p. 17. Moore, Irish Hepat., p. 344. *Jungermania barbata* Schr., Pearson, Hepat. Brit. Isles, p. 344, plate 148.

Districts I. — — IV. V. — — VIII. — X. XI. XII.

Hab.—On damp shady rocks and banks.

I. Connor Hill, 1877: McA. 1880. Frequent in the Dingle Peninsula: McA. 1901.

IV. Co. Wicklow: Moore 1876. Douce Mtn., 1897: McA.

V. Co. Dublin, frequent: Moore 1876. In Howth demesne, April 1885: McA. 1897.

VIII. Nephin, May 1901: Lett & McA.

X. Bank among *Diplophyllum albicans*, Slieve Glah, Co. Cavan, very scarce, 1893: McA. 1898.

XI. Co. Donegal, abundant: Moore 1876. Near the lake at Macamish and behind the church at Rathmullen, July 1902: Hunter.

XII. Co. Antrim, frequent, 1838: Moore. Near Claggan, and on

Slemish, Co. Antrim, rare, 1836: Moore (under *J. incisa*). Rasharkin bog, Co. Antrim (Lett): Stewart 1895.

20. **Jungermania lycopodioides** Wallroth.

J. lycopodioides Wallr., Fl. Crypt. Germ., iii., p. 76. *J. barbata* var. *lycopodioides* Nees, Nat. Eur. Leb., ii., p. 185. *Lophozia lycopodioides* Cogn., Hepat. Belg., p. 31. Pearson, Hepat. Brit. Isles, p. 346, plate 149.

var. *Floerkii* Web. et Mohr.

J. Floerkii Web. et M., Bot. Taschenb., p. 410. *J. barbata* var. *Floerkii*, G. L. N., Syn. Hepat., p. 123. Moore, Irish Hepat., p. 651. *J. lycopodioides* var. *Floerkii* Lindb., Musc. Scand., p. 7. Pearson, Hepat. Brit. Isles, p. 348, plate 150.

Districts — — — — — — — VIII. — — XI. —.

Hab.—On damp rocks in subalpine situations.

VIII. Croaghpatrick, Sept. 1901: McA.

XI. Muckish: Moore 1876.

Sub-genus 4. **Sphenolobus** Lindb.

21. **Jungermania minuta** Crantz.

J. minuta Crantz ex Dicks., Pl. Crypt. Brit., fasc. xi., p. 13. Hook. Brit. Jung., t. 44. *Diplophyllum minutum* Dum., Recueil, p. 16. *Jungermania (Sphenolobum) minuta* Moore, Irish Hepat., p. 649. Pearson, Hepat. Brit. Isles, p. 353, plate 153.

Districts I. II. — IV. V. — — VIII. — — — —.

Hab.—On heaths and rocky banks in subalpine districts.

I. About Bantry (Miss Hutchins): Hooker 1816. Mangerton: Carrington 1863. Connor Hill, and banks about the Coumanare Lakes near Dingle, 1898; shores of Lough Duff in the Brandon Valley, 1899; Barnanaghea Lough near Anascaul, 1898: Lett & McA.

II. Knockmeildown Mtns., Co. Tipperary, June 1902: McA. Boola Lough, Coomeraghs, Co. Waterford, July 1902: Waddell.

IV. Lough Bray: Taylor 1836. Fertile there, 1889: Scully & McA. Seven Churches: Moore 1876.

V. Glencullen, Co. Dublin, 1890: Scully & McA. On a peaty bank among rocks at Ballykill, Howth: McA. 1893 *a*. Howth demesne, very fine, 1896: McA. 1897.

VIII. Nephin, May 1901: Lett & McA. Slievemore, Achill, Sept. 1901: Lett.

Sub-genus 5. **Anastrepta** Lindb.

22. **Jungermania orcadensis** Hook.

J. orcadensis Hook., Brit. Jung., tab. 71. *Mesophylla orcadensis* Dum., Hepat. Eur., p. 130. *Jungermania orcadensis* Hook., Moore, Irish Hepat., p. 650. Pearson, Hepat. Brit. Isles, p. 357, plate 155.

Districts I. — — — — — — VIII. — — — —.

Hab.—Growing in loose patches on rock-ledges, or mixed with other Hepaticæ or Mosses, in alpine and subalpine situations.

I. On the summit of Brandon among *Hypnum loreum*, 1813 (Taylor): Hooker 1816. On the east side of Brandon, near the summit, among *Scapania ornithopodioides*, June 1900: Lett & McA. Connor Hill, among *Herberta adunca*, 1873: Lindberg 1875. Glencar, and at 2500 ft. on the Reeks: Scully 1890.

VIII. On Slievemore, Achill, Sept. 1901: Lett.

Note.—An interesting *Jungermania* was found by Mr. Hunter on schist rocks at Rathmullen, Co. Donegal, in 1893, unfortunately without fruit. Prof. Kaalaas, to whom specimens were sent for identification, writes:—"The most striking character in the plant is the almost rectilinear truncate leaves, which, with regard to their form, are very like those of *Jungermania alpestris*; but it cannot for many reasons be referred to that species. In most respects, it seems to come near *J. Wenzelii*, which, however, is somewhat larger, and moreover an alpine species that is not likely to be met with in Ireland. I do not know any European species to which your plant with certainty can be referred. Until fertile specimens shall be found it will be difficult to settle this question."

Genus 29. **Nardia** Gray and Bennett.

Subgenus 1. **Eucalyx** Lindberg.

1. **Nardia hyalina** Lyell, Carrington.

Jungermania hyalina Hook., Brit. Jung., tab. 63. *Aplozia hyalina* Dumort., Hepat. Eur., p. 58. *Nardia hyalina* Carrington, Brit. Hepat., p. 35, pl. 11, fig. 36. Moore, Irish Hepat., p. 657. Pearson, Hepat. Brit. Isles, p. 364, plate 158.

Districts I. — III. IV. V. — — VIII. — X. XI. XII.

Hab.—Moist banks and by the sides of streams in rocky places.

I. Aooreagh River near Sneem, rare: Taylor 1836. Brandon, 1823 (W. Wilson): Moore 1876; and in 1881: F. W. M. & McA. Connor Hill, 1881: F. W. M. & McA. Between Emalough and Inch, 1899:

Lett & McA. Glencar and the Paps: Scully 1890. Dunboy Wood, Bere Island, and Dursey Island: McA. 1894.

III. Graigue, Co. Carlow, rare: McA. 1896 *a*.

IV. Luggielaw and Seven Churches: Moore. Lough Bray, 1887 (F. W. M.): McA. 1890. Glencullen, Co. Wicklow, 1887: McA. Near Arklow, 1895: McA.

V. Seefin Mtn. near Dublin: Hooker 1816; Taylor 1836. Anglesey Mtn., Co. Louth, rare: Lett 1890.

VIII. Co. Galway, 1891: McWeeney. Nephin, very rare, May 1901; Lett & McA.

X. Slieve Glah, Co. Cavan: McA. 1898. Slieve Gullion, Co. Armagh, 1894: McA.

XI. Among rocks, Columbkil Lake, and wet bank near Milford, Sept. 1902: McA.

XII. Co. Antrim (Moore): Carrington 1863. Rostrevor Mtn., Tollymore Park, and Spinkwee Glen, Co. Down (Waddell): Stewart 1888. Slievenabrock and Slievenamaddy, Cove Mtn. and Hen Mtn., Co. Down: Lett 1890. Parkmore, Co. Antrim (Lett): Stewart 1895. Narrow-water demesne, Co. Down, 1894: McA.

2. **Nardia obovata** Nees, Carrington.

Jungermania obovata Nees, Nat. Eur. Leb., i., p. 332. *Eucalyx obovata* Lindb., Bot. Not., 1872. *Southbya obovata* Dum., Hepat. Eur., p. 133. *Nardia obovata* Carr., Brit. Hepat., p. 32, pl. 11, fig. 35. Moore, Irish Hepat., p. 657. Pearson, Hepat. Brit. Isles, p. 366, plate 159.

Districts I. II. — IV. — VI. — VIII. — X. XI. XII.

Hab.—On moist rocks and by the sides of streams.

I. Torc Mtn., Killarney, 1829 (W. Wilson): Moore 1876. Killarney: Scully 1890. Cromaglown, fertile, June 1861: Carrington 1874. Brandon, 1823 (W. Wilson): Carrington 1874; and 1895: McA. Connor Hill (Moore): Pearson 1902; 1881: F. W. M. & McA.; 1898: Lett & McA. Rocky shores of Lough Duff, 1899; Coumanare Lakes near Connor Hill, 1898: Lett & McA. Mt. Eagle, 1881: F. W. M. & McA.

II. Glengarra Wood and among rocks over Lough Muskry, Galtee Mtns., Co. Tipperary, June 1902: McA.

IV. Lough Bray (Moore): McA. 1890.

VI. Carn Seefin, Co. Clare: McA. 1895 *a*.

VIII. On the slopes of Devil's Mother, Co. Mayo, Sept. 1901: Lett.

X. Moist bank among stones, Slieve Glah, Co. Cavan: McA. 1898.

XI. Hill above Mintiaghs, Rathmullen, July 1902: Hunter. Gartan Wood, Columbkil Lake near Milford, Sept. 1902; Goat Island near Lough Eask, June 1903: McA.

XII. Rocks in a stream on Slieve Donard, Co. Down, very rare: Lett 1890. Tollymore Park: Waddell 1892.

Sub-genus 2. **Eunardia** Lindberg.

3. **Nardia compressa** Hook., Gr. & Benn.

Jungermania compressa Hook., Brit. Jung., tab. 58. *Nardia compressa* Gr. & B., Nat. Arr. Brit. Pl., p. 694. *Alicularia compressa* Hook., Moore, Irish Hepat., p. 656. Pearson, Hepat. Brit. Isles, p. 368, plate 160.

Districts I. — — IV. V. — — VIII. — — XI. XII.

Hab.—On wet rocks and stones by sub-alpine rivulets.

I. Near Bantry (Miss Hutchins): Hooker 1816. Aooreagh River near Sneem, 1831 (Taylor): Moore 1876. Near the Hunting Tower, Killarney: Scully 1890. Killarney, rare (Moore): Carrington 1863. Near the summit of Barnanaghea Mtn. near Anascaul, plentiful, Sept. 1898: Lett & McA. Rare in the Dingle Peninsula: McA. 1901.

IV. Lough Bray (Taylor): Hooker 1816. Abundant at Upper Lough Bray, more sparingly at Luggielaw and Seven Churches (Moore): McA. 1890.

V. Kelly's Glen, Co. Dublin: Moore.

VIII. Kylemore, 1874: Moore. Nephin, May 1901: Lett & McA.

XI. On rocks in river at Errigal and at Lough Belshade, June 1903: McA.

XII. Slieve Donard, June 1903: Hunter. On stones in the Blue Lake, Slieve Lamagan, Spinkwee River glen, stream west of Slieve Meel More, and Diamond Mountain, Co. Down; Lett 1890. Eagle Mtn. and in the Windy Gap, rare (Waddell): Lett 1890.

var. *rigida* Lindberg, Moore.

Lough Bray, 1873: Lindberg 1875. On boggy land near Seven Churches: Moore 1876.

Note.—" Near *N. sphacelata,* stems shorter, narrower, and more rigid, more branched, more densely foliaceous, and here and there flexuose. Leaves more spreading and rigid. Cells twice the size and thickened, generally highly coloured. Dr. Lindberg states that this form is intermediate between the typical form of the species and its var. *Carringtonii* (*Adelanthus Carringtonii* Balfour MS., *Nardia Carringtonii* Lindberg). The first plants of this which I collected were sent to Dr. Lindberg, who named them *N. Carringtonii* without any reservation."—Moore.

4. **Nardia scalaris** Schrad., Gr. & B.

Jungermania scalaris Schrad., Syst. Samml. Krypt. Gew., ii., p. 4. *Nardia scalaris* Gr. & B., Nat. Arr. Brit. Pl., 694. *Alicularia scalaris* Corda in Opiz., Nat., p. 653. *Nardia scalaris* Sch., Moore, Irish Hepat., p. 656. Pearson, Hepat. Brit. Isles, p. 370, plate 161.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On moist clay banks and rocks, heaths, &c., common.

var. *compressa* Carrington, Brit. Hepat., p. 24.

Jungermania Walrothiana Hüben., Hepat. Germ, p. 85, no. 20.

Among wet stones, Connor Hill, Sept. 1897 : Lett & McA.

var. *distans* Carrington, Brit. Hepat., p. 24.

In wet places on Brandon, June 1900 : Lett & McA.

var. *rivularis* Lindberg.

In wet places, often in running water, and among *Sphagnum cuspidatum* and on submerged rocks in mountain streams. Lough Bray, Co. Wicklow, 1873 : Lindberg 1875 ; Moore 1876 ; McA. 1890.

var. *robusta* Lindberg.

On wet rocks at Lough Bray, 1872 : Moore ; McA. 1890.

Genus 30. **Marsupella** Dumort.

1. **Marsupella emarginata** Ehrhart, Dum.

Jungermania emarginata Ehrh., Beitr., iii., p. 80. *Marsupella emarginata* Dumort., Comm. Bot., p. 114. *Sarcoscyphus Ehrharti* Corda, in Opiz., Nat., p. 632. *Nardia emarginata* Ehrh., Moore, Irish Hepat., p. 655. *Marsupella emarginata* Pearson, Hepat. Brit. Isles, p. 375, plate 163.

Districts I. II. III. IV. V. VI. VII. VII. IX. X. XI. XII.

Hab.—On wet rocks and stones from the plains to high elevations by mountain rivulets.

I. Common in the Dingle Peninsula: McA. 1901. Frequent about Killarney : Carrington 1863.

II. Galtee and Knockmeildown Mtns., Co. Tipperary, June 1902: McA.

III. Rocks by the River Barrow, Graigue, Co. Carlow: McA. 1896 *a.* On stones in a stream on Slieve Bloom, Queen's Co.: McA. 1892 *a.*

IV. Rocks by the Urrin River at Knockroe, Co. Wexford, May 1899: McA. 1903. Lough Bray, 1873: Lindberg 1875; McA. 1890.

V. Anglesey Mtn., Co. Louth: Lett 1890. Co. Dublin, common: Moore 1878.

VI. Carn Seefin, Co. Clare: McA. 1895 *a.*

VII. King's Co.: McA. 1892 *a.*

VIII. Maam Turk, Connemara (Moore): Carrington 1863. Nephin and shores of Lough Conn at Pontoon, 1891: Lett & McA. Gentian Hill near Galway: McA. 1895 *a.*

IX. Benbulben, 1880: McA.

X. Wet rocks, Ballyhaise Wood, and in Farnham demesne, Co. Cavan: McA. 1898. Camlough Mtn. and Slieve Gullion: Lett 1890.

XI. Rathmullen, Febr. 1903; Buncrana, March 1902: Hunter. Errigal, Lough Belshade, Goat Island near Lough Eask, June 1903: McA.

XII. Frequent in the Mourne Mts., Co. Down: Lett 1890. Co. Antrim, frequent, 1836–7: Moore.

var *minor* Carrington, Brit. Hepat., p. 14.

Hab.—On wet rocks and stones, rare.

Cromaglown, Killarney: Moore 1876. On exposed rocks, Lough Adoon, Co. Kerry, rare: McA. 1901. On stones near the summit of Slieve Glah, Co. Cavan: McA. 1898. On Slievenabrock above Newcastle, Co. Down, among *Andræa alpina*, 1884: Lett. Rare in Co. Down: Lett 1890; Stewart 1888. On stones in the Ring Wood by the Slaney River, Co. Wexford, May 1899: McA. 1903. Nephin and Devil's Mother, 1901: Lett. Cratleagh Woods, Co. Donegal, Sept. 1902: McA.

var. *picea* Carrington, Brit. Hepat., p. 14.

On wet rocks, Connor Hill, Co. Kerry, Sept. 1898 (Lett & McA.): McA. 1901.

var. *major* Carrington, Brit. Hepat., p. 14.

On exposed rocks, Lough Adoon, Co. Kerry, rare, Sept. 1897: Lett & McA.

2. **Marsupella sphacelata** Gieseke, Dumort.

Jungermania sphacelata Gieseke, in Lindenberg, Syn. Hepat., p. 76, tab. 1, fig. 9. *Nardia sphacelata* Carr., Brit. Hepat., p. 11, pl. 2, fig. 5. Moore, Irish Hepat., p. 655. *Marsupella sphacelata* Dum., Recueil, p. 24. Pearson, Hepat. Brit. Isles, p. 377, plate 165.

Districts I. — — IV. — — — VIII. — — — XII.

Hab.—On wet rocks by the side of mountain rivulets, wet rocky boulders in glens at high elevations.

I. Horse's Glen, Mangerton: Scully 1890. Loughanscaul near Dingle, May 1894: McA. Derrymore Glen near Tralee, 1899: Lett & McA.

IV. Lough Bray, 1869 (Moore): Lindberg 1875; Carrington 1874. Station verified by F. W. M., July 1887: McA. 1890, and (fertile), 1889: Scully & McA.

VIII. Nephin, May 1901: Lett & McA. Bangore, Co. Mayo, Sept. 1901: Lett.

XII. Slieve Donard, Co. Down (Andrew & Lett): Stewart 1895.

3. **Marsupella Funckii** Web. et Mohr., Dumort.

Jungermania Funckii Web. et Mohr., Deutsch. Krypt., p. 422. *Marsupella Funckii* Dumort., Recueil, p. 24. Moore, Irish Hepat., p. 655. Pearson, Hepat. Brit. Isles, p. 379, plate 166.

Districts — — — — — — — VIII. — X. — XII.

Hab.—On rocks and sheep paths at high elevations.

VIII. Mountains above Kylemore Lake, 1874: Moore. Maam Turc Mtns. (Moore): Carrington 1863. On Slievemore, Achill, Sept. 1901: Lett. Nephin, May 1901: Lett & McA.

X. Camlough Mtn., Co. Armagh, June 1902: Lett.

XII. Black Mountain near Belfast, 1837: Moore.

Genus 31. **Cesia** Gr. & Benn.

1. **Cesia corallioides** Nees.

Gymnomitrium corallioides Nees, Nat. Eur. Leb., i., p. 118. McArdle, New or Rare Irish Hepat., Sci. Proc. R. D. S., vol. iii., plate 5, fig. 1, 1880. *Acolea corallioides* Dum., Recueil, p. 25. *Cesia corallioides* Carruth., in Journ. Bot., iii., p. 300. Pearson, Hepat. Brit. Isles, p. 401, plate 177.

Districts I. II. — IV. — — — — — — — —.

Hab.—On mountain rocks.

I. On rocks near the Tunnel, Cromaglown, Killarney: Carrington.

Dunkerron and Knockavohil Mtn.: Taylor. Carantual: Moore. Brandon, 1840 (Moore): McA. 1880.

II. Galtee Mtns., Co. Tipperary (I. Carroll): Carrington 1863.

IV. Lugnaquilla (I. Carroll): Carrington 1863.

2. **Cesia obtusa** Lindberg.

Cesia obtusa Lindberg, Musc. Scand., p. 9. *Gymnomitrium concinatum* var. *crenulatum* Limpr., in Cohn, Krypt. Schles., i., p. 246. *Cesia obtusa*, McArdle, New or Rare Irish Hepat., in Sci. Proc. R.D.S., vol. iii., plate 5, fig. 9, 1880. Pearson, Hepat. Brit. Isles, p. 405, plate 179.

Districts — — — — — — — VIII. — — — XII.

Hab.—On exposed mountain rocks.

VIII. Mweelrea, 1874 (Moore): McA. 1880.

XII. On Slieve Donard: Lett 1890; and 1903: Hunter. Slieve Commedagh at 1800 ft., and Slievenamady: Lett 1890. Thomas Mtn., Hen Mtn., and Hare's Gap (Waddell): Stewart 1888.

3. **Cesia crenulata** Gottsche.

Gymnomitrium crenulatum Carrington, Irish Crypt. p. 18, pl. i., fig. v., 1863. Gottsche et Rabenhorst, Hepat. Europ. Exsicc., no. 478. *Jungermania concinnata* Tayl., in Fl. Hib., part ii., p. 59. *Cesia crenulata* Moore, Irish Hepat., p. 659. Pearson, Hepat. Brit. Isles, p. 407, plate 180.

Districts I. II. — IV. V. — — — — — — XII.

Hab.—On exposed rocks and stones, in alpine and sub-alpine situations, rarely descending to sea-level.

I. Cromaglown and Carantual, 1851: Moore. Near the Tunnel, Cromaglown: Carrington. Connor Hill, 1873: Lindberg 1875; and 1881: F. W. M. & McA. Dunkerron and Knockavohil Mountains, Co. Kerry (Taylor): Carrington 1874. Rocks on the west side of Brandon, April 1897: F. W. M. & McA.; and 1900 (Lett & McA.): McA. 1901. Glengariff, May 1851 (Moore): Carrington 1874.

II. Galtee Mountains, Co. Tipperary (I. Carroll): Carrington 1874.

IV. Lugnaquilla (I. Carroll): Carrington 1874.

V. Rocks on Howth (Moore): McA. 1893 *a*. Golden River, Co. Louth (Lett): Pearson 1901.

XII. Mountain above Carnlough, Co. Antrim, Sept. 1836: Moore. Granite rocks on Slieve Donard (Stewart), Slieve Commedagh and Slievenamady (Lett): Stewart 1888. West side of Clontygeragh, 1836: Moore. Metamorphic rocks, Mullaghmore, Co. Derry: Stewart

1888. Hen and Pigeon Rock Mountains, rare : Lett 1890. Rocks, north-east side of Slemish, Co. Antrim (Lett & Waddell) : Stewart 1895.

Genus 32. **Acrobolbus** Nees.

Acrobolbus Wilsoni Taylor, Nees.

Gymnanthe Wilsoni Tayl., G. L. N., Synop. Hepat., p. 192. *Acrobolbus Wilsoni* Nees, G. L. N., Synop. Hepat., p. 5. Moore, Irish Hepat., p. 659. Pearson, Hepat. Brit. Isles, p. 410, plate 181.

Districts I. — — — — — — VIII. — — — —.

Hab.—In scattered tufts in moist shaded places, mostly epiphytic, on *Frullania*, *Radula*, &c.

I. Near Bantry with young fruit, Nov. 1812 (Miss Hutchins): Carrington 1874 (with excellent fig.). Glengariff, on *Frullania germana*, 1869 (Carrington): Moore 1876. Banks of a ravine near the Hunting Tower, Cromaglown, in fruit, Nov. 1829 (W. Wilson): Carrington 1874. Torc Mountain, Killarney, Sept. 1841 (Taylor): Carrington 1874 ; Moore 1876.

VIII. On the slopes of Devil's Mother, Co. Mayo, Sept. 1901 : Lett.

Genus 33. **Saccogyna** Dumort.

Saccogyna viticulosa Linn., Dumort.

Jungermania viticulosa Linn., Sp. Pl., p. 1597. Hook., Brit. Jung., tab. 60. *Saccogyna viticulosa* Dum., Comm. Bot., p. 113. Moore, Irish Hepat., p. 633. Pearson, Hepat. Brit. Isles, p. 413, plate 182.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On damp ground, on rocks, &c.

I. Near Bantry, in fruit, 1813 (Miss Hutchins) : Hooker 1816. Killarney woods: Moore 1876. O'Sullivan's Cascade, and Cromaglown, in fruit, 1873: Lindberg 1875. Torc Waterfall, Killarney, Sept. 1898 : McA. & Lett 1899. Connor Hill, 1873 : Lindberg 1875. Common in the Dingle Peninsula : McA. 1901.

II. Glengarra Wood, Galtee Mountains, Co. Tipperary, June 1902 : McA.

III. Wood by the roadside at Graigue, Co. Carlow : McA. 1896 *a.* Slieve Bloom, Queen's Co., 1891 : McA. 1892 *a.*

IV. Lough Bray : Moore 1876 ; McA. 1890. Killoughrim Forest near Enniscorthy, Co. Wexford, May 1899 : McA. 1903.

V. Killakee Glen, Co. Dublin : Moore 1878. Bank in Howth demesne, 1895 : McA. 1897. Clermont Carn, Co. Louth (Waddell) : Lett 1890.

VI. Carn Seefin, Co. Clare: McA. 1895 *a*.

VII. Ard Bog, King's Co. (Russell): McA. 1892 *a*.

VIII. Co. Mayo: Moore 1876. Pontoon on Lough Conn, and Nephin, May 1901: Lett & McA. Bangore, and Slievemore on Achill, Sept. 1901: Lett. Croaghpatrick, Sept. 1901: McA. Letterfrack, Co. Galway, 1891: McWeeney.

IX. Slish Wood, Co. Sligo: Waddell 1892.

X. Ballyhaise Woods, Co. Cavan, 1893: McA. 1898.

XI. Co. Donegal: Moore 1876. Rathmullen Wood, and Saltpans Wood, Rathmelton, July 1902: Hunter. Columbkil Lake and Cratleagh Wood near Milford, Sept. 1902; Lough Eask, June 1903: McA.

XII. Rostrevor Mountain, Donard demesne, White River Glen, Spinkwee River, and Tollymore Park, Co. Down: Lett 1890. Glenariff, 1836 (Moore); Woodburn and rocks at the summit of Ballygally Head (Stewart): Sallagh Braes, Co. Antrim (Lett): Stewart 1888.

Sub-tribe 7. **FOSSOMBRONIÆ.**

Genus 34. **Scalia** Gray & Bennett.

1. **Scalia Hookeri** Lyell, Gray & Bennett.

Jungermania Hookeri Lyell, Eng. Bot., tab. 2555. Hook., Brit. Jung., tab. 54. *Scalia Hookeri* Gr. & Benn., Nat. Arr. Brit. Pl., p. 704. Moore, Irish Hepat., p. 660. Pearson, Hepat. Brit. Isles, p. 427, plate 189.

Districts I. — — — V. — — — — — — —.

Hab.—Heaths and damp sandy places.

I. Connor Hill, one female plant, among *Riccardia pinguis* var., 1873: Lindberg 1875; Moore 1876.

V. On damp sandy flats between sand-hills, Malahide, 1878 (Moore) (a single plant, shown to F. W. M. and D. McA.): McA. 1880.

Genus 35. **Fossombronia** Raddi.

1. **Fossombronia pusilla** Dill., Linn., Dumort.

Jungermania pusilla Linn., Sp. Pl., p. 1603. *Fossombronia pusilla* Dumort., Rev. Jung., p. 11. Lindberg, Manipulus Musc. Secund., p. 384, tab. 1, fig. 5. Moore, Irish Hepat., p. 661. Pearson, Hepat. British Isles, p. 418, plate 183.

Districts I. — — — — — — — — — XI. XII.

Hab.—On moist clay or sandy ditch banks and fallow fields.

I. On clayey soil near Dingle, 1875: Moore. Bank in Burnham

Wood, Ventry, near the sea, Sept. 1898; wet bank between Emalough and Inch, May 1899: Lett & McA. In the fissures of rocks between Dingle and Ventry with *Anthoceros lævis*, 1873: Lindberg 1875. Bank of Finglas River, Waterville: Scully 1890. Near the Hunting Tower, Killarney: Scully 1890. Among rocks near the sea, Bere Island, and banks of the Pulleen River near the sea, Berehaven: McA. 1894.

XI. Field near Rathmullen with *Anthoceros punctatus* and *Riccia glauca*, 1903: Hunter.

XII. Island of Rathlin, Co. Antrim: Moore. Saintfield, Co. Down: Waddell.

var. *ochrospora* Lindb., Not. pro F. et. Fl. Fenn., p. 387.

Co. Kerry (Moore): Pearson 1901.

2. **Fossombronia cristata** Lindb.

Fossombronia cristata Lindb., apud Soc. pro F. et Fl. Fenn. (1873), Not. pro F. et Fl. Fenn., 382 (1874). Pearson, Hepat. Brit. Isles, p. 420, plate 184.

Districts — — — — — — — — — — — XII.

Hab.—On bare damp soil, sides of ditches, margin of ponds, &c.

XII. On whitish clay, shore of Loughbrickland, Co. Down, Oct. 1890 (Lett): Pearson 1901. Holywood, 1902: Hunter.

3. **Fossombronia angulosa** Mich., Dicks., Raddi.

Jungermania angulosa Dicks., Fasc. Pl. Crypt. Brit., i., 7, 1785. *J. pusilla* Sm., Eng. Bot., xxv., tab. 1775. *Fossombronia angulosa* Raddi, in Att. Soc. Sc. Modena, xviii., p. 40. Moore, Irish Hepat., p. 661. Pearson, Hepat. Brit. Isles, p. 421, plate 185.

Districts I. — — — — — — — — — — —.

Hab.—On ditch banks and fissures of rocks, near the sea.

I. Very fine at Dingle Bay and on cliffs near the sea between Dingle and Ventry: Moore. Abundant on a ditch bank near the sea by the entrance of Dingle Harbour, April 1897 (F. W. M.): McA. 1901. Dingle Bay opposite Ventry, male et c. fr., 1873: Lindberg 1875. Burnham Wood, Ventry, Sept. 1898: Lett & McA. Ross Bay, Killarney: Carrington 1863; Moore 1876. In fissures of rocks near the sea, Dursey Island: McA. 1894. Rocks in the Pulleen River and on Bere Island, Co. Cork: McA. 1894.

4. **Fossombronia Dumortieri** Hüb. et Genth., Lindberg.

Codonia Dumortieri Hüb. et Genth., Deutchl. Leberm., no. 80. *Fossombronia foveolata* Lindb., Not. pro F. et Fl. Fenn., p. 382. *Fossombronia Dumortieri* Hüb. et G., Lindb., Not. pro F. et Fl. Fenn., xiii., p. 380.

Districts I. — — — — — — — — — — —.

Hab.—On damp moorlands and banks of ditches.

I. Damp field near Farranfore, Co. Kerry, August 1901: Scully.

5. **Fossombronia cæspitiformis** De Not.

Fossombronia angulosa var. *cæspitiformis* Raddi, in Att. Soc. Sc. Modena, xviii., p. 41. *F. cæspitiformis* De N., in G. R., Hepat. Eur., dec. xiii. et xiv., no. 123. Pearson, Hepat. Brit. Isles, p. 424, plate 187.

Districts — — — — — — — — — — XI. —.

Hab.—On bare damp soil.

XI. Boggy ground, Ned's Point, Buncrana, 1903: Hunter.

Genus 36. **Petalophyllum** Gottsche.

Petalophyllum Ralfsii Wils., Gott.

Jungermania hibernica var., Wils., Eng. Bot., tab. 2750. *J. Ralfsii* Wils., Eng. Bot., Suppl., tab. 2874. *Petalophyllum Ralfsii* Wils., Gott. in Lehm., Pug. Pl. Nov. et Min. Cogn., viii., p. 29. Moore, Irish Hepat., p. 663. Pearson, Hepat. Brit. Isles, p. 430, plate 190.

Districts I. — — — V. — — — — — — —.

Hab.—On damp sandy ground near the sea.

I. Damp hollows in sand-hills on both sides of Inny ferry, Waterville: Scully 1890. Abundant a mile west of the ferry on the north side: Scully 1890.

V. On damp sandy flats among sand-hills, Malahide: Moore 1876; and sparingly, January 1902: Lett & McA. On the North Bull near Dublin, plentiful, 1880: F. W. M. & McA.

Genus 37. **Pallavicinia** Gr. & Benn.

1. **Pallavicinia Lyellii** Gr. & Benn.

Jungermania Lyellii Hook., Brit. Jung., tab. 77. *Blyttia Lyellii* Endl., Gen. Pl., 1840. *Pallavicinia Lyellii* Gr. & Benn., Nat. Arr. Brit. Pl., p. 775. Moore, Irish Hepat., p. 662. Pearson, Hepat. Brit. Isles, p. 432, plate 191.

Districts I. — — IV. V. — — — — — — —.

Hab.—Boggy places among *Sphagnum* and on wet dripping rocks.

I. Near Bantry (Miss Hutchins): Hooker 1816. Woods at Killarney: Taylor 1836. Maghanabo Glen near Fermoyle and by the lakes between the glen and Connor Hill, 1865: Moore.

IV. Lough Bray: Taylor 1836; Moore 1878. Same station, among *Sphagnum*, 1887: F. W. M. & McA.

V. Railway bank near the Ryewater River at Leixlip railway station, Co. Kildare, very scarce, 1890: Scully & McA.

2. **Pallavicinia hibernica** Hook., Gr. & Benn.

Jungermania hibernica Hook., Brit. Jung., tab. 78, suppl., tab. 4. *Moerckia hibernica* Gottsche, in G. & R., Hepat. Eur. Exsicc., no. 295. *Pallavicinia hibernica* Gr. & Benn., Nat. Arr. Brit. Pl., p. 684. Moore, Irish Hepat., p. 662. Pearson, Hepat. Brit. Isles, p. 434, plates 192–193.

Districts — — — IV. — — — — — — — —.

Hab.—In marshy places among *Sphagnum*, &c., at high elevations.

IV. Among *Sphagnum cuspidatum* and *Jungermania emarginata* on the shores of Lough Bray: Taylor; Moore; and July 1878: McA.

var. *leptodesma* Tansley, Pearson.

Pallavicinia leptodesma Tansley and Childs, in Annals of Bot., vol. xv., March 1901.

Hab.—In marshy places on the coast.

Among the sand-hills, Malahide: Moore; McA.; and January 1902: Lett & McA. Between Malahide and Portrane: Moore. On the North Bull near Dublin: Moore; rare there: McA. Cushendun, Co. Antrim: Lett 1890. Sand-hills north of Newcastle, Co. Down: Stewart 1888.

Genus 38. **Blasia** Micheli.

1. **Blasia pusilla** Linn.

Blasia pusilla Linn., Sp. Pl., p. 1605, 1753. *Jungermania Blasia* Hook., Brit. Jung., tab. 82–84. Tayl., in Fl. Hib., pt. ii., p. 56. *Blasia pusilla* Linn., Moore, Irish Hepat., p. 663. Pearson, Hepat. Brit. Isles, p. 440, plate 196.

Districts I. II. — IV. V. — — VIII. — X. XI. XII.

Hab.—On wet clayey banks in woods, by the side of streams, &c.

I. At the foot of Brandon: Moore 1876; and 1881: F. W. M. &

McA. Connor Hill, Sept. 1898, and Lough Duff in the Brandon Valley, 1899: Lett & McA. Near Waterville and Ballybunion, Co. Kerry: Scully 1890.

II. By the River Suir near Carrick, Co. Tipperary: Hart 1886.

IV. Woodenbridge: Moore 1876. On a bank by a stream in Altadore Glen, Co. Wicklow: McA. 1889. Killoughrim Forest near Enniscorthy, May 1899: McA. 1903.

V. Castlekelly Mtn., Co. Dublin, fertile, March 1836: Taylor. Anglesey Mtn., Co. Louth (Waddell): Lett 1890. Boggy place at Ballykill, Howth, fertile, March 1894: McA. 1897. Railway bank near Leixlip, Co. Kildare: McA. 1893 *b*.

VIII. Slievemore on Achill, Sept. 1901: Lett.

X. Southern end of Lough Allen: Stewart 1885. Side of a stream at Killakeen, Co. Cavan, 1893: McA. 1898. Camlough Mtn., Co. Armagh, Oct. 1898: Lett. On Slieve Gullion, Co. Armagh, 1894: McA.

XI. Saltpans Wood, Rathmullen, July 1902: Hunter.

XII. Tollymore Park and Victoria Park, Co. Down: Stewart 1888. Moygannon Glen and Narrow Water (Waddell): Stewart 1888. Slievenamaddy, Omeath Glen, Brown Bog near Loughbrickland: Lett 1890. Bank of a stream on Knockagh, Co. Antrim: Stewart 1888. Glendun, Co. Antrim, 1836: Moore.

Genus 39. **Pellia** Raddi.

1. **Pellia epiphylla** Linn., Lindberg.

Jungermania epiphylla Linn., Sp. Pl., i., ed. 2, p. 1135. Hook., Brit. Jung., tab. 47, figs. 1, 4, 8, 17. *Pellia Fabroniana* Raddi, in Att. Soc. Sci. Modena, xviii., p. 49. *Pellia epiphylla* Linn., Moore, Irish Hepat., p. 664. Pearson, Hepat. Brit. Isles, p. 443, plate 197.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—Growing in large patches on clay banks, on rocks and bogs, from sea-level to high elevations.

2. **Pellia calycina** Tayl.

Jungermania calycina Tayl. in Fl. Hib., part ii., p. 55. *Jungermania endivæfolia* Dicks., Pl. Crypt. Brit., fasc. iv., p. 19. *Jungermania epiphylla* var. *furcigera* Hook., Brit. Jung., tab. 47, fig. 18. *Pellia calycina* Tayl., Moore, Irish Hepat., p. 664. Pearson, Hepat. Brit. Isles, p. 447, plate 198.

Districts I. — III. IV. V. VI. VII. — IX. — XI. XII.

Hab.—In wet boggy places, dripping rocks, often submerged.

I. Dunkerron: Taylor 1836. Torc Cascade and Cromaglown, 1863 (Carrington): Moore 1876. On wet rocks, Torc Cascade, 1897: Lett & McA. Stream on Brandon, Sept. 1897: F. W. M. & McA. Loughanscaul near Dingle, Sept. 1898 (Lett & McA.): McA. 1901.

III. Stream on Slieve Bloom, Queen's Co.: McA. 1892 *a.*

IV. Altadore Glen and Lough Bray: Moore (under *Pellia endivæfolia*); Lindberg 1875; McA. 1890. Dargle River: McA. 1889. Wood by the Slaney River near Enniscorthy, May 1899: McA. 1903.

V. In a marshy place at Kilrock quarries, and on a shallow bog at Ballykill, Howth: McA. 1893 *a.* Beauparc, Co. Meath, 1893: McA. Leixlip, Co. Kildare: McA. 1893 *b.*

VI. Carn Seefin, Co. Clare: McA. 1895 *a.*

VII. Geashill, King's Co., 1890: Russell.

IX. Glencar, Co. Sligo: Moore 1876.

XI. Gartan Wood, Bunlin Waterfall, wet rocks at Columbkil Lake near Milford, Sept. 1902; Goat Island, Lough Belshade, Errigal, June 1903: McA.

XII. Glenballyemon, Co. Antrim: Moore. Dundonald Glen: Stewart 1888. Moygannon Glen and Tollymore Park: Lett 1890. Colin Glen and Carr's Glen, Co. Antrim: Stewart 1888. Aghaderg Glebe (Lett): Stewart 1895. Drumnasole, Co. Antrim: Brenan. Parkmore, Co. Antrim: Lett.

3. **Pellia Neesiana** Gottsche, Limpr.

Pellia epiphylla β. forma Neesiana Gottsche in Hedwigia, p. 69, 1867. *Pellia Neesiana* Limpr., in Cohn, Krypt. Fl. Schles., p. 329. Macvicar, Journ. of Bot., vol. xxxviii., p. 275, 1900. Pearson, Hepat. Brit. Isles, p. 445.

District I. — — — — — — — — — — —.

Hab.—In moist rocky places, and on wet grassy ground.

I. By the banks of the Pulleen River in a marsh among rocks near Pulleen Cove, Castletown Berehaven, Co. Cork (*fide* Slater): McA. 1894.

Sub-tribe 8. **METZGERIEÆ**.

Genus 40. **Aneura** Dumort.

1. **Aneura palmata** Hedw., Dum.

Jungermania palmata Hedw., Theor. Gen., ed. i., p. 87. *Aneura palmata* Dum., Comm. Bot., p. 115. *Riccardia palmata* Carruth., in

Journ. of Bot., iii., p. 302, 1865. Moore, Irish Hepat., p. 667. *Aneura palmata* Pearson, Hepat. Brit. Isles, p. 450, plate 199.

Districts I. — — IV. — — — VIII. — X. — —.

Hab.—On decayed wood.

I. Cromaglown, Killarney: Moore. Torc Mtn. and Eagle's Nest: Carrington 1863. Torc Waterfall, Sept. 1897: McA. & Lett 1899. Mangerton and Muckross, Killarney: Scully 1890. Brandon, 1881: F. W. M. & McA. Connor Hill, 1875: McA. Lough Adoon and Loughanscaul, 1897; Barnanaghea Lough and Mt. Eagle, 1898 (Lett & McA.): McA. 1901. Glengariff: Carrington 1863.

IV. Altadore Glen, Co. Wicklow: Moore.

VIII. Abundant on a small island off Ballykill Harbour, Co. Galway, 1874: Moore. Murrisk and Croaghpatrick, Sept. 1901: McA. Nephin, May 1901: Lett & McA.

X. Shores of Lough Cultra, Co. Cavan, rare: McA. 1898.

2. **Aneura multifida** Linn., Dumort.

Jungermania multifida Linn., Sp. Pl., p. 1602, 1753. *Riccardia multifida*, Gr. & Benn., Nat. Arr. Brit. Pl., i., p. 683. *Aneura multifida* Dumort., Comm. Bot., p. 115. *Riccardia multifida* Moore, Irish Hepat., p. 667. *Aneura multifida* Pearson, Hepat. Brit. Isles, p. 451, plate 200.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—In marshy places, damp woods, bogs, sides of ditches, &c.

3. **Aneura ambrosioides** Nees.

Aneura multifida var. *ambrosioides* Nees, Nat. Eur. Leb., iii., p. 450. G. L. N., Syn. Hepat., p. 497. *Riccardia multifida* var. *ambrosioides* Nees, Lindberg, in Acta Soc. Sci. Fenn., x., p. 511. Moore, Irish Hepat., p. 668. Carrington, Irish Crypt., 1863. *Aneura ambrosioides* Pearson, Hepat. Brit. Isles, p. 453, plate 201.

Districts I. — — — — — — — — — — —.

Hab.—Among wet Mosses and shaded wet rocks.

I. Cromaglown and Glena: Carrington 1863. Near Ventry, Connor Hill, and O'Sullivan's Cascade, 1873: Lindberg 1875. Glensiskin, Co. Cork (T. Chandlee): Carrington 1863.

4. **Aneura latifrons** Lindberg.

Jungermania multifida Schmidt, Icon. Pl., iii., pp. 213–216 (excl. Synon. et pp.) 1797. Hook., Brit. Jung., p. 19, fig. 75. *Riccardia multifida* Gr. & Benn., Nat. Arr. Brit. Pl., p. 684, no. 1. *Aneura palmata* var. *major* Nees, Nat. Eur. Leb., iii., p. 459. G. L. N., Syn. Hepat., p. 498. *Aneura latifrons* Lindb., Soc. Fl. Fenn., 1873. *Riccardia latifrons* Lindb., Hepat. Hib., p. 513, 1875. Moore, Irish Hepat., p. 668. *Aneura latifrons* Lindb., Pearson, Hepat. Brit. Isles, p. 454, plate 102.

Districts I. — III. IV. V. VI. VII. VIII. — — — —.

Hab.—On moist turfy banks, and decayed wood.

I. O'Sullivan's Cascade, Killarney, 1873: Lindberg 1875. Upper Glencar and Torc Waterfall: Scully 1890; and Sept. 1897: McA. & Lett. In the Dingle Peninsula it occurs as follows:—Anascaul, 1894: McA.; and 1898: Lett & McA. Lough Adoon, 1894: McA. Coumanare Lakes, Barnanaghea Lough, Lough Nalachan on Brandon, 1898: Lett & McA. Caha Mtn., Co. Cork: McA. 1894.

III. Slieve Bloom, Queen's Co.: McA. 1892 *a*.

IV. On decayed wood, summit of the waterfall at Powerscourt, May 1897: McA.

V. Bog at Ballykill, Howth: McA. 1897.

VI. Doon Bog, Clonbrock, Co. Galway: McA. 1896 *b*.

VII. Bog near Geashill, King's Co., 1890: Russell.

VIII. Nephin, 1901: Lett & McA.

4. **Aneura sinuata** Dicks., Dumort.

Jungermania sinuata Dicks., Pl. Crypt. Brit., fasc. ii., p. 16. *J. multifida* var. *sinuata* Hook., Brit. Jung., tab. 45, fig. 2. Moore, Irish Hepat., p. 667. *Aneura sinuata* Dum., Comm. Bot., p. 115. *Aneura pinnatifida* Carrington, Irish Crypt., 1863. *Riccardia multifida* var. *major* Lindberg, Hepat. Hib., 1875. *Aneura sinuata* Dicks., Pearson, Hepat. Brit. Isles, p. 456, plate 203.

Districts I. II. — IV. — — — — — X. — XII.

Hab.—On wet rocks, often within the spray of waterfalls.

I. Eagle's Nest, Cromaglown, and Glena, Killarney: Carrington 1863 (under *A. multifida* var. *major*); Moore 1876. On Torc Cascade with *Frullania Hutchinsiæ*: Carrington 1863 (under *A. pinnatifida*). Fermoy, Co. Cork (T. Chandlee): Carrington 1863.

II. Galtee Mountains, Co. Tipperary: Moore 1876.

IV. Luggielaw and Lough Bray: Moore 1876 (under *Riccardia multifida* var.); and McA. 1890. Glencullen, 1887: McA.

X. Killakeen, Co. Cavan, sparingly, 1893: McA. 1898 (under *Riccardia*).

XII. Tollymore Park, Co. Down, very rare (Lett & Waddell): Lett 1890. Saintfield, Co. Down, Jan. 1903: Waddell.

5. **Aneura pinguis** Linn., Dumort.

Jungermania pinguis Linn., Sp. Pl., p. 1136. Hook., Brit. Jung., tab. 46. *Aneura pinguis* Dumort., Comm. Bot., p. 115. *Riccardia pinguis* Gray & Benn., Nat. Arr. Brit. Pl., i., p. 684. Moore, Irish Hepat., p. 668. *Aneura pinguis* Pearson, Hepat. Brit. Isles, p. 457, plate 204.

Districts I. II. III. IV. V. VI. VII. VIII. — X. XI. XII.

Hab.—Damp shaded banks, among rocks in wet places, often submerged in mountain streams, and among wet heather.

I. Cromaglown, Killarney, 1873: Lindberg 1875. Waterville and Glencar: Scully 1890. Brandon, June 1900, Connor Hill, and Coumanare Lakes, 1898: Lett & McA. Maghanabo Glen, April 1897: F. W. M. & McA. Anascaul, 1894: McA. Bog between Emalough and Inch, 1899: Lett & McA. Frequent in the Dingle Peninsula: McA. 1901.

II. Galtee Mountains, Co. Tipperary, June 1902: McA.

III. Stream bank, Slieve Bloom, Queen's Co.: McA. 1892 *a.* Goresbridge, Co. Carlow: McA. 1896 *a.*

IV. Lough Bray, 1876 (Moore): McA. 1890.

V. On wet sandy flats, Malahide: Moore 1876. Quarries near Sutton, and on a small bog at Ballykill, Howth, plentiful: McA. 1893 *a.* Leixlip, Co. Kildare: McA. 1893 *b.* Side of the River Liffey near Lucan, Co. Dublin, June 1902: McA. Anglesey Mountain and Omeath Glen, Co. Louth: Lett 1890.

VI. Bog on Carn Seefin, Co. Clare: McA. 1895 *a.*

VII. Bogs at Welsh Island and Geashill railway station, King's Co.: McA. 1892 *a.*

VIII. Wood at Pontoon on Lough Conn, and on Nephin, May 1901: Lett & McA. Slopes of Devil's Mother, Sept. 1901: Lett.

X. Derrytrama bog, Mintiaghs, Co. Armagh, 1888: Lett.

XI. Errigal Waterfall, woods about Lough Eask, and Goat Island, June 1903: McA.

XII. On moist banks, Co. Antrim, 1838: Moore. Falls Park, Co. Antrim: Stewart 1888. Slieve Donard and Bencrom: Lett 1890. Rostrevor Mtn. (Waddell): Stewart 1888. Portstewart, Co. Derry: Stewart 1895.

var. *denticulata* Mich., Nees.

Lindberg in Acta Soc. Sci. Fenn., x., p. 514.

In wet rocky places among *Cylicocarpum Mougeotii*, Connor Hill, Co. Kerry, 1873: Lindberg 1875.

Genus 41. **Metzgeria** Raddi.

1. **Metzgeria pubescens** Schrank.

Jungermania pubescens Schrank, Prim. Fl. Germ., i., p. 231, no. 860. Hook., Brit. Jung., p. 20, tab. 79. *Metzgeria pubescens* Raddi, in Att. Soc. Sci. Modena, xviii., p. 46. Moore, Irish Hepat., p. 665. Pearson, Hepat. Brit. Isles, p. 460, plate 205.

Districts — — — — — — — — — — — XII.

Hab.—On moist limestone rocks and banks in woods.

XII. Mountains near Belfast (Templeton): Taylor 1836. On limestone rocks between Larne and Glenarm, and at Sallagh Braes, Co. Antrim, 1837 (Moore): Stewart 1888. Carr's Glen (Stewart), and Sallagh Braes (Stewart, Lett, and Waddell): Stewart 1888.

2. **Metzgeria furcata** Linn., Raddi.

Jungermania furcata Linn., Sp. Pl., 1602, 1753. Hook., Brit. Jung., tab. 55, 56. *Metzgeria glabra* Raddi, Jung. Etr., in Mem. Modena, xviii., p. 43, tab. 7, fig. 1. *Metzgeria furcata* Dumort., Rev. Jung., p. 26. Moore, Irish Hepat., p. 665. Pearson, Hepat. Brit. Isles, p. 461, plate 206.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—On the trunks of trees, on moist banks and rocks.

var. *æruginosa* Hook.

M. furcata var. *fruticulosa* Dicks., Lindb. Monogr.

Hab.—On the trunks of trees.

Muckross, Killarney: Carrington 1863. Torc Waterfall, Sept. 1897: McA. & Lett. Burnham Wood, and woods between Dingle and Ventry, 1894: McA. Wood at Goresbridge, Co. Carlow: McA. 1896 *a.* Cappard and Killeagh Abbey, Queen's Co., 1891 (Russell): McA. 1892 *a.* On trunks of trees, Co. Wicklow, and frequent in Co. Dublin: Moore 1878. Lough Allen and Slieveanierin Mtns., Co. Leitrim: Stewart 1885. Farnham Demesne and oakwood at Ballyhaise, Co. Cavan: McA. 1898. Batt's Wood, Rathmelton, Co. Donegal, July 1902: Hunter. Kirkcassock and Gillhall, Co. Down: Waddell.

var. *prolifera* McArdle.

McArdle, Proc. R. I. Acad., 3rd series, vol. iv., no. 1, p. 116, 1897.

Hab.—On trees by a stream near the ground, and on a small bog at Ballykill, both at Howth, March 1894: McA. 1897.

3. **Metzgeria conjugata** Lindberg.

Jungermania furcata (non Linn.), Weiss., Pl. Crypt. Fl. Gott., p. 108, 1770, and others. *Metzgeria conjugata* Lindberg, in Act. Soc. F. & Fl. Fenn., x., p. 495, no. 27, 1875. Schiffner in Engler & Prantl, Pflanzenfamilien, 91 and 92 Lief., p. 53, with figures, 1893. McArdle, in Proc. R. I. Acad., 3rd ser., vol. iv., no. 5, with plate, 1898. Pearson, Hepat. Brit. Isles, p. 463, plate 207.

Districts I. II. III. IV. V. VI. VII. VIII. — X. XI. XII.

Hab.—On shaded rocks and on the trunks of trees, and among the larger Hepaticæ and Mosses.

I. Glena, Torc Cascade and O'Sullivan's Cascade, among *Hookeria lætevirens,* 1873 (Lindberg): Moore 1876. Glencar: Scully 1890. Torc Waterfall, Sept. 1897: McA. & Lett. Ross I., 1893 and 1899: McA. Frequent in the Dingle Peninsula: McA. 1901. Dunboy Wood, Castletown Berehaven: McA. 1894.

II. Fertile in woods at Scariff, Galtee Mtns., Co. Tipperary, June 1902: McA.

III. On granite rocks, side of the River Barrow at Graigue, Co. Carlow, and on trees near Goresbridge: McA. 1896 *a.*

IV. Altadore Glen, Co. Wicklow: McA. 1889. Near Ferns, Co. Wexford, Dec. 1895: Greene. Killoughrim Oak Forest near Enniscorthy, Co. Wexford, May 1899: McA. 1903.

V. On *Frullania Tamarisci* among rocks near the Baily Lighthouse, Howth: McA. 1893 *a.* Beauparc, Co. Meath, Sept. 1893: McA.

VI. Clare Glen, Glenstal, Co. Limerick: Hart 1886. Carn Seefin, Co. Clare: McA. 1895 *a.* Tycooly Wood, wood at Sheep-pool Bog, and very fine in old orchard, Clonbrock, Co. Galway: McA. 1896 *b.*

VII. Geashill, King's Co., 1891 (Russell): McA. 1892 *a.*

VIII. Bangore, Sept. 1901: Lett. Pontoon near Foxford, and on Nephin, May 1901: Lett & McA.

X. Farnham demesne, Ballyhaise Wood, shores of Lough Cultra (on *Frullania*), Co. Cavan, 1893: McA. 1898.

XI. Rathmullen Wood, July 1902: Hunter. Wet rocks at Bunlin Waterfall near Milford, Sept. 1902; Lough Eask, June 1903: McA.

XII. Colin Glen near Belfast (Stewart), Sallagh Braes, Co. Antrim (Waddell): Stewart 1888. Tollymore Park, and in Rostrevor Wood, Co. Down (Waddell): Lett 1890.

var. *prolifera* McArdle, I. Nat., vol. v., p. 238, 1896.

Tycooly Wood, Clonbrock, Co. Galway: McA. 1896 *b.*

4. **Metzgeria hamata** Lindberg.

Metzgeria hamata Lindberg, Soc. F. Fl. Fenn., 1874. *Jungermania furcata* var. *elongata* Hook., Brit. Jung. tab. 55. *Metzgeria hamata* Lindberg, Monogr. Metzg., p. 25, fig. 5. *Metzgeria linearis* non Aust., Lindberg, Hepat. Hib., p. 494, 1875. *Metzgeria hamata* Pearson, Hepat. Brit. Isles, p. 464, plate 207.

Districts I. — — — — — — VIII. — — — —.

Hab.—On the ground among mountain heaths, on damp banks, and by the sides of streams, often submerged.

I. Stream on Brandon, 1865: Moore; and 1897: Lett & McA. Cromaglown, Killarney, 1873: Lindberg 1875; and 1878: McA. Torc Waterfall, and Magillicuddy's Reeks at 2500 ft.: Scully 1890. Torc Waterfall, Sept. 1897: McA. & Lett. On damp peat on the ascent to Brandon near Cloghane, and on Mt. Eagle, July 1881: F. W. M. & McA. Bank of the Coumanare Lakes near Connor Hill, and at Loughanscaul near Dingle, Sept. 1898: Lett & McA.

VIII. Bangore, and on the slopes of Devil's Mother, Sept. 1901: Lett.

Order 2. MARCHANTIACEÆ.

Genus 42. **Marchantia** March. fil.

Marchantia polymorpha Linn., Sp. Pl., p. 1603, 1753.

Marchant fil., in Acta Gal., 1713. Dill., Musc., tab. 76–77, fig. 7. Eng. Bot., tab. 100. Tayl., in Fl. Hib., pt. ii., p. 49. Moore, Irish Hepat., p. 601. Pearson, Hepat. Brit. Isles, p. 466, plate 208.

Districts I. — — IV. V. VI. — VIII. — X. XI. XII.

Hab.—By the sides of streams, drain banks in bogs, old damp walls. Flourishing on the surface mould of pot-plants in gardens.

I. Dunkerron, Co. Kerry: Taylor 1836. Frequent on moist rocks, seldom fruiting: Carrington 1863. Common in the Dingle Peninsula: McA. 1901.

IV. Lough Bray: McA. 1890. Altadore Glen: McA. 1889.

V. Old damp wall near Drumcondra, Co. Dublin, 1878: McA. Anglesey Mtn., Co. Louth: Lett 1890.

VI. Co. Clare and Co. Limerick: Stewart 1890. Ballyvaughan: McA. 1895 *a*. Drain on Sheep-pool Bog, Clonbrock, Co. Galway, abundant, male and female: McA. 1896 *b*. Abundant on the bog near Geashill railway station, King's Co., fertile: McA. 1892 *a*.

VIII. River bank, Westport, Sept. 1901: McA.

X. Camlough Mtn., Co. Armagh, 1897: Lett.

XI. Goat Island near Lough Eask, fertile, June 1903: McA.

XII. Frequent on moist shady banks near waterfalls, Co. Antrim, 1836: Moore. Common in the N.E.: Stewart 1888. Tollymore Park and Black Stairs on Slieve Donard, Co. Down: Lett 1890.

Genus 43. **Conocephalus** Neck.

Conocephalus conicus Neck., Dumort.

Hepatica vulgaris Mich., Nov. Pl. Gen., p. 3, 1729. *Marchantia conica*, Eng. Bot., tab. 504. *Conocephalus conicus* Dumort., Comm., p. 115. Steph., Sp. Hepat., p. 141, 1900. *Fegatella conica* Corda, in Opiz., Beitr., i., p. 649. *Conocephalus conicus* Moore, Irish Hepat., p. 601. Pearson, Hepat. Brit. Isles, p. 469, plate 209.

Districts I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII.

Hab.—In damp shaded places sides of streams, abutments of bridges, in caverns in mountainous places, on old walls, &c.

Genus 44. **Reboulia** Raddi.

Reboulia hemisphærica Raddi.

Marchantia hemisphærica Linn., Sp. Pl., p. 1604. *Asterella hemisphærica* p. p., Beauv., in Encycl. Meth., suppl. i., p. 502. Moore, Irish Hepat., p. 603. *Reboulia hemisphærica* Raddi, in Att. Soc. Sci. Modena, ii., p. 357. Pearson, Hepat. Brit. Isles, p. 470, plate 210.

Districts I. — — — V. VI. — VIII. — — XI. XII.

Hab.—On damp rocky places, walls of bridges and on damp sandy ground.

I. Dunkerron, Co. Kerry: Taylor 1836. Dingle Bay (Carrington): Moore 1876. In the crevices of moist rocks, Killarney: Wade Rar. 1804. Near Cork and Fermoy (I. Carroll): Moore 1876.

V. On sandy ground at the North Bull, Dublin (McA.): Moore 1876.

VI. Abundant on the walls at the bridge, Cong, Co. Galway: Moore 1876. In the crevices of moist rocks near Kilronan, Aran Islands: McA. 1895 *a*. Doon Bog, Clonbrock, Co. Galway: McA. 1896 *b*.

VIII. Connemara: Wade Rar. 1804.

XI. Poisoned Glen: Hart 1886.

XII. Sallagh Braes, Co. Antrim: Moore. Shady wall, Parnell's Bridge, Tollymore Park, Co. Down, very rare: Lett 1890. Rathlin Island (Stewart), basaltic rocks, Benevenagh, Co. Derry, 1836 (Moore): Stewart 1888 (under *Asterella*).

Genus 45. **Preissia** Corda.

Preissia commutata Lindenberg, Nees.

Marchantia hemisphærica Linn., Fl. Suec., no. 1052. *Marchantia androgyna* Tayl., in Trans. Linn. Soc., xvii., p. 380, 1835. *Preissia commutata* Nees, Nat. Eur. Leb., iv., p. 117. *Chomiocarpon quadratus* Scop., Lindb., Musc. Scand., 1879. *Preissia commutata* Moore, Irish Hepat., p. 602. Pearson, Hepat. Brit. Isles, p. 473, plate 211.

Districts I. — — — V. — — VIII. — — XI. XII.

Hab.—In fissures of damp rocks, and on damp ground in mountainous places, more frequent in limestone districts, occasionally at sea-level on damp sandy flats, among sand-hills.

I. Killarney: Moore. Ravine below the Eagle's Nest, 1863: Carrington. Dunkerron: Taylor. Kenmare (W. Wilson): Carrington 1863.

V. North Bull near Dublin, and in Co. Kildare: Moore. Railway bridge over Ryewater River, Leixlip, Co. Kildare: McA. 1893 *b*.

VIII. Rocks above Kylemore Castle and by the side of the lake at Letterfrack, 1874: Moore. Abundant near Cong, Co. Galway: Moore 1876.

XI. In the crevices of rocks, Goat Island, Lough Eask, June 1903: McA. Millfield, Buncrana, and behind Batt's Wood, 1903: Hunter.

XII. Sallagh Braes, Co. Antrim, 1837: Moore. Cregagh Glen and Carr's Glen: Stewart 1888. Scarva demesne and Parkmore (Lett), Glendun, Co. Antrim (Brenan): Stewart 1895.

Genus 46. **Lunularia.**

Lunularia cruciata Linn., Dumort.

Lunularia vulgaris Mich., Nov. Gen., p. 4, tab. 4, 1741. *Marchantia cruciata* Linn., Sp. Pl., p. 1137. *Lunularia cruciata* Dumort., Comm., p. 116. Moore, Irish Hepat., p. 604. Pearson, Hepat. Brit. Isles, p. 476, plate 212.

Districts I. — — IV. V. — VII. — — X. XI. XII.

Hab.—On damp walls and banks, pathways, &c., exceedingly common in gardens. Very rare in fruit.

I. Dunkerron, Co. Kerry, fertile in August: Taylor 1836. Torc Waterfall, Killarney, 1873: Lindberg 1875. Plentiful on the wall and on the ground at the entrance to glen at Torc Waterfall, Sept. 1897: McA. & Lett. Near Kenmare: Carrington. Ross I., on wall-tops, banks, and pathways, 1893: McA. 1900. Old walls about

Dingle: McA. Burnham Wood, Ventry, 1898; bank between Emalough and Inch, 1899; old walls about Cloghane and Fermoyle, June 1900: Lett & McA. Roadside, Connor Hill: McA.

IV. Altadore Glen, Co. Wicklow (Moore): McA. 1889. Woodenbridge, Co. Wicklow, 1894: McA. Damp bank, Ballybeg near Ferns, Oct. 1896 (Greene): McA. 1903.

V. In Glasnevin Botanic Gardens, once seen fertile: Moore 1876. Roadside near Finglas bridge, Co. Dublin, Aug. 1894: Nellie McArdle. Howth demesne: McA. 1897. Beauparc demesne, Co. Meath, 1893: McA.

VII. Shady places, Geashill Rectory, King's Co., 1890 (Russell): McA. 1892 *a*.

X. Ditch bank, Farnham demesne, Co. Cavan, 1893: McA. 1898.

XI. Millfield, and behind Batt's Wood, Buncrana, 1902: Hunter.

XII. Belfast Botanic Gardens, 1837: Moore. Drumcro, Co. Down (Waddell), Aghaderg, Co. Down (Lett), moss-hole at Seymour Hill, Co. Antrim, 1806 (Templeton): Stewart 1895.

Genus 47. **Dumortiera** Nees.

Dumortiera irrigua Wilson, Nees.

Marchantia irrigua Wilson, in Hooker's Brit. Fl., vi., 106, no. 5. *Hygrophylla irrigua* Taylor, in Fl. Hib., pt. ii., p. 54; Trans. Linn. Soc., xvii., p. 303, tab. 15. *Dumortiera irrigua* Wilson, Nees, Nat. Eur. Leb., iv., p. 159. *Dumortiera hirsuta* Swartz, Steph., Sp. Hepat., p. 224. *Dumortiera hirsuta* Sw., var. *irrigua* Tayl., Spruce, Hepat. Amaz. et And., p. 566, 1885. Schiffn., in Eng. & Prantl, Pflanzenf., 91 und 92 Lief., p. 36, 1893. *Dumortiera irrigua* Moore, Irish Hepat., p. 602. Pearson, Hepat. Brit. Isles, p. 477, plate 213.

Districts I. — — IV. — — — — — — — —.

Hab.—In sheltered rocky places, about waterfalls, and in caverns in the mountain streams.

I. Blackwater Bridge near Dunkerron, 1820 (Taylor): Moore 1876; Scully 1890. Torc Waterfall, Killarney, 1829 (W. Wilson): Moore 1876; Lindberg 1875. Plentiful within the spray of this waterfall, Sept. 1897: McA. & Lett. Maghanabo Glen near Fermoyle, Co. Kerry, 1829 (W. Wilson): Moore 1876; also 1875: McA.; and May 1897: F. W. M. & McA. On wet rocks in the stream which flows into Loughanscaul, Sept. 1897: Lett & McA. Ballinahassig Glen near Cork: Power's F. & Fl. Cork, 1844. Dunscombe's Wood near Cork (I. Carroll): Moore 1876.

IV. Altadore Glen, Co. Wicklow (Lord Gough): Moore 1876. Collected in the same glen, 1872-74: Moore; also 1887–9: McA. Waterfall at Luggielaw sparingly; Moore 1876.

Genus 48. **Targionia** Micheli.

Targionia hypophylla Linn., Sp. Pl., p. 1604.

Web. et Mohr, Crypt. Germ., p. 391, tab. 12. Eng. Bot., tab. 287. Tayl., in Fl. Hib., pt. ii., p. 55. *Targionia Michelii* Corda, in Opiz., Beitr., i., p. 649. *T. hypophylla* Moore, Irish Hepat., p. 605. Pearson, Hepat. Brit. Isles, p. 480, plate 214.

Districts I. — — — — — — — — — — XII.

Hab.—On dry rocks, and on the ground among rocks.

I. Among rocks on bank near the chapel, Cahirciveen, April 1877: McA. Near Muckross Abbey and Blackwater Bridge, Kenmare, Co. Kerry: Scully 1890. On dry limestone rocks, Carrigaline near Cork (I. Carroll): Moore 1876.

XII. On Cave Hill near Belfast (Templeton): Moore 1876. Rediscovered there by Lett in June 1902. Very rare, only observed on an exposed bank in the Little Deer Park, Glenarm, Co. Antrim, 1836: Moore in Ordn. Surv. Coll.

Genus 49. **Sphærocarpus** Micheli.

Sphærocarpus terrestris Mich.

Sphærocarpus terrestris Mich., Nov. Pl. Gen., p. 4, tab. 3. Dill., Hist. Musc., p. 536, tab. 78, fig. 17. Smith, Eng. Bot., tab. 297. *Targionia sphærocarpus* Dicks., Pl. Crypt. Brit., fasc. i., p. 8. *Sphærocarpus lagenarius* Dumort., Comm. Bot., p. 78. *Sphærocarpus terrestris* Mich., Moore, Irish Hepat., p. 669. Pearson, Hepat. Brit. Isles, p. 482, plate 215.

Districts — — — — — — — — — — — XII.

Hab.—In clover fields and stubble land, and on clay banks.

XII. On a wet clay bank at Colin Glen, near Belfast: David Orr. Dr. Moore writes—"I have never seen any Irish specimens of this plant, nor have I heard of its having been observed by any other person than Mr. Orr in Ireland."

Note.—Stubble fields and similar places have been neglected by collectors, and there is no reason why the plant should not be rediscovered.

Order 3. RICCIACEÆ.

Genus 50. **Riccia** Micheli.

Riccia glauca Linn.

1. **Riccia glauca** Linn., Sp. Pl., p. 1605, 1753.

Eng. Bot., tab. 2546. Lindenberg, Monogr. Ricc., p. 417, tab. 19. Tayl., in Fl. Hib., pt. ii., p. 70. Moore, Irish Hepat., p. 606. Pearson, Hepat. Brit. Isles, p. 484, plate 216.

Districts I. — — IV. V. — — — — — XI. XII.

Hab.—On damp ground, and on wet clay banks.

I. Mud walls, Ross Bay, Killarney: Carrington 1863.

IV. Co. Wicklow: Moore 1878.

V. Co. Dublin: Moore 1878.

XI. Wet places beside the Mill River, Buncrana, July 1903, and field near Rathmullen, Sept. 1903: Hunter.

XII. Clay bank, Holywood near Belfast, Jan. 1903: Hunter. Colin Glen, and rocks at Bangor: Waddell in Guide to Belfast, 1902.

2. **Riccia crystallina** Linn.

Lichen palustris Dill., Hist. Musc., p. 535, tab. 78, fig. 12, 1741. *Riccia crystallina* Linn., Sp. Pl., 1605, 1753. Pearson, Hepat. Brit. Isles, p. 485, plate 217.

Districts — — — — — — — — — — — XII.

Hab.—On damp clay in fields, and on wet banks.

XII. On moist banks near Glenarm and Cushendall, Co. Antrim, 1836: Moore.

3. **Riccia sorocarpa** Bischoff.

Riccia sorocarpa Bischoff, Hepat. Nov. Act. N. Car., xvii., p. 1053, tab. 71, fig. 11, 1835. *Riccia minima* Linn., Schiffn., in Engl. und Prantl Pflanzenf., 91 und 92 Lief., p. 15, 1893. *Riccia sorocarpa* Bisch., Moore, Irish Hepat., p. 606. Pearson, Hepat. Brit. Isles, p. 487, plate 218.

Districts I. — — — — — — — — — — —.

Hab.—Fissures and tops of old walls.

On an old wall near Dingle, 1873 (Lindberg & Moore): Lindberg 1875. Wall top by the roadside leading from Dingle to Ventry, on the Dingle side of the river near the Union Workhouse, Sept. 1898: Lett & McA.

4. **Riccia glaucescens** Carrington.

R. glaucescens Carrington, in Carr. & Pears., Hepat. Brit. Exsicc., fasc. 1, no. 66. *Riccia Michelii* Raddi, Lindb., Musc. Scand., p. 2, 1879. *Riccia bifurca* Hoffm., Steph., Sp. Hepat., p. 30, 1900. *Riccia glaucescens* Carr., Pearson, Hepat. Brit. Isles, p. 493, plate 222.

Districts — — — — — — — — — — XI. XII.

Hab.—On damp mud-covered rocks and stubble fields.

XI. In a stubble field near Lough Salt, Sept. 1902 : McA.

XII. On rocks in Glendun River, Co. Antrim, 1895 : Brenan & Lett, Journal of Botany, vol. xxxiii., p. 283, 1895.

Genus 51. **Ricciella** Braun.

Ricciella fluitans Linn., Braun.

Riccia fluitans Linn., Sp. Pl., 1606. Lindenberg, Monogr. Ricc., p. 443, tab. 24–25. Hook. et Taylor, Muscol. Brit., ed. ii., p. 213. Dumort., Hepat. Europ., p. 171. *Ricciella fluitans* Braun, Bot. Zeit., p. 754, 1821. Moore, Irish Hepat., p. 606. Pearson, Hepat. Brit. Isles, p. 495, plate 224.

Districts — — — — V. VI. — — IX. X. — XII.

Hab.—Floating in stagnant pools and ditches.

V. Side of the River Boyne above Drogheda : Moore 1876. Ditches at North Wall, Dublin : Wade Rar. 1804.

VI. Ditches near the Shannon, Co. Limerick : Moore.

IX. Among *Lemna*, ditch by the Shannon below Carrick, Co. Leitrim, June 1899 : Praeger.

X. Closet River and bog drains near Raughlan, Co. Armagh : Lett.

XII. Lough Neagh, where the canal joins the lough at Lurgan, Co. Down : Moore. Abundant in a drain at Meenan Bog, Loughbrickland, Co. Down : Lett 1890; Stewart 1895. Several places in Newry Canal : Stewart 1888 ; Lett 1890. Lagan Canal at Kilmore, Co. Down : Waddell in Guide to Belfast, 1902.

Genus 52. **Ricciocarpus** Corda.

Ricciocarpus natans Linn., Corda.

Riccia natans Linn., Syst. Nat., ed. v., vol. xii., p. 2, 1753. Eng. Bot., tab. 252. *Ricciocarpus natans* Corda, in Opiz., Nat., p. 651. Moore, Irish Hepat., p. 607. Pearson, Hepat. Brit. Isles, p. 497, plate 225.

Districts — — — — V. VI. — — — — — —.

Hab.—Floating on stagnant pools, drains, and ditches.

V. Drain near Newbridge, Co. Kildare, 1897: Praeger. Ditch near the Grand Canal at Ballyfermont near Inchicore, Co. Dublin, August 1893: Colgan. Ditch by the River Barrow, three miles below Athy, Co. Kildare, 1889: Scully. Abundant in a large pool about half way between Drogheda and Navan, near the railway, right-hand side going from Navan to Drogheda, 1870: Moore. Braganstown Bog, Co. Louth, 1897: Praeger.

VI. Ditch by the side of the Shannon, near Portumna, Co. Galway: Moore. Ditches near Passy, Co. Limerick (Harvey): Moore 1876

Order 4. ANTHOCEROTACEÆ.

Genus 53. **Anthoceros** Micheli.

1. **Anthoceros lævis** Linn.

Anthoceros lævis Linn., Sp. Pl., p. 1606, 1753. Lindenb., Hepat. Eur., p. 112. Nees, Europ. Leb., iv., p. 329. Moore, Irish Hepat., p. 670. Pearson, Hepat. Brit. Isles, p. 499, plate 226.

Districts I. — — — — — — — — — — —.

Hab.—On clay banks, fields, and pathways.

I. Wet clay bank by the roadside leading from Dingle to Ventry, July 1873: Lindberg & Moore. On a pathway in Burnham Wood, Ventry, Sept. 1898 (Lett & McA.): McA. 1901.

2. **Anthoceros punctatus** Linn.

Anthoceros punctatus Linn., Sp. Pl., p. 1606. Eng. Bot., tab. 1537. Moore, Irish Hepat., p. 670. Pearson, Hepat. Brit. Isles, p. 500, plate 227.

Districts I. II. — IV. V. — — VIII. — — XI. XII.

Hab.—In damp fallow fields, ditch banks, and by the sides of streams.

I. Frequent in Co. Kerry: Moore. Moist banks near Kenmare: Carrington. Brandon, 1829: W. Wilson. Brandon Head, Sept. 1898: Lett & McA. Maghanabo Glen, Co. Kerry, 1875: McA.; 1881, and April 1897: F. W. M. & McA.

II. Co. Cork, frequent: Moore. Among paving-stones on the ground at Queen's College, Cork, June 1899: Prof. Hartog.

IV. Sugarloaf Mountain (E. P. Wright): Moore 1876.

V. Kelly's Glen, Co. Dublin: Moore. Sandy flats and banks at Malahide, Co. Dublin, 1880: McA.

VIII. Slievemore, Achill, Sept. 1901: Lett.

XI. Field near Rathmullen, 1903: Hunter.

XII. Glendun, Co. Antrim: Moore. Belfast Botanic Gardens and river bank in Glendun (Lett): Stewart 1895. Ditch bank shaded with grass on the Stranmillis road, Belfast, 1803 (Templeton); and Lignapieste, Co. Derry, rare, 1836 (Moore): Stewart 1888. Fallow fields, Loughbrickland, Co. Down, 1897: Lett. On a clay bank at Holywood, Jan. 1903: Hunter.

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PROCEEDINGS

OF THE

ROYAL IRISH ACADEMY

VOLUME XXIV

SECTION C.—ARCHÆOLOGY, LINGUISTIC, AND LITERATURE

DUBLIN
PUBLISHED AT THE ACADEMY HOUSE, 19, DAWSON STREET
SOLD ALSO BY
HODGES, FIGGIS, & CO., LIMITED, 104, GRAFTON STREET
AND BY WILLIAMS & NORGATE, LONDON, EDINBURGH, AND OXFORD
1902–1904

THE ACADEMY *desire it to be understood that they are not answerable for any opinion, representation of facts, or train of reasoning that may appear in any of the following Papers. The Authors of the several Essays are alone responsible for their contents.*

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SECTION C.—ARCHÆOLOGY, LINGUISTIC, AND LITERATURE

DATES OF PUBLICATION

PART	1.	Pages	1	to	46.	August, 1902.
,,	2.	,,	47	,,	132.	December, 1902.
,,	3.	,,	133	,,	168.	April, 1903.
..	4.	,,	169	,,	226.	September, 1903.
,,	5.	,,	227	,,	276.	January, 1904.

ERRATA

SECTION C

Page 10, line 9, *for* "witnesses" *read* "witnessed".
,, 17, ,, 21, *for* "and" *read* "or".
,, 19, ,, 1, *for* "1786" *read* "1686".
,, 20, ,, 20, note 2, *for* "of" *read* "to"; *for* "by" *read* "of".
,, 24, ,, 18, *for* "were" *read* "was".
,, 25, footnote, line 4, *for* "Orlandais" *read* "irlandais".
,, ,, ,, ,, 9, *for* "sé our" *read* "séjour".
,, 28, } By inadvertence these pages went to press uncorrected. A number of obvious errors occur in the Duke of Portland's letter.
,, 29, }
,, 30, line 3 from end, *for* "general" *read* "several".
,, 85, line 8 from end, *for* "1870" *read* "1879".
,, 86, paragraph 3, *insert* "It" at commencement last line of text; *for* "ract" *read* "tract".
,, 89, line 13, *for* "last" *read* "east".
,, 91, 1st line of note, *for* "Fich" *read* "Fieh".
,, 95, line 1, *for* "plants" *read* "planks".
,, ,, line 12, *for* "edges" *read* "ridges".
,, 110, line 29, *for* "broad" *read* "thick".
,, 118, note 3, last sentence, *for* "been" *read* "has been", and *add* at end of sentence "for the lithograph".
,, 141, line 21, *for* "Broadstreet" *read* "Bradstreet".
,, 146, last line of footnote, *for* "Commercial Buildings" *read* "Grafton Street".
,, 135, first line of footnote, *for* "Historical" *read* "Historic".
,, 175, line 30, *for* "Greenville" *read* "Geneville".
Pages 183–191, *for* "Sydney" *read* "Sidney".
Page 188, lines 15 and 18, *for* "O'Conors" *read* "O'Connors".
,, 269, line 23, *for* "1009" *read* "1111".

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

PAPERS READ BEFORE THE ACADEMY.

I.

ON THE DISCOVERY OF AN ANCIENT GRAVE, NEAR ARDRAHAN, COUNTY GALWAY.

J. MARRIS ROBERTS, B.A.I. (Dublin).

[communicated by george coffey, b.e.]

[Read January 14, 1901].

I have the honour to submit to the Members of the Royal Irish Academy the following account of the discovery of an ancient grave in the neighbourhood of Ardrahan, Co. Galway. During the early part of January, 1900, while Mr. Stephen Tarpey was excavating gravel from a newly-opened pit on his farm, which lies about $2\frac{1}{2}$ statute miles to the N.N.W. of Ardrahan, the workmen came upon a flag, standing vertically in the "face" of the pit. This fell out, disclosing the grave (fig. 1). Inside the grave, which was formed of four flags set on edge, with another on top acting as a cover, were a quantity of bones and two urns. One of the latter, unfortunately, got broken at the time, and, before the grave could be carefully examined, the bones and urns were disturbed from their original positions. A drawing of the urns, as shown (fig. 2), and a detailed report on the bones by Dr. Brown of the Anthropometrical Laboratory, Trinity College, Dublin, is appended. The internal dimensions of the grave were 4 feet in length, by 2 feet 3 inches in breadth, by 2 feet in height. The plan and cross-section (figs. 1 and 3) will show the arrangement of the flags. There was no flag in the bottom of the grave, the contents resting directly on the gravel. This, by the way, is limestone glacial detritus. The side flags were from 3 to 4 inches in thickness, and were placed outside the end ones, which were of the same description. The covering-stone was very rough and irregular. The top of this cover was situated 1 foot below the surface of the ground, and the grave was placed due north and south. On inquiry I was informed that, when first found, the skulls were at

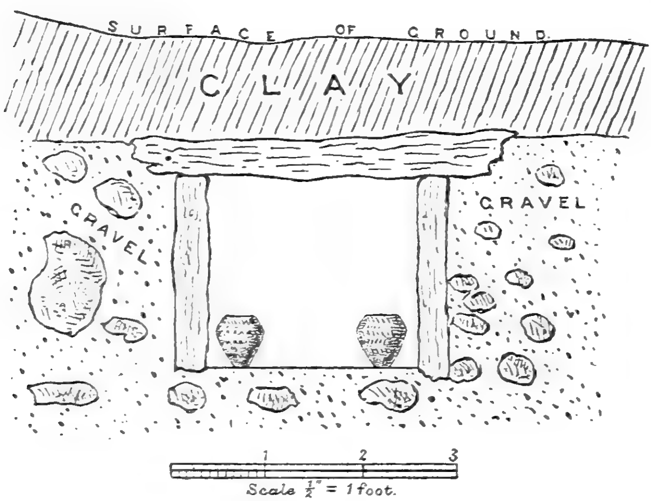


Fig. 1.—Section of Cist.

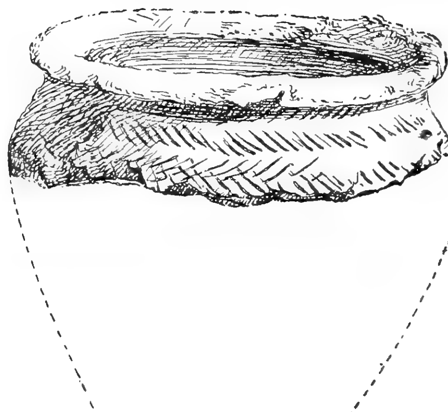
the north end—one in each corner; the bones scattered along the grave, and the urns exactly at the centre at the east and west points, and resting on their bases.

The measurements of the complete urns are—4½ inches in height, 5½ inches across the rim, 2¾ inches across the base.

The remnant of the broken one measures—5 inches across the rim.

There were no markings on the base. The ornamentation appears to be deeper and clearer on the broken one than on the one that is complete. On each there is a pattern inside the lip. When found,

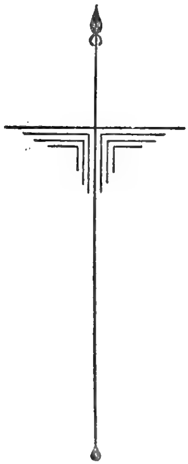
(a)



(b)

FIG. 2.—THE URNS.

they were quite wet and easily broken. The pottery of which they are composed is coarse and unevenly burnt, quite black at the centre, and brown outside and inside. Prior to the discovery of this grave, the workmen found some bones, but re-buried them. The pit is now



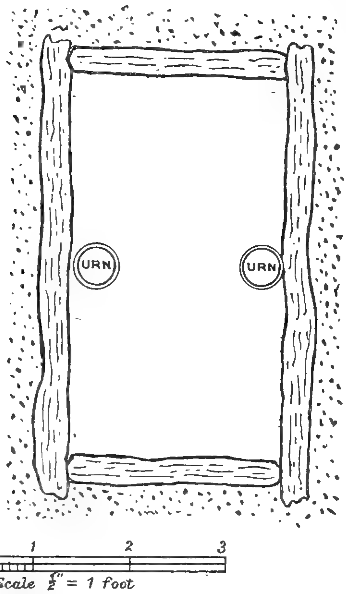


Fig. 3.—Plan of Cist.

nearly half excavated, and it is quite possible that another cist will be unearthed.

No beads, or ornaments, or celts were found in the neighbourhood of the grave, nor in the cist itself.

Report by Dr. Charles Browne.

Anthropological Laboratory,
Trinity College, Dublin.

Having examined the remains submitted to me I have to report that they consist of—

(*a*) Bones which have been cremated or subjected to great heat. These are in so fragmentary a state, and so distorted by the action of fire, that little or nothing can be said about them except that they seem all to belong to one skeleton (there being no duplicate of parts), which, it may be assumed from the size of the mastoid processes, was that of an adult male.

(*b*) The greater part of a skeleton of an infant.

These bones show no traces of the action of fire.

(*c*) The skull and many of the other bones of a young person, all much "weathered," and extremely brittle from loss of animal matter. The skull was in so fragile a condition, that in order to enable it to stand the handling necessary for examination and measurement it had to be painted over with a solution of gelatine.

The body evidently lay on its left side, as the bones of that side (especially the bones of the skull) are much more affected by damp than those of the right. The skull is that of a young person under eighteen years of age and most probably a female. Much injured by damp, the outer table of the left parietal bone and the left zygoma being weathered away. It is of small size and symmetrical in shape. Viewed in *norma verticalis*, the shape of the cranium is a broad blunt oval, in *norma lateralis* the forehead is seen to be upright, with well-marked frontal eminences, vertex high and prominent, occipital region flattened off above superior curved line.

Mastoid processes very small, and glabella absent, all markings slight. The cephalic index is on the border line between the mesaticephalic and brachycephalic classes. Frontal bones grooved. Face, medium width. Left molar bone and zygoma weathered away. Nose, evidently leptorhine. Orbits round, megaseme. Palate deep. Teeth all present at time of death, small and sound. Third molars not erupted.

Mandible, much weathered on left side, so no measurements are obtainable. The angles are strongly marked, and the mental process prominent and square; slightly concave at symphysis, so that it has an almost forked appearance. Teeth were all present at time of death, sound, and not much worn on crowns.

Sutures.—All open (including the basilar suture), those of the vault very complex ; three epactals in lambdoid suture.

There is little worthy of record to be observed in the other bones, ribs, vertebræ, clavicles, scapular radii, and ulnæ, fibulæ, patellæ, bones of the hands, feet, and tibiæ, except that by their stage of development they aid in determining the age of the person to whom they belonged, and that by the absence of any duplication of parts the presence of only the one body is ascertained. The important skeletal bones are the femora, ossa innominata, and sacrum, and all are those of a young person. The femora are much weathered, and the epiphyses had not at the time of death joined the shafts of the bones, but were among the bones recovered, and where those of the right femur were placed *in situ* the whole bone thus set up measured 415 mm.

The ossa innominata are not fully developed, the three primary divisions ilium, ischium, and pubes, all existing as separate bones.

The Sacrum.—The body of this bone is in good preservation, and is rather broad and flat, lateral masses absent, the fourth and fifth segments are united, but all the rest are detached.

From the condition of these bones and the skull it may be concluded that they belonged to a young person under seventeen years of age, and most probably a female.

On account of the weathered condition of the skull, and the youth of the subject, the cranial measurements are not very valuable, but are given here in case they may prove of interest.

Calculating from the length of the right femur, the stature was 1482 mm., or about 4 feet 10 inches.

Cranial Measurements.

Glabello-occipital length, . . .	173	Horizontal circumference, . . .	497
Maximum breadth, ...	140	Foramen magnum length, . . .	85
Basio-bregmatic height, . . .	130	Foramen magnum breadth, . .	36
Auriculo-vertical height, . . .	117	Basio-alveolar length, ...	86
Frontal longitudinal arc, . . .	115	Basio-nasal length, ...	90
Parietal longitudinal arc, . . .	125	Auriculo-nasal length, ...	90
Occipital longitudinal arc, . . .	110	Auriculo-alveolar length, . . .	87
Bi-asteric width, ...	113		

Face.

Face length, ...	104	Nasal breadth, ...	20
Nasio-alveolar length, ...	63	Orbital height, ...	33
Facial breadth, ...	20	Orbital width, ...	36
Nasal height, ...	44		

Indices.

Cephalic, ...	80·9	Alveolar, ...	95·6
Altitudinal, ...	75·1	Nasal, ...	45·5
Auriculo-vertical, ...	67·6	Orbital, ...	91·7

CHARLES R. BROWNE.

II.

THE IRISH GUARDS, 1661–1798.

By C. LITTON FALKINER, M.A.

[Read November 30, 1901.]

The recent addition to the strength of the British Army of a Regiment of Irish Guards has been hailed with acclamation as an appropriate compliment to the soldierly qualities of Irishmen, and as a graceful recognition of the valour displayed by Irish troops on the battle-fields of South Africa. The innovation has also been criticised, on the other hand, as a somewhat tardy recognition of the claims of Ireland to a share in the honour of furnishing those regiments which are most closely associated with the personal service of the Sovereign, and which have enjoyed for centuries a traditional precedence in the regimental roll. It is not a little curious that a people, who, differing among themselves in many things, are at one in their common pride in those martial instincts which Irishmen have manifested wherever and whenever opportunity has served, should have so completely forgotten an episode so interesting in the history of Irish arms as the raising of the first regiment of Irish Guards. Yet it is a fact that what has been greeted as a belated innovation is really only a revival of a corps which is coeval in antiquity with the institution of the standing army, and which, under the title of "His Majesty's Regiment of Guards in Ireland," enjoyed a distinguished reputation for valour and military efficiency at a most interesting period of Irish history.

The occasion, therefore, seems appropriate for an attempt to trace the record of a regiment which anciently held a distinguished place at the head of the military establishment of Ireland, and to recall the history of the remarkable corps which constituted the flower of the Irish army from the Restoration to the Revolution. And the inquiry is not the less interesting because it is in this Restoration Regiment of Irish Guards that we shall find the origin of one of the most eminent of the distinguished corps which subsequently constituted the Irish Brigade abroad. For though disbanded after the Boyne, the regiment, taking service abroad, achieved under a succession of brilliant officers an honourable place in the military history of eighteenth-century France. And preserving in exile that fealty to the principle of hereditary right which, combined with devotion to the Roman Catholic faith, had led its officers to adhere through evil days to the fallen fortunes of James the Second, it renewed, on the fall of Louis XVI., its allegiance to the Sovereign of the Three Kingdoms, and was re-enrolled for a brief period in the ranks of the British army.

The oblivion into which the origin of the regiment has fallen is, however, not very surprising, and is explained in great part by the circumstance that the compilers of Irish military history have given but scanty attention to the records of Irish regiments at home. For example, O'Conor's "Military Memoirs of the Irish Nation," useful as an account of the exploits of the Irish Brigade abroad, is absolutely silent on the military establishment of Ireland at the Restoration. D'Alton, again, in his "Historical and Genealogical Illustrations of King James's Army List," begins, as is natural, only with Tyrconnel's viceroyalty. And though O'Callaghan, in his admirably minute and exhaustive "History of the Irish Brigade in the Service of France," does not omit all notice of the origin of the distinguished regiments whose subsequent careers he traces in so much detail, his references to their pre-Revolution story are brief and parenthetic. To this explanation of our ignorance of the earliest records of the first regiment of Irish Guards it may be added, that it is only in years comparatively recent that the materials for tracing the origin of the regiment with any semblance of completeness have become available. No investigator in this field of our seventeenth-century history can fail to acknowledge a large debt to our distinguished and lamented academician, the late Sir John Gilbert, who, by his labours as editor of the Ormonde Manuscripts and of the Records of the Corporation of Dublin, has thrown open to the students of seventeenth-century Ireland two splendid treasuries of historical, topographical, and antiquarian lore.

The process by which the regiments raised by various royalist officers became the parents of several of the most distinguished of existing regiments has its best known examples in the Grenadier Guards and the Coldstream Guards, and need not be delineated here. And the circumstances which, immediately following on the

Restoration, led to the institution of a standing army, and laid the foundations of the existing military system of the United Kingdom, are familiar to every student of our political and constitutional history. But it may be well to glance at the beginning of the system in Great Britain, since it was there that the model was provided for the military establishment which, on the appointment of the Duke of Ormond to the Viceroyalty, was at once instituted in Ireland. Especially is this necessary to the elucidation of the origin of the Irish Guards, because the conception of a regiment directly associated with the Crown, a regiment formed to be, in fact as well as name, "His Majesty's Guards," goes back to a period prior to the Restoration.

Four years before the Restoration, Charles II., hopeless of the renewal of the ineffectual and half-hearted succour extended to him at the beginning of his exile by the French Court, which under the inspiration of Mazarin had become convinced of the permanence of the Cromwellian *regimé*, imagined that he had found in Spain the assistance necessary to regain his throne. In connexion with a project for the invasion of England by a Spanish expedition, it was resolved to organise, for service with the Spanish forces in the Low Countries, the considerable soldiery which had accompanied their Sovereign abroad, and had earned distinction in the armies commanded by Turenne. Accordingly, several regiments, both British and Irish, were gathered together into a division, and placed under the Spanish commander in Flanders. The English officers, by whom Charles was more immediately surrounded, were formed into what was called a Royal Regiment of Guards under Lord Wentworth, and some regiments of Irish were organised at the same time.[1] The command of the largest of these, a corps seven hundred strong, was assigned to the Marquis of Ormond, and quartered near Bruges, and ultimately took part in the unsuccessful operations at Dunkirk. The officers included many of the Confederate Catholic officers who had fled from Ireland.[2]

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[1] Clarendon's account of the matter is as follows:—"The king resolved to raise one regiment of Guards, the command whereof he gave to the lord Wentworth, which was to do duty in the army as common men till his majesty should be in such a posture that they might be brought about his person. The marquis of Ormond had a regiment in order, to be commanded by his lieutenant-colonel, that the Irish might be tempted to come over."—"History of the Rebellion," xv., p. 68.

[2] Sir F. Hamilton, in his "History of the Grenadier Guards," mentions that Charles I., during his stay at Oxford in 1642–3, had raised a regiment which was known as "The King's Guards," and states that "the Regiment of King's Guards, as well as all the rest of the Royalist troops in England, ceased to exist as regiments

Wentworth's Regiment of Guards survived the ill-success of Charles the Second's negotiations for aid from Spain; and remaining abroad at the Restoration as part of the garrison of Dunkirk, it escaped inclusion in that general disbandment of the army of the Commonwealth, in September, 1660, which was almost the first act of the restored monarchy. The young Sovereign, however, whose whole conception of the kingly dignity was coloured by his familiarity with continental courts, had no intention of remaining without a personal guard; and at the very moment which witnesses the dispersion of the remnant of Cromwell's Ironsides, he entrusted Colonel John Russell, a brother of the Duke of Bedford, with a commission to raise a Regiment of Foot Guards, twelve hundred strong, under the title of the King's Royal Regiment of Guards. Lord Wentworth's earlier formed regiment remained abroad until the sale of Dunkirk, when it came to England, where it was maintained as a distinct corps during Wentworth's life. But on the death of its colonel, three years later, on the eve of the outbreak of the Dutch War, Wentworth's was merged in Colonel Russell's regiment, to which the existing regiment of Grenadier Guards proudly traces its origin. [1]

No one who has had occasion to consider the character of the arrangements made upon the restoration for the machinery of the constitution and the equipment of the public service, can have failed to be struck by the closeness with which the institutions of every sort set up in Great Britain were followed in the organisation of the

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in 1646–7; and the English troops raised subsequently by Charles II., with which he endeavoured to recover the Crown of his ancestors, were disbanded after the battle of Worcester in 1651; so that though we trace among the officers of the Regiment of Guards which Charles II. raised in Flanders many Royalists who had either served in the King's Guards or in other corps during the Civil War, both in the time of Charles I. and II., there is no connexion as a regiment between these two corps of Guards" (vol. i., p. 8). It appears, however, from a letter published in the "Ormonde Papers" (Hist. MSS. Comm., 14th Rep., vol. i., p. 97), that Wentworth's regiment existed in some form in 1649:—"Thomas Wentworth to Edward Broughton. Breda, June 24, 1649. You are to receive such men as shall be delivered you on shipboard as part of a Regiment to (*sic*) the King's Guards, and you to command them as Serjeant-Major to the said Regiment, and at your landing in Ireland you are to obey such orders and directions as you shall receive from the Marquis of Ormond, the Lieutenant-General of the kingdom of Ireland." It is noticeable that this letter is addressed by the subsequent colonel of Charles the Second's post-Restoration Guards, to an officer who subsequently held a commission in that regiment. The letter is addressed, "For Major Edward Broughton, Major to the King's Guard of Foot."

[1] Sir F. Hamilton's "History of the Grenadier Guards," pp. 30–34.

Irish Government. The formal constitution of a standing army by Charles II., and the formation of His Majesty's Regiment of Guards, took place early in 1661. It does not appear how far, if at all, the King's advisers then contemplated the provision of a separate military establishment for Ireland. It is probable that the question remained in abeyance until after the selection of the first Restoration Viceroy, an appointment which was delayed until the autumn of that year. When the Duke of Ormond was appointed to the Viceroyalty, he was careful to imitate in all respects, as far as possible, the model provided in England. The establishment for Ireland, both civil and military, followed closely upon the lines laid down by Clarendon and the other advisers of Charles II. Ormond was given a free hand in Ireland, "the places, as well in the martial as civil list, being left freely to his disposing." He at once proceeded to exercise his authority, by providing for the civil and military needs of Ireland upon a scale of great magnificence. And as a means, both of emphasising the dignity of the Viceregal office, and of supplying an efficient force for service in emergency, one of his first steps was to procure a commission to raise a Regiment of Guards for service in Ireland. Accordingly, on April 23rd, 1662, a commission was issued to the Viceroy.[1]

The Duke of Ormond[2] received his commission on April 23rd, 1662, and he lost no time in acting on the authority thus given to him. On the following day the regiment was formally constituted, and provision was made for the enrolment of twelve companies of one hundred men each. The Viceroy's second son, Lord Richard Butler, who was immediately afterwards created Earl of Arran, was gazetted Colonel of the regiment with the captaincy of a company; and eleven other officers were appointed to the remaining companies.[3] The establishment of the regiment was calculated on a generous scale, no less a sum

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[1] The following is the text of this Commission:—

"Whereas we have already constituted and appointed James, Duke of Ormond. to be Governor of our Kingdom of Ireland, and of all our armies there raised and to to be raised: And whereas we have thought fit to raise within this our kingdom of Ireland, a regiment of 1200 foot to be our Regiment of Guards in our said Kingdom of Ireland: We do give and grant to our said Lieutenant and Chief Governor full power, liberty and authority, by beat of drums, proclamations, or otherwise, to raise the said number of men in England, and to conduct, lead and transport them into Ireland, with power and authority to him to give and grant commissions under his hand and seal to such persons as he shall think fit to be officers and commanders of the said regiment."—Ormonde MS., unprinted.

[2] Ormonde, MS., vol. i., 239.

[3] "Sir William Petty's Political Anatomy."

than £24,518 8*s.* 8*d.* per annum being allocated to its maintenance. Its roll included, in addition to the Colonel, a Lieutenant-Colonel, a Major and nine Captains of companies, twelve Lieutenants, twelve Ensigns, forty sergeants, thirty-six corporals, a drum-major with twenty-four drummers, a piper to the King's Company, and twelve hundred soldiers. In addition to the fighting strength of the regiment, there were attached a Chaplain, an Adjutant Quarter-Master, a Surgeon and Surgeon's mate.[1]

It does not appear from any document from what district the rank and file of the regiment was recruited; but it is evident that at the date of the commission to Ormond considerable progress had been already made in finding the men and arranging for their equipment, and the original list of officers included some who had served in the regiment commanded by Ormond in Flanders. On April 14th, 1662, the Vice-Treasurer received orders to pay to Lieutenant-Colonel Sir William Flower, the sum of £1897 8*s.* 8*d.*, "towards the raising, sending to the sea-side, and transporting into Ireland of the officers and soldiers of the said regiment."[2] Two days later, a similar sum, "being one month's pay of the Regiment of Guards for Ireland," was ordered to be paid to the same officer. On April 21st, orders were given for £663 14*s.* to be paid to John Wall, "for 600 scarlet coats, bought of him for His Majesty's Regiment of Guards for Ireland, and £755 12*s* to be paid to Henry Prescott for 661 red coats, and embroidering twenty-four drummer's coats, with sacks to pack them up in."[3] This uniform is identical with that prescribed for Colonel Russell's Regiment of Guards in England. A little later Alderman Daniel Bellingham, afterwards the first Lord Mayor of Dublin, received an order to furnish all the non-commissioned officers and men with a "red cassock," a term not as yet appropriated by the clergy, together with "cloth breeches, two shirts, one pair of stockings, and one pair of shoes."[4]

No time was lost in transferring the newly raised regiment to its destination. As early as May, the news-letters of the day chronicled the embarkation of the Guards for Ireland.[5] "On the 9th instant," according to the Chester correspondent of Mercurius Publicus, "Sir

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[1] Ormonde, MS., vol. i.

[2] Carte Papers, 165, 3.

[3] See Sir F. Hamilton's "History of the Grenadier Guards."

[4] Orrery's *State Letters*, p. 58.

[5] Mercurius Publicus, May 9 and 28, 1662. See also "M'Kinnon's "History of the Coldstream Guards," i. 109, *note*.

William Flower, who had the conduct of His Majesty's Regiment of Guards for Ireland, under the command of the Earl of Arran, arrived here with that regiment, in order to their transportation for Ireland," and on the 14th May, it was reported that "Sir William commenced to ship twelve companies in eleven ships at Weston." We are further informed that "during the march from London with this regiment, Sir William himself constantly marched with the men. Sir William Flower, my Lord Callan and other chief officers in the regiment were entertained by the Mayor at Chester." They reached Dublin safely before the end of May; and on the 28th of that month, the same journal announced that "the King's Regiment of Foot, under the command of the Earl of Arran, consisting of twelve companies, that came this week from England, marched this day, completely armed and clothed through the city, and are all quartered in and about it for the Guards."

The conception of the regiment being that of a body-guard for the person of the Lord Lieutenant as the representative of the King, it was not contemplated that the corps should serve, in time of peace at least, outside the capital. Accordingly, arrangements were at once made for quartering the soldiers in Dublin, and for this purpose communications passed between the Government and the City Corporations. Between the Court and the City the liveliest accord existed throughout Ormond's Viceroyalty, the Duke having, as one of his first acts, secured a payment of £500 a year from the exchequer to the Mayor in consideration of the loyalty of the city in the years following the Rebellion of 1641, and of the civic poverty resulting from the Civil wars, and having exerted himself to the utmost at the restoration for the protection and enlargement of the liberties of Dublin. And it was to Ormond's intervention that the dignity of Lord Mayor shortly afterwards conferred on the head of the Corporation, the royal gift of a collar of SS. and cap of maintenance, and other marks of royal favour, were directly due.[1]

The City Assembly was therefore prepared to comply with a loyal alacrity with the direction of the Viceroy to provide quarters for the Guards. On the 28th May the Lords Justices and the Council, by direction from the Lord Lieutenant, ordered the sheriffs of Dublin and seneschals of the Liberties "to provide lodging for the officers and soldiers of His Majesty's Regiment of Guards lately arrived out of

[1] Speech of Sir W. Davys, the Recorder, Dublin Corporation Records, iv. p., 679, and see vol. i., p. 42.

England, in inns, wine-taverns, ale-houses, or victualling houses.[1] The officers were likewise quartered on the city. On June 14th Ormond wrote to the Mayor, and sheriffs requiring them "forthwith to appoint convenient quarters as near the Castle of Dublin as may be for our son Richard Earl of Arran, Colonel of His Majesty's Regiment of Guards and his servants"[2]; and shortly afterwards provision was made by the city, pursuant to his Excellency's warrant for the quartering of the commissioned officers of the King's Regiment in the city and suburbs. Thenceforward and down to the Revolution, Dublin appears to have continuously remained the head-quarters of the Guards; and although the arrangements for their lodging appear to have involved some burthen on the city, the best relations seem, in general, to have been maintained between citizens and soldiery. The troops seem to have been quartered partly in the Castle, partly through the city, especially at the city gate-houses,[3] which, at that time, were still utilised for residential purposes, as appears from the complaint of one John Eastwood who had contracted to pay £4 per annum to the city for St. Nicholas' Gate, but represented that "the said gate was taken up from him by the soldiers, by special orders from the Lord Lieutenant, to his very great damage." The provision of fire and candlelight for the Guards were also constituted a charge upon the city, and assessments were annually made for this purpose on a warrant from the Viceroy, this being, in the language of a resolution of 1665, "required to be done by act of state and a business of public concernment to this city."[4] The amount of the assessment for this purpose was usually from £150 to £200 a year. The tax appears to have, in general, been readily contributed, though in June, 1667, one John Quelch, a freeman of the city and member of the Corporation, refused "in violation of his oath as freeman to pay his portion of the charge amounting to half-a-crown" as unlawful and unwarrantable.[5]

In addition to the occasional restiveness excited by the tax for their maintenance, the Guards appear to have provoked some unpopularity by their demeanour towards the citizens. In August, 1667, a petition was presented to the Lord Lieutenant by the City Council "for a redress against the several oppressions of the officers and soldiers on the inhabitants of the city under the pretence of quartering." This, however, was resented by the Colonel, Lord Arran, and the officers of

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[1] Carte Papers, 37, 228.
[2] Corporation Records, iv., p. 273. [3] *Ibid.*, p. 299.
[4] Dublin Corporation Records, iv., p. 347. [5] *Ibid.*, p. 435.

the regiment, who, in a counter-petition, demanded an inquiry into the matters complained of, averring their indignation at aspersions which they stigmatised as "a high reflection on the officers and soldiers of the said Guards, either in committing or suffering such oppressions to be committed by those under their command."[1] But in general the relations between soldiery and civilians were harmonious, and Dublin was proud of the regiment. In 1666[2] "his grace the Duke of Ormond, taking notice of the many buildings lately made on Oxmantown Green, which have taken up so much room there that His Majesty's Horse and Foot Guards and the City Militia have not conveniency to exercise as formerly," and "recommending the city to take present orders that the grounds upon St. Stephen's Green, lately walled in, be forthwith made fit for that purpose," the Assembly cheerfully ordered that the ground should be levelled and made smooth with that object. This was accordingly done, and thenceforth St. Stephen's Green became the parade-ground of the Guards. A review of the regiment on this ground twenty years later is described in Clarendon's State Letters.[3]

A further memorial of the connexion of the Irish Guards with Dublin is supplied in the records of two Dublin parishes. The regiment appears to have attended Divine service regularly every Friday, sometimes in St. Michael's and sometimes in St. Audoen's, and in 1671 Lord Arran contributed a sum of £150 towards the rebuilding of the latter church. In requital of his liberality it was ordered "that the arms and supporters of the said Earl of Arran be fairly presented and erected in the said church";[4] and further, that every commissioned officer of the Royal regiment, from the said Earl to the ensign, should henceforth enjoy all privileges and indemnities of parishioners in regard to marriage, christenings, and burials. The parish of St. Michael was less fortunate, when two years later it solicited a like contribution, notwithstanding that it was averred that "for several years past the several companies of the Royal regiment practised in this city have made use of the Church of St. Michael, but in all that time nothing hath been contributed towards the reparation of the said church or the seats thereof."

Mention has just been made of the City Militia, and some confusion might easily occur between the two bodies, which in the Assembly rolls

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[1] Dublin Corporation Records, iv., p. 423.
[2] *Ibid.* p. 383, 11th Aug. 1666.
[3] Clarendon's "State Letters," vol. i., 434, 8th June, 1686.
[4] Gilbert's "History of Dublin," i., 281.

are sometimes referred to indifferently as the Guards of the city. The two forces were, however, entirely distinct, and had no relation to each other, save in so far as each was in its degree responsible for the defence of the city. A militia, 24,000 strong, was raised to supplement the regular army; and in 1660 two foot regiments of city militia had been formed, one for service within the other without the city, the Mayor for the time being acting as Commander-in-Chief. The Mayor was likewise designated commander of a foot company through the good offices of Sir Theophilus Jones, the Scout-Master-General of the army, a distinction which was so much appreciated by the city dignitary that the city assembly voted a sum of £50 for a piece of plate to be presented to Lady Jones in recognition of her husband's exertions.[1] Some friction seems occasionally to have been provoked between the City Guards and the King's regiment. The author of "Ireland's Sad Lamentation"[2] imputes to the latter a slackness little creditable to the gallantry of the corps, alleging that the militia would not be suffered to guard within the city, the King's Guard being appointed to defend the same, and were obliged to serve outside the walls, "so that upon any attempt, our volunteer inhabitants might certainly have perished before the King's soldiery who receive pay had entered into any dangerous engagement." But this innuendo, with the rest of the publication in which it appeared, was declared by the city Assembly to be "a black and ugly libel."

Another force not to be confounded with his Majesty's Regiment of Guards was the Lord Lieutenant's Guard of Halbertiers or Battle Axes, which, during the reign of Charles II., from the opening of Ormond's Viceroyalty[3] in 1661 down to 1665, was maintained as part of the Military Establishment. This body which was known sometimes as the Company of Battle Axes, sometimes as the Guard of Halbertiers, consisted of a captain, lieutenant, two sergeants, and sixty men, dressed in buff coats, and was modelled on the Yeomen of the Guard.[4] The provision made at the Restoration for such a retinue to attend the Viceroy was in accordance with the ancient traditions of the Viceregal office, for as early as the reign of Henry VIII. when the Earl of Surrey came over as Deputy, one hundred Yeomen of the Guard were sent to Ireland with him to serve as his body-guard.[5] It

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[1] Dublin Corporation Records, iv., p. 221.

[2] "Ireland's Sad Lamentation," 1681. Dublin Corporation Records, v, Preface.

[3] Ormond Manuscripts, i., p. 406.

[4] "Sir W. Petty's Political Anatomy."

[5] Preston's "Yeomen of the Guard," p. 100.

would appear that in their uniform and accoutrements this Guard closely followed its English prototype.[1] On April 2, 1662, Colonel, afterwards Sir Daniel, Treswell, who was appointed to its command, received from Ormond a warrant for £275 4*s.* towards buying "64 buff coats and 64 belts at £4 6*s.* for each coat and belt for our guard of foot." The forces having been equipped in England came to Ireland in that year, and "for the more convenient performance of their duty"[2] were ordered to be quartered as near to Dublin Castle as possible. Treswell, their Colonel, who had come to Ireland in 1641 in command of a troop of horse, had "faithfully served his Majesty in honourable employment during the whole war in England and Ireland," in the course of which he had commanded the Lord Lieutenant's regiment of horse, and Ormond, loyal in prosperity to his friends in adversity, not only rewarded his fidelity with the command of his Battle-axes,[3] but procured him, in 1665, the honour of a baronetcy, and recommended him in the same year to the burgesses of Downpatrick by whom he was returned to Parliament.[4]

In addition to the city guard the Lord Mayor, in emulation of the Lord Lieutenant, seems also to have instituted a small body-guard of halbertiers; but it is not surprising to learn that this force, six in number, was "not found so useful as it was expected," and that it was in consequence ordered that as many of them as the Lord Mayor and sheriffs should think fit to be officers at mace should be so appointed, and discharged from their place of bearing halberts.

That his Majesty's Regiment of Guards was from the first intended to hold the highest place in the regimental roll in Ireland there can be no manner of doubt. When, during the Viceroyalty of Lord Clarendon, at the opening of the reign of James II., several of the officers of the Guards were displaced by Tyrconnel in pursuance of his programme to new-model the Irish army on a Roman Catholic basis, Major Billingsley, one of the displaced officers, in protesting against his removal, averred that "to be a Major of the Royal Regiment of Guards is better and more honourable than to be Lieutenant-Colonel of any other regiment."

[1] Carte Papers.

[2] Order for quartering the Battle-axes, Dec. 8, 1662, Ormond MS., Dublin Corporation Records, iv., p. 545.

[3] Hist. MSS. Com., 6th Rep., 14th Report, i. and ii.

[4] The following inscription appears upon a tomb in the chancel of the old church at Finglas, near Dublin:—"Heere under lyeth the body of Sir Daniel Treswell knight and baronett who faithfully served his Majesty in honourable employment during the whole war in England and Ireland and dyed the 24th day of May, 1670."

The prestige of the regiment derived *éclat* at the outset from the fact that the commission for the raising of the regiment was given to the Viceroy. The Duke of Ormond was not alone the King's representative and the General-in-Chief of the army in Ireland, but the first of his Irish subjects in rank, fame, and fortune. He had held the post of Lieutenant-General or Commander-in-Chief of the army formed by Strafford as far back as 1640. His association with the regiment would have been sufficient of itself to stamp the corps with peculiar distinction; and Ormond was careful to secure that its honour should undergo no diminution in the persons of its officers, who were selected largely from the ranks of the Irish nobility, and included several who had followed his fortunes through the whole course of the civil war and foreign exile.

Unable himself, with the multifarious duties of the Viceroyalty, to assume the direct command, Ormond asserted in the most marked way his personal interest in the fortunes of the regiment by nominating to the Colonelcy his second son Richard, Earl of Arran, a nobleman, who, if less distinguished than his gifted brother, Lord Ossory, was yet a man of considerable ability, who, on more than one occasion during Ormond's absence in England, filled the office of Lord Deputy. Arran gave proofs of considerable military capacity in command of his regiment, first in suppressing a formidable mutiny of the soldiers of other regiments at Carrickfergus, in 1666, and later, in 1673, by his distinguished conduct under the Duke of York, in the sea-fight with the Dutch in that year, in which, after the manner of those days, the Guards took a part serving on board ship.[1] For his services on this occasion, Arran was rewarded with an English peerage. "No man," says Carte, "was more active, more eager, and more intrepid in danger." During his tenure of the office of Deputy in 1684, he exhibited great personal gallantry in dealing with a very serious fire in Dublin Castle, by which a great part of the castle buildings was destroyed.[2] An address of congratulation was presented on this occasion by the citizens of Dublin, in which Arran's energy is eulogised in glowing terms: "By your Excellency's presence of mind, care, and conduct, in the midst of the devouring flames which encompassed you, not only the remaining part of the buildings of the Castle, but the great magazine of powder to which the fire had within a few steps approached, was wonderfully preserved, and the ancient records of this Kingdom, then also in the Castle, rescued from those

[1] Carte's "Ormonde," ii., 544. [2] Dublin Corporation Records, v., p. 312.

flames." On Lord Arran's premature death, early in 1786, shortly after his father had been recalled from the Irish Government by James II., the direct association of the Ormond family with the Guards was maintained by the bestowal of the command of the regiment on Lord Ossory, son of the distinguished soldier-statesman of that name and afterwards second Duke of Ormond, a selection which, as the new Viceroy, Clarendon, reported to Sunderland, gave as lively a satisfaction in Ireland as could be imagined.[1]

At the time of his original appointment, Lord Arran was too junior to have acquired the military knowledge necessary in the commander of the regiment in the field; and for the Lieutenant-Colonelcy Ormond selected, as we have seen, Sir William Flower, an officer who was well qualified by his experience to undertake the effective control of the newly enrolled corps.[2] Flower, whose father had come to Ireland towards the close of Queen Elizabeth's reign, and had served in James the First's time as Governor of Waterford, had been one of Ormond's officers in the troubled years that followed the rebellion. As early as 1641, he had held a Captain's commission in Ormond's own regiment of foot, which had its quarters in Christchurch yard, and had formed part of the garrison of Dublin down to 1648; and he had risen to its command. He had suffered imprisonment at the hands of the Parliamentary party on Ormond's departure from Ireland in 1648. At the Restoration, he was at once raised to eminence by his old patron, becoming a member of the Privy Council, with a seat in the Irish Parliament as member for St. Canice, and being appointed one of the trustees for satisfying the arrears of the '49 officers. He received considerable grants of land; and his son extending the family influence by a matrimonial alliance with the daughter of Sir John Temple, the family became important enough to win, in the person of Sir William Flower's grandson, the peerage of Castle Durrow, a rank which, in the generation following, was merged in the still existing dignity of the Viscounty of Ashbrook.[3]

The other officers appointed to the command of companies at the institution of the regiment were likewise persons of distinction. The King's Company was given to Sir Nicholas Armorer, who had acted

[1] "Clarendon Correspondence," i., 229.

[2] Archdall's "Lodge's Peerage," vol. v., p. 283.

[3] There is good reason to suspect that during the eclipse of the royalist fortunes Flower, like not a few of Ormond's Irish adherents, was among those who conformed to the government of Commonwealth, and to have held a command in Fleetwood's Regiment. See the Leyburne-Popham Papers, Hist. MSS. Commissioners Report, p. 153.

as equerry to the King in exile, and was a close friend of the Duke of Ormond, by whose influence he was returned to Parliament for County Wicklow, and appointed Governor of Cork.[1] Sir John Stephens, who, like Sir William Flower, had held a commission in Ormond's old regiment as far back as 1643, and who, after the Restoration, represented Fethard in the Irish Parliament—who had married a sister of Flower's, and held the office of Governor of Dublin Castle —was appointed Major; and the other officers included Lord Callan, afterwards the third Earl of Denbigh, Lord John Butler, Ormond's youngest son, and Colonel Francis Willoughby, well known in the ten years' warfare in Ireland, from 1641 to 1651. It is thus evident that the note of pre-eminence and distinction which has ever been associated with the Guards in England was characteristic of the Irish regiment from the date of its institution.

A corps, whose sphere of service was restricted in time of peace to the capital, and which even in war was only likely to be actively employed in circumstances of emergency, was naturally deprived for some years of many opportunities of distinguishing itself, and it is not very easy to recall the record of the regiment in the first few years of its existence. Its earliest active service appears to have been in suppressing the mutiny at Carrickfergus in 1666 already noted,[2] but down to 1673, such mention of it as we find is chiefly in connection with ceremonial display. On the occasion of the Duke of Ormond's state entry into Dublin, in 1665, a pageant of unusual magnificence, the regiment formed the guard of honour, from St. James's Gate to the Castle, the King's Company being in close attendance on the Viceroy, and following immediately the Guard of Battle-axes. In 1672, they were ordered for service with the fleet on the outbreak of

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[1] Cholmondeley Papers, Hist. MSS. Com., 5th Rep.

[2] The following reference of the services by the Guards on this occasion is taken from McSkimmin's "History of Carrickfergus," pp. 18, 19 :—

"1666, about the beginning of May, the garrison, consisting of about 200 men, mutinied for want of their pay, and, choosing corporal Dillon for their commander, seized the town and castle. On the 25th of the same month, the Earl of Arran, son to the Duke of Ormond, arrived by sea in the Dartmouth frigate, with four companies of Guards, and he assaulting the town by sea, and Sir William Flower by land, the mutineers were forced to retreat into the castle, with the loss of Dillon their commander, and two others. The Earl also lost two soldiers. Next day the Duke of Ormond arrived from Dublin with the Horse Guards, and the mutineers surrendered at discretion. The corporation (of Carrickfergus) received thanks from the Government for their loyalty on this occasion, and gave a splendid entertainment to the Earl of Arran."

the Dutch War, and two companies, of which Lord Arran's was one, were sent to Chester, and appear to have taken part in the action at Solebay.[1]

The military annals of the Restoration still remain very scrappy and imperfect; and even the achievements of the British Guards, have been insufficiently recorded. Little or nothing is known of the career of the Irish Guards from 1675 to 1685, when, as already mentioned, the colonelcy passed to the young Lord Ossory on the death of his uncle Lord Arran, although very full lists of its officers for several years of this obscure decade are still extant. The changes in the regiment within this period do not seem to have been many; the most important being the appointment of Sir Charles Fielding—a member of the ancient family of which the Earl of Denbigh is the head—to be Lieutenant-Colonel on the death, in 1680, of Sir William Flower. The Guards appear, however, to have been maintained in vigorous efficiency. On April 23, 1685, Major Billingsley reported to his Colonel, that he "drew out the Regiment to solemnise the coronation, which was performed after the usual way on state days."[2] Lord Clarendon, who superseded Ormond in the Irish Government in 1685, reported very favourably of their appearance in a letter to James II.:—"The other day," he wrote, "I saw your Majesty's Regiment of Guards drawn out; and though I am no soldier, yet I may assure your Majesty they exercise and perform all their duty as well as your Guards in England can do. If they had the honour to be in your presence you would have no cause to be ashamed of them."[3]

But the regiment was now about to become involved in those far-reaching changes which shortly after the accession of James II. became so universal in every department of the public service, and were ere long to lead to such startling results. The King resolved on a drastic reform of the *personnel* of the army, and Tyrconnel came to Ireland to superintend and carry out the changes which had been resolved upon. This is not the occasion on which to discuss the policy of James the Second's dealing with his Irish forces prior to the events which obliged him to rely upon their services in his unsuccessful effort to retain his Crown. It must suffice here to observe, that under Tyrconnel's direction a sweeping reform was rapidly and even violently

[1] Sir F. Hamilton's "History of the Grenadier Guards," vol. i., p. 163.

[2] Ormonde MS.

[3] "Clarendon Correspondence," i. 231.

carried out. The process may be traced in the correspondence of Lord Clarendon, who, though unquestionably loyal to his Sovereign, was alarmed at the vehemence of the subordinate who was so shortly to be his successor. Clarendon's letters, written during the period of his Viceroyalty, shed a flood of clear light on events in Ireland in the years immediately preceding the Revolution. Though of liberal opinions on the Roman Catholic question, he was, despite his close family connexion with King James, far from endorsing every item in the policy of his royal master, disliking the rapidity and violence with which changes were introduced into the system of government he was administering, and particularly resenting the interference of Tyrconnel, who, as Lieutenant-General of the army in Ireland, exercised plenary powers independently of the Viceroy. His letters, descriptive of Tyrconnel's proceedings, contain several references to the Guards. [1] In letter after letter he represented to James and to his ministers his disapproval of proceedings which, apart from their unfortunate effect in alienating a large section of the Irish population, he considered injurious to the efficiency of the army in Ireland, and especially to the Regiment of Guards.

Pursuant, however, to the commands of the king who, as he told Clarendon, was "resolved to employ his subjects of the Roman Catholic religion," and "not to keep one man in his service who ever served under the usurpers,"[2] Tyrconnel proceeded to put out of the regiment such of the officers as were unlikely to lend themselves to the new order of things, and at the same time to make large changes in the *personnel* of the rank and file. The true reasons for these alterations were not of course publicly avowed, the ostensible reason being that, in the language of Tyrconnel, "the Scotch battalion, which is newly come into England, has undone us; the King is so pleased with it that he will have all his forces in the same posture. We have here a great many old men, and of different statures: [3] they must be all turned out, for the King would have all his men young and of one size"; this, however, was only a pretext, for, according to Clarendon, the new men were "full as little" as those who were turned out.

On June 8th the Guards were reviewed in St. Stephen's Green by Tyrconnel, who owned to Clarendon that "it was a much better regiment than he could have imagined, and that the men did their exercises

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[1] Clarendon State Papers, i. 433, *et seq.* [2] *Ibid.*, i., p. 431.
[3] *Ibid.*, i., p. 468.

as well as any regiment in England";[1] but this did not prevent Tyrconnel from proceeding with his reforms. The new officers were commissioned and presented to the regiment on parade. Sir Charles Fielding, who had served with the regiment from its formation and risen from ensign to be lieutenant-colonel, was superseded in his command—the King, as Tyrconnel put it, "being so well satisfied in the long services of Sir Charles Fielding that he had removed him to prefer him to a better post";[2] and Sir William Dorrington, a native of England and the youngest major in the army, whose subsequent career evinced considerable military ability, but who was a complete stranger to his new command, was appointed in his place.[3] Other old officers of long standing in the regiment, such as Major Billingsley and Captain Margetson,[4] a son of the Irish Primate, were likewise suspended. The changes among the officers were followed by the dismissal of 500 men, at least 350 of whom, according to Clarendon, were "able and lusty men," and a credit to the regiment. The hardship of their dismissal was aggravated by the fact that they had just bought fresh uniforms by direction of their colonel, the young Duke of Ormond, and were not reimbursed for their expenditure. To fill the places of these men, Dorrington received orders to recruit in such counties as he thought fit; and accordingly despatched Arthur,[5] one of his captains, to Connaught to raise men for the Guards—a proceeding much resented by Clarendon, who forbade Dorrington to proceed in it.

So violent an exercise of authority inevitably excited alarm. "All men,"[6] wrote Clarendon, "who have any consideration and care of the King's service are extremely troubled at the method which is taken of doing things. To turn out, in one day, 400 men of the Regiment of Guards, 300 of whom have no visible fault, and many of them cheerfully went the last year first into the north and afterwards into England, does put apprehensions into men's heads which they would otherwise have no cause for, and putting in none but natives in their rooms, who really to the eye, as to stature and

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[1] Clarendon State Papers, i., p. 440.

[2] *Ibid.*, i., p. 434.

[3] *Ibid.*, ii., p. 45. There is no authority for D'Alton's statement, followed by O'Callaghan, that Dorrington was connected with the regiment from its formation. His name does not appear in any of the early lists of officers.

[4] *Ibid.*, i., p. 435.

[5] *Ibid.*, i., p. 578.

[6] *Ibid.*, i., p. 476, July 4, 1686.

ability, makes worse figures than those that are put out, confirms their jealous apprehensions."[1] But though the composition of the corps was largely altered, and the principal positions confided to officers of Tyrconnel's way of thinking, there does not appear to have been any general surrender of commissions by the old officers who escaped immediate dismissal, and these appear to have remained in the regiment down to the landing of William III. at Torbay, when, with their Colonel, Lord Ossory, they embraced the cause of the Prince of Orange.

From the sweeping changes inaugurated by Tyrconnel, it resulted that, notwithstanding that the Colonel, Lord Ossory, who, in 1688, succeeded to the Dukedom of Ormond, and had been left undisturbed in his nominal command, went over to William III. as soon as he landed at Torbay, the regiment took part with James II. in his struggle for the Crown of the Three Kingdoms, though in numbers considerably short of its proper strength. The colonelcy was then given to Dorrington, under whose command the Guards took part in the siege of Derry, and subsequently were present at the Boyne and Aughrim. In the latter battle Dorrington was taken prisoner, and Barker, who had been appointed Lieutenant-Colonel, was killed; and it does not appear under what officers the last services of the Irish Guards on Irish soil were rendered at the defence of Limerick. After the capitulation of that city the Royal Regiment of Guards was the foremost of those which made choice of the cause of King James and exile, and in that dramatic scene, so powerfully painted for us by Macaulay, when the garrison of Limerick was ordered to pass in review before the rival commanders, Ginkell and Sarsfield, and those who wished to remain in the Ireland of King William were directed to file off at a particular spot, all but seven of the Guards, marching fourteen hundred strong, went beyond the fatal point and embraced the alternative of exile. Not all of these, however, adhered to their resolution, and only five hundred appear to have been included in the thousands, who, in the language of the historian, "departed to learn in foreign camps that discipline without which natural courage is of small avail, and to retrieve, on distant fields of battle, the honour which had been lost by a long series of defeats at home."[2]

Reference has been made above to the fact that the career of the Irish Guards was not closed with the defeat of the cause with which

[1] Clarendon State Papers, i., p. 485, July 6.
[2] Macaulay's *History of England*, chap. xvii.

their last years in Ireland were identified. After 1690, indeed, they disappeared from the roll of the regiments in the service of the British Crown, and it is hardly surprising that William III. made no attempt to revive a corps which had fought for his opponent. But though exiled to France for above one hundred years, the identity of the regiment was never completely lost. It still continued to be recruited abroad from the "wild geese" who flocked in a continuous stream from Ireland to the Continent through the course of the eighteenth century. Under the leadership of Dorrington it served with distinction at Loudon and Charleroy, and though broken up in 1698, after the Peace of Ryswick, when it ceased to retain its old title, it was substantially re-embodied under its old chief, and was known until his death, in 1718, as the Dorrington Regiment.

The regiment continued during this period, by desire of King James II., to retain the uniform and colours it had worn in the British Service.[1] Thenceforward it was distinguished by the names of its successive Colonels, Counts Michael de Roth and Edward de Roth, Robert Dillon, Lord Roscommon, and Count Antoine Walsh de Serrant, all of them representatives of old Irish families, and all of them soldiers of capacity. In the Marlborough wars, the regiment served with the army of Flanders, and was present at Malplaquet under Count Michael de Roth; it served with the Duke of Berwick in Spain, and during the colonelcy of his son took part in the battles of Dettingen and Fontenoy. Finally under Count Walsh

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[1] See on this point, "*Historique du 87e Régiment d'Infanterie de Ligne, 1690–1892.*" *Par Capitaine Mallaguti. Paris, 1892,* from which the following extracts are taken:—

"Il semble que, dès cette époque (1698), les regiments Orlandais et suisses etaient distingués par l'habit rouge garance ; tandis que toute l'infanterie francaise portait l'habit gris-blanc," p. 16.

"*Notes sur l'uniforme du Regiment de Dillon de 1690 a 1791.*"—"Nous n'avons pu trouver aucun renseignement sur l'uniforme de Dillon pendant les quarante premières annees de son sé our en France. Le premier ouvrage qui nous ait furni une donnée précise est la Carte abrégée du militaire de la France (de Leman de la Jaise) qui, pour les années 1730 et 1733 attribué à Dillon : habit rouge et parements bleus," p. 75. The "habit rouge-garance" was worn continuously to 1791 by all the Irish regiments in the French service. The facings varied in colour, and in the case of the Irish Guards were of St. Patrick's blue. A representation of the uniforms of the French army in 1772 shows the Guards or Roscommon Regiment, as it was then called, to have worn a red coat or tunic with blue facings, buff breeches, white Hessian boots, and a plumed helmet.

The colours of the Regiment at this time showed a white cross on a ground of St. Patrick's blue.

de Serrant the regiment maintained its old traditions down to the Revolution, when it merged in the 92nd Regiment of the Army of France. But its officers were still, for the most part, Irishmen, and on the fall of the Bourbons, it was natural that the representatives of a traditional loyalty to hereditary right should prefer the Fleur-de-lys to the Tricolor. The successors of those who had refused to concur in the English Revolution were too proud of their consistent loyalty to be content to accept the French one. Almost without exception its officers followed their Colonel, Count Walsh, in his refusal to serve under the banner of the Republic, and were among those who, in 1794, accepted with alacrity the invitation conveyed to the Colonels of the three surviving regiments of Dillon, Berwick, and Walsh by the Duke of Portland, to take service under the British Crown under the title of the Irish Brigade.[1] It was intended that the regiment should be placed upon the Irish Establishment, and be recruited exclusively in Ireland for service abroad; and its officers came over to raise a fresh corps in Ireland. But the times were out of joint for such an enterprise. The emigrant officers found Ireland in a turmoil of agitation, which had much more in common with the France of the Revolution than with that of the *ancien régime*, and their efforts were almost entirely unsuccessful. The Rebellion of 1798 quickly following, put a final end to whatever hopes might have previously been entertained, by filling the English Government with misgivings as to the use to which an Irish Catholic Brigade might possibly be turned in spite of the unquestioned loyalty of its leaders. Recruits being forthcoming in quite insufficient numbers, it was found necessary to amalgamate the regiments forming the Brigade, with the result that no place remained for many of the returned officers. Weak and insufficient in numbers the corps was sent to North America and the West Indies, but it was found impossible to maintain the Brigade as an independent organization, and within a few years it had ceased to exist.

This last chapter in the history of the regiment is a sad one. Making every allowance for the exacerbation of feeling at the time, the treatment accorded to the returned officers was little creditable to Irishmen of any shade of opinion; whilst the conduct of the War Office in regard to their pay and allowances was equally deserving of disapproval. Wolfe Tone, in his Journal for 1796, describes how the officers intending to go to Mass on Christmas Day in full uniform were obliged to give up the idea for fear of being hustled by the populace

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[1] See note added in the Press.

of Dublin. On the other hand, the Duke of Fitz James, the descendent of the great soldier Berwick, and the principal personage among those to whom the invitation to join the British army had been addressed, was insulted by some observations from Lord Blaney in the Irish House of Lords, and fought a duel with that nobleman in the Phœnix Park in assertion of the honour of his *confrères.*[1] The unemployed officers were treated with so little consideration by the military authorities that some of them were reduced to a half-starving condition, and had to wait several years for arrears of pay: while the Colonels on the final disbandment of the Brigade were refused the rank as half-pay officers for which they had stipulated when entering the British service. Thus the final chapter in a story that had extended over a space of above one hundred and thirty years was one of misfortune and even humiliation. But none the less the record of the Irish Guards, from their formation in 1662 to the final dispersal of the last remnant of the regiment, is one in every respect creditable to the martial traditions of Ireland; and rooted in the history of its country, whether as Jacobite or Williamite, as loyalist or rebel, as fighting for or against the Crown to which it owed its origin, its career is one in which were exhibited at every stage the stainless honour of Irish gentlemen, and the indomitable valour of the Irish race.

NOTE ADDED IN THE PRESS.

Mr. Lecky, in his "*History of England in the Eighteenth Century,*" vol. vii., p. 254, gives some account of that final chapter in the history of the Irish Brigade, to which O'Callaghan in his otherwise exhaustive narrative gives but scant attention. Reference is also made to the episode in Mrs. M. A. O'Connell's *Last Colonel of the Irish Brigade*. But much the fullest authority for the later history of the Irish Guards is to be found in a volume entitled: "*Une Famille Royaliste, Irlandaise et Francaise, et Le Prince Charles-Edouard,*" privately printed at Nantes in 1901 by the Duc de la Trémoïlle. In this work several documents relating to the regiment under the Colonelcy of Antoine Count Walsh de Serrant are reproduced. From it are extracted the documents following, viz.: the letter of the Duke of Portland above referred to, and the

[1] Annual Register, 1797.

Commission of George III. to the Comte de Serrant as a Colonel of Infantry in the Irish Brigade :—

Letter of the Duke of Portland to Count Walsh de Serrant.

À Whitehall, ce 30 *Sept.* 1794.

Monsieur,

Le Roi desirant remplir les intentions de la legislature d'Irlande, et de douner à ses sujets catholiques de ce royaume, un prompte témoinage de son affection et de sa confiance, s'est déterminé à rétablir le corps connû cy devant sous le nom de la brigade Irlandaise, et comme vous etiez colonel d'un des regiments dont elle etoit composée, Sa Majesté m'a donné l'ordre de vous offiir dans ce nouveau corps le même rang de colonel que vous teniez dans l'ancien.

L'intention de Sa Majesté est, que cette brigade soit maintenant composée de quatre regiments, le commandement de trois desquels, elle m'a ordonné d'offirir aux colonels (ou à leurs representans) qui out commandé les trois corps qui composoient la brigade, lorsqu'elle étoit au service de sa Majesté trés chretienne, et eclui du quatriême à Monsieur O'Connell, cy devant officier général au service de France, et certainement bien connu de vous et de tous les gentilshommes irlandois qui out servi dans ce corps.

Il a aussi pler à Sa Majesté de déterminer que tous les officiers, tant de l'état-major que les autres, excepté vous, Monsieur le comte et Monsieur le duc de Fitz James, seront pris d'entre ceux de ses sujets qui sont nés en Irlande, et qui se seront distingués par leurs services, dans les mêmes grades dans la brigade, et que si l'on manque d'officiers (comme il y a toute apparance) pour remplir les grades infèrieurs, on les choisisse dans les familles des gentilshommes de la même réligion dout la demeure à toujours été en Irlânde.

L'intention de Sa Majesté est de plus, que cetté brigade soit mise, du moment qu'elle sera complette, sur l'état militaire de ce royaume, ou de celui d'Irlande, en sorte que, dès ce moment là, les officiers qui y tiendront des places, prendront rang avec les autrés officiers des armées de Sa Majesté, et en cas que le corps soit reformé, ils auront droit â la dernière paye.

Sa Majesté recevra aussi la récommendation des colonels dans le choix des officiers, et cela surtout, quand ces recommendations seront faites en faveur de ceux qui ont servi cy devant dans la brigade irlandoise. Mais elle ne permettra pas, qu'aucune considération pécunière soit donnée pour obtenir aucun rang dans ce corps; et en consequence, comme il n'aura éte permis à ancun officier de quelque rang qu'il soit, de rien payer pour sa place, il doit comprendre clairement, que sous aucun prétexte il ne lui sera permis de la vendre.

Sa Majesté m'a commandé aussi de vous informer qu'elle est déterminer a ce que ce corps soit spècialement affecté au services des colonies de Sa Majesté dans les Autilles, ou dans telle autre possession de Sa Majesté, hors de ces deux royaumes de la grande Bretagne et de Irlande, qu'il lui plaira de les employer; et que Sa Majesté d'attendra à ce que tout officier de quelque rang qu'il soit, qui a l'honneur d'avoir un brevet dans ces corps, de tiendra comme indispensablement obligé de venir avec son regiment dans quelque partie de monde que se soit.

Sans entrez dans de plus grand détails sur se sujet, j'ajontérai seulement, à l'occasion de votre qualité de colonel proprietaire d'un des régiments de l'ancienne brigade irlandaise, qu'il est très essentiel que je vous rappelle, Monsieur le Comte, que la constitution de ce pays-ci n'admet n'aucune proprieté semblable, attendû comme vous devez vous le rappeler, que les fonds pour l'établissement militaire ne sont accordé que pour l'année, et que par conséquent il ne peut avoir qu'une existence annuelle.

Capendant, quoique place ne vous soit confiée par la législature que pour un an, ou doit en considérer la possession comme vous étant assurée, durant votre bonne conduite, terme que je ne juis regarder de moindre durée que celui de votre vie.

Je vous ai maintenant exposé toutes les circumstances qui m'ont paru nécessaires pour vous aider à déterminer si vous devez accepter les offres gracieuses de Sa Majesté ; je n'ai qu'ajouter, que, si après mûre considération, il vous parait plus convenable de ne pas vous en prévaloir, la bonté naturelle de Sa Majesté la disposera à interpreter les motifs qui vous auront déterminé, de la manière la plus favorable pour vous ; et je juis même voux assurer, que dans le cas même où vous accepteriez la proposition que je suis chargé de vous faire, et que la guerre finie, ou même pendant sa durée, vous avez l'avis, de quitter le service de Sa Majesté, et de reutrer à celui de Sa Majesté très Chrétienne, que vous trouverez le Roi disposé de même de vous accorder votre congé, et de considérer cette mesure avec sa bonté accouturmée.

Je ne scaurois douter, que vous n'avez la bonté d'informer les officiers de la brigade, qui out eu l'honneur de servir sous vos ordres, des intentions du Roi, à leur égard, selon la forme et les conditions que je vous ai specifié cy-dessus ; et que je vous vondrez bien aussi leur recommander, le peutôt possible, à quelque endroit convenable d'où il pourront le plus commodément se rendre en Irlande, et se mettre en état de remplir les devoirs qui leur seront consignés de la part da Roi.

Je n'ai pas besoin de vous dire, que dans le cas, où vous vous décideriez à accepter la proposition que Sa Majesté m'a autorisé à vous faire, il n'y aura pas un moment à perdre pour vous rendre ici, à in de règler tout ce qui à rapport à la levée des corps, le plus promptement possible.

Il ne me reste qu'à vous prier assuré, que je m'estime très heureux d'avoir été autorisé à vous donner ce témoignage, non équivoque, de la bonne opinion et l'estime de Sa Majesté.

J'ai l'honneur d'être, Monsieur le Comte, votre très humble et tres obeissant serviteur.

PORTLAND.

Palais de st. James. 1er, 1794. Brevet de colonel d'infanterie (dans la brigade irlandaise) pour Antoine Walsh, Comte de Serrant, au nom du Roi Georges III. sous la signature de lord Portland.

George the Third, by the Grace of God, King of Great Britain, France, and Ireland, Defender of the Faith, etc., to our trusty and well beloved Antony, Count Walsh de Serrant, greeting: We reposing especial trust and confidence in your loyalty, courage, and good conduct, do by their presents constitute and appoint you to be Colonel of a Regiment of Foot, forming part of the corps known by the name of the Irish Brigade, and likewise to be a Captain of a company in our said regiment. You are therefore to take our said regiment as Colonel, and the said company as Captain into your care and charge, and duly to exercise as well the officers as soldiers thereof in arms, and to use your best endeavours to keep them in good order and discipline: and we do hereby command them to obey you as their Colonel and Captain respectively; and you are to observe and follow such orders and directions from time to time as you shall receive from us, or any other your superior officers, according to the rules and discipline of war, in pursuance of the trust we hereby repose in you.

Given at our Court at St. James's, the first day of October, 1794, in the thirty-fourth year of our reign,

By His Majesty's command,

PORTLAND.

ANTHONY COUNT WALSH DE SERRANT,
Colonel of a Regiment of Foot.

[The authorities on which this Paper is based are for the most part indicated in the foot-notes, or in the body of the text. The writer has also derived assistance from articles on the subject in the *Nineteenth Century*, for June, 1900, and in the *Household Brigade Magazine*, for the same year, contributed respectively by the late Fitzalan Manners, and by Lt.-Col. R. Holden, Secretary of the United Service Institute. In addition the writer desires to express his obligations to Major-General Sir Martin Dillon, K.C.B., and to Mr. V. Hussey Walsh, for much valuable information; to Mr. F. Elrington Ball, M.R.I.A., for transcripts of documents in the Carte Papers at the Bodleian Library; to Dr. W. J. O'Donnavan, M.R.I.A., for references to general useful authorities; and to the officials of the Irish Record Office who have assisted his searches with their usual courtesy and helpfulness.—C.L.F.]

[1] "Une Famille Royaliste," Appendix, p. 95.

III.

SCARABS IN THE DUBLIN MUSEUM.

By MISS M. A. MURRAY, F.S.A. Scot.

[COMMUNICATED BY COL. G. T. PLUNKETT, C.B.]

[Read April 14th, 1902.]

The Dublin Museum contains, among many other interesting Egyptian antiquities, a fairly representative collection of "scarabs," those little beetles made of stone or faïence, which were held in high estimation by the ancient dwellers on the Nile. The living scarabæus beetle was the symbol of the god Khepra, the Creator, and was also emblematic of the Resurrection; its effigy is therefore appropriately deposited in the tomb as the symbol of life hereafter and as placing the dead body under the direct protection of its Maker. This, however, accounts only for the scarabs found with the dead, and gives no clue to their use among the living. All scarabs, whether for the living or for the dead (with the exception of the so-called heart-scarabs which had a special purpose), are pierced as if for threading, or for setting on a swivel as the bezil of a ring, and are plainly intended for a more definite use than mere ornament.

The underside of the scarab is flat, and this little oval space is inscribed, the interest and value of the scarab depending entirely upon the inscription. The reason for this use of the scarab has never been explained, nor, as I said before, has the real use of scarabs themselves ever been satisfactorily demonstrated. The generally-accepted theory is that some were seals and some were charms, and this though not altogether satisfactory, serves as a convenient foundation for classification.

The meaning of the signs in the inscriptions is one of the chief difficulties in the study of scarabs. Take, for instance, the very common hieroglyph Neb, Lord, which appears continually on scarabs. It is impossible to say whether it is inserted merely as being of a convenient shape to fill the curved ends of the oval, or as a semi-sacred word, and therefore appropriate on a protective amulet. The latter reason would account for the constant use of other semi-sacred signs, such as Nub, Gold, which convey no special meaning to us, and which by their shape cannot have been inserted as purely decorative designs to fill an otherwise empty space. Unfortunately the amulitic scarabs have never been studied thoroughly and scientifically, and our knowledge on that subject is still very limited.

Scarabs may be divided into nine classes:

I. Kings' names.
II. Names of private persons.
III. Records of events.
IV. Titles, royal or priestly.
V. Names of gods.
VI. Sacred signs.
VII. Charms expressed in words.
VIII. Sacred animals.
IX. Decorative designs.

I. Of royal names there are fourteen in this collection. The earliest is Nub-hetep (No. 1) of the XVIth dynasty. The dark-brown of this scarab was not its original colour. It was once green, but the greens and blues of copper, with which scarabs are glazed, are fugitive under certain conditions, and the green changes to brown while the blue fades to white. It is very tempting to place No. 52 in the Vth dynasty, as the scarab of King An.[1] The name An is written with a fish, but, as Professor Petrie pointed out to me, in this case the lotus-design is distinctly of the XIXth dynasty (compare the lotus in the scarab of Rameses II., No. 11). This scarab, therefore, falls under class VIII., and must be considered there. The scarabs of Menkheper-Ra (Thothmes III. of the XVIIIth dynasty) are the most numerous of all royal names. There are several varieties in this collection. No. 2 has the king's cartouche upheld by two kneeling figures, emblematic of the Upper and Lower Nile, symbolising the king's sovereignty over the Two Lands, *i.e.* North and South Egypt. No. 3 has the royal name flanked on each side by a degenerate form of the crown of Lower Egypt repeated four times. The crown of Lower Egypt, the Red Crown, appears to have had some peculiarly symbolic meaning, as it is constantly found on scarabs. No. 4 shows the king as a sphinx, beneath whom is the prostrate figure of an enemy. No. 5, a very

[1] *Vide* "Petrie's Historical Scarabs."

worn scarab of this king, with a rude representation on each side of the crown of Lower Egypt. No. 6 is a square plaque engraved on both sides; obverse, the royal cartouche, flanked by serpents, wearing respectively the crowns of Upper and Lower Egypt, symbolising, as in the case of the two Niles, the sovereignty of the king over the two parts of Egypt. On the reverse, is the king as the sphinx, wearing the double crown; behind him the serpent, emblem of power, and the winged disk, emblem of protection; beneath is the sign Neb, Lord. No. 7 has merely the king's title, followed by the epithet "Chosen of Ra."

No. 8 is the throne-name of Thothmes IV., Menkheperu-Ra, finished with the Neb sign below.

No. 9 is doubtful, though it may possibly be Neb-maat-Ra, the throne-name of Amenhetep III. The throne-name was assumed by the king when he actually succeeded to the crown. It is always compounded with the name Ra, showing the king's descent from the sun-god Ra. The throne-name is the one generally used on scarabs, though the personal name is occasionally found.

No. 10 belongs to a very curious class of scarab which, as Professor Petrie has shown, contain the names of two kings. In some scarabs—unfortunately this collection has no specimen of the kind—the hieroglyphs are so arranged that one sign will do duty in both names. In this scarab the names are Thothmes III. of the XVIIIth dynasty, and Sety I. of the XIXth dynasty, two kings separated by a space of more than a hundred years. Obverse, the throne-name of Sety I., Men-maat-Ra, associated with the crown of Lower Egypt, a couchant lion, and the Neb sign. Reverse, the throne-name of Thothmes III., Men-kheper-Ra, the crown of Lower Egypt, the hieroglyphic titles of the king of Upper and Lower Egypt, the sign Nefer (good luck or happiness), and the Neb-sign. It is interesting to observe that in this specimen the bee, the hieroglyph for the king of Lower Egypt, is much larger than the hieroglyph for the parallel title of the king of Upper Egypt. This, taken in conjunction with the constant occurrence of the crown of Lower Egypt, would seem to show that the title has a specially symbolic significance. Another explanation is that these scarabs were made in Lower Egypt. In all other places, except on scarabs, the dominion of Upper Egypt takes precedence over Lower Egypt, so much so that it it is a generally received opinion that the king of Upper Egypt conquered Lower Egypt and added the title to the one he already possessed.

No. 11 is the throne-name of Rameses II., User-Maat-Ra, of the

XIXth dynasty, surmounted by a design of lotus flowers and buds. Next to Thothmes III., this king's scarabs are the most common.

No. 12, Ba-en-Ra, Merenptah, son and successor of Rameses II. This king is usually supposed to be the Pharaoh of the Exodus. No. 13 is of an obscure king, Se-Amen, of whom little is known but the name.

No. 14, the last of the royal scarabs in this collection, is that of Shishak II., Kheper-sekhem-Ra, abbreviated to Kheper-Ra, and surrounded by a conventional cord border. This Shishak was the descendant and successor of Shishak I. who defeated Rehoboam and spoiled the temple of its golden shields. Nos. 15 and 16 are doubtful. They may be royal, but I think that they belong to the next class.

II. Besides these there are only two private-name scarabs in this collection.

No. 17, Mentu-sa.

No. 18, son of the sun, ? Nefer-Maat.

III. The extremely interesting series of scarabs, apparently struck like medals to commemorate some great event, are unfortunately quite unrepresented here. In Professor Petrie's collection there are several specimens of Thothmes III. They are all of the same type—the king's name in a cartouche, followed by the record of the event, *e.g.* born in Thebes, crowned in Thebes, and so on. The great scarabs of Amenhetep III., recording his hunting and lake-making exploits as well as his marriage, are too well known to need description.

IV. This class of scarab presents many difficulties, and it is almost impossible to say anything about them. They may have been seals of office, but some are probably amulitic.

No. 19, of the VIth dynasty, shows the bee of Lower Egypt, and a quadruped of uncertain character.

No. 20. The royal title Sa Ra (Son of the Sun), the unoccupied space being filled with a lotus flower.

No. 21. Hieroglyphs giving the ordinary title of the sovereign, King of Upper and Lower Egypt.

No. 22. The King as Lord of the Two Lands.

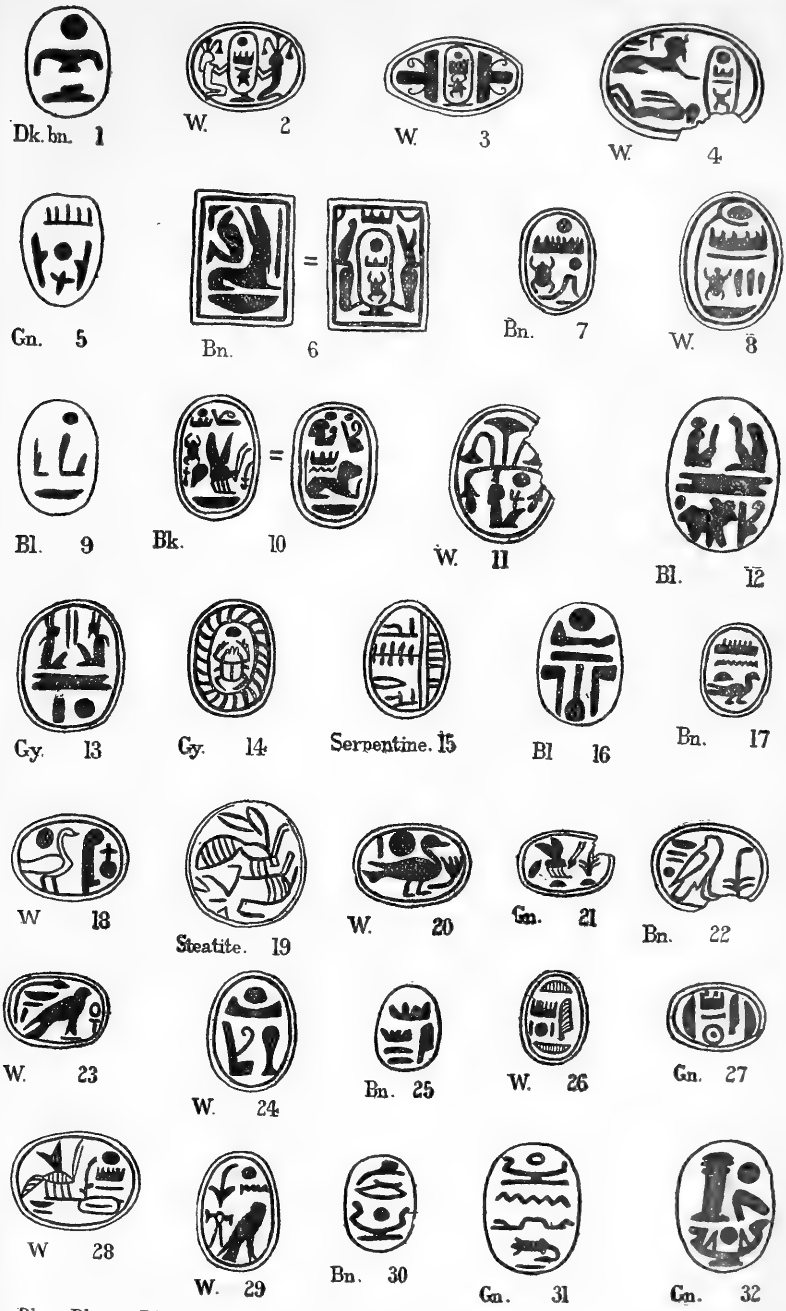
No. 23. The Living Horus, Lord of the Two Lands.

No. 24. The servant of Ra. This is read backwards.

V. Scarabs bearing the names of gods are apparently mere charms, the wearer being placed in this manner under the special protection of the god.

Nos. 25–27. Amen-Ra.

1:1



Bl. = Blue. Dk. bl. = Dark blue. Bn. = Brown. Gn. = Green. Gy. = Grey.
W = White.

I am inclined to place in this class No. 28 with the doubtful reading "Amen-Ra, king of the North and South, Lord of the Two Lands."

VI. and VII. Sacred signs, and charms expressed in words are so closely connected that it is impossible to separate them with any accuracy. They form the largest class of scarabs and are undoubtedly amulets against evil. So little have scarabs been studied—Professor Petrie's Historical Scarabs is the only book giving anything like a classification of the subject, and he unfortunately confines himself entirely to Royal Scarabs—that amulitic scarabs are still an unsolved mystery.

No. 29. Khonsu as protection. Khonsu appears from a popular story to have been the chief protector against evil spirits.

Scarabs engraved with the Boat of Ra form a large division of the amulitic class. They are placed by Professor Petrie in the XXIInd dynasty.

No. 30. Worthy before the Boat of Ra.

No. 31. The Boat of Ra, [therefore] fear not.

Nos. 32 and 33. The legends on these are not decipherable.

No. 34. Gladdening [literally, Enlarging] of the heart, establishing goodness, giving life.

No. 35. Life and Happiness. Or perhaps "Life and Luck" is a better rendering.

Nos. 36–47 are untranslateable. No one has yet ventured to suggest how the perfectly legible hieroglyphs of amulitic scarabs should be read.

Nos. 48 and 49, though also untranslateable, show the worship of the Sun-god Ra under the form of an obelisk.

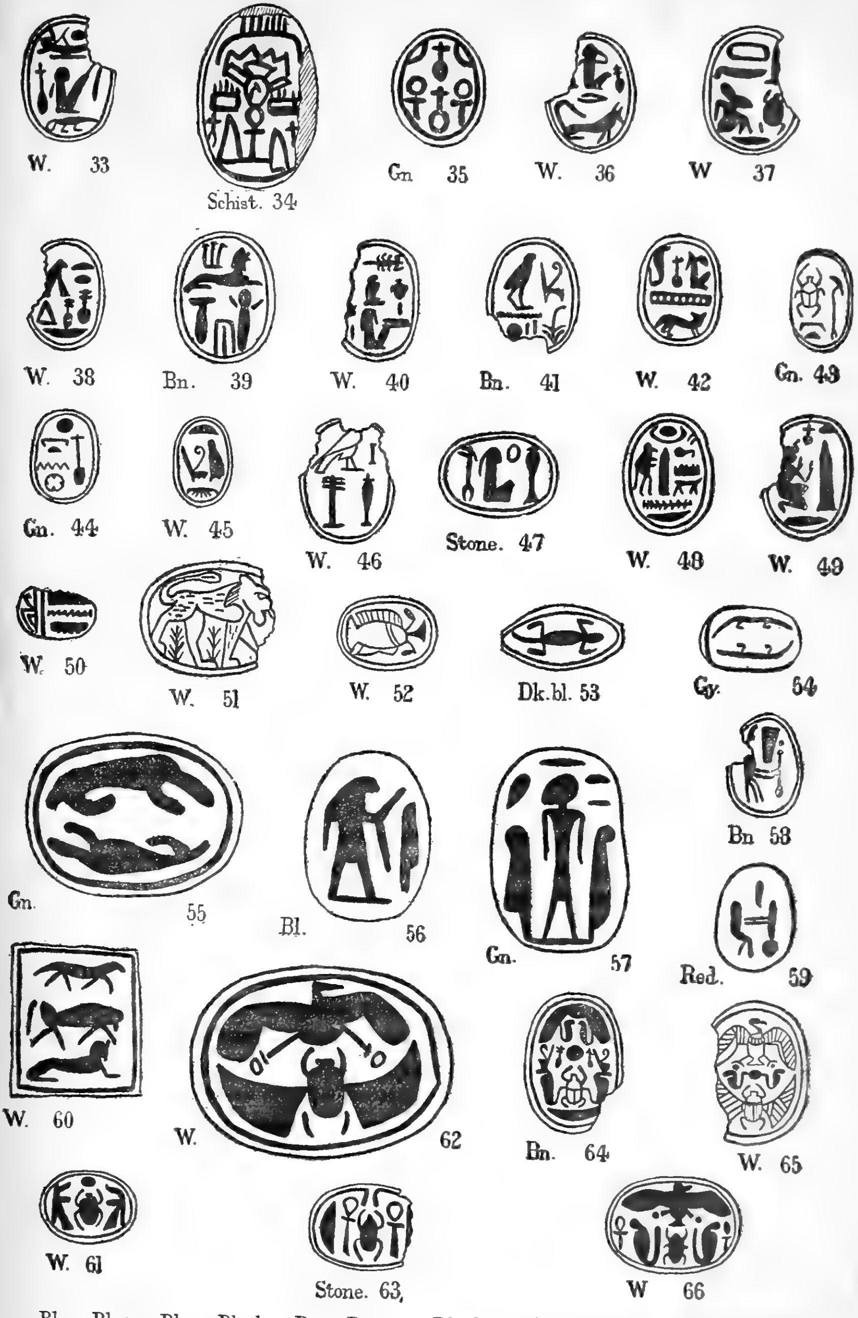
No. 50 gives the Crown of Lower Egypt, and two untranslateable signs.

VIII. Sacred animals and figures are placed on scarabs with some idea of protection.

The lion (No. 51), the fish (52), the lizard (53), and the crocodiles (54 and 55), are animals who were supposed to possess powers of enchantment. The double crocodiles figure largely in those curious magical objects called Cippi of Horus, where the youthful god is represented standing on two crocodiles.

Nos. 56 and 57 are figures of deities, associated with the ostrich feather, the emblem of Truth and Righteousness.

1 : 1



Bl. = Blue. Bk. = Black. Bn = Brown. Dk. bn. = Dark Brown. Gn. = Green.
Gy. = Grey. W. = White.

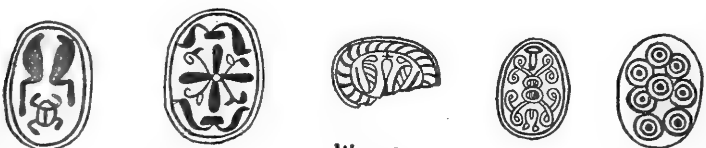
Nos. 58 and 59. Rude representations of the ape holding the sign Nefer, Luck.

No. 60. Two nondescript animals and a sphinx. This may possibly be a charm invoking the king, as the sphinx bears the royal snake on the forehead.

Very curious specimens of the Sacred-animal class are the Vulture, Beetle, and Snake scarabs, which are found in every variety of combination, Nos. 61–69. Undoubtedly some special significance was attached to the union of these three creatures together. The Beetle is the emblem of Creation, the Vulture of Protection, and the Snake of Power or of Death. The winged snake (61) is also symbolical of Protection. Often the sacred animals are combined with sacred signs, as in 64, where the Nefer and Neb signs appear; 66, two signs of Life; 63, two Neb and Ankh (Life) signs; 69, the sign Hes, Praise.

No. 68. Apparently a purely conventional design, but it still shows its origin, namely, four snakes and four crowns of Lower Egypt symmetrically arranged.

1 : 1



W 67 W. 68 W. 69 Gn 70 W. 71

W = White. Gn. = Green.

IX. The purely decorative designs are very commonly found, and vary in beauty according to the period to which they belong. The spiral and the lotus are the most usual forms of decoration.

No. 70. Spiral design, combined with the hieroglyphs Uaz and Ka.

No. 71. Concentric circles.

Of lotus designs there are only two in this collection, Nos. 11 and 52, in neither case appearing separately, but in combination.

IV.

NOTES ON AN UNPUBLISHED MS. INQUISITION (A.D. 1258), RELATING TO THE DUBLIN CITY WATER-COURSE. FROM THE MUNIMENTS OF THE EARL OF MEATH. By HENRY F. BERRY, M.A.

[Read February 24, 1901.]

In the year 1244, Maurice FitzGerald, then Chief Justiciary of Ireland, issued a writ directing an inquiry as to the best and most suitable place from which water might be diverted from its course, and conveyed to the city of Dublin. The citizens, who appear to have badly needed an additional supply, were prepared to pay the costs of the necessary works, and special enquiries were to be made as to loss and injury to property consequent on the formation of a watercourse, which must necessarily run through the lands of divers persons. The undertaking was duly carried out, and the ancient city watercourse, as we still know it, from its "head" beyond Templeogue, where the river Dodder is diverted, was constructed in pursuance of the Justiciary's writ.

Prior to this period, low lying portions of the city and suburbs depended on the waters of the Poddle, which, flowing from Tymon and the green hills of Tallaght, through Harold's Cross, lazily meandered through the Liberties into the river Liffey. The more ancient portion of the city, built on high ground, was supplied by wells, and that the Castle itself had no other resort, is proved by an entry in a Pipe Roll, 12 and 13 Henry III. In Easter Term, 1228-9, the Sheriff of the Vale of Dublin made a payment of 2*s*. for a bucket for the well of Dublin Castle.

It is certain that the authorities and the residents within the precincts of the Castle were anxious to acquire a more abundant supply of water, as in the year 1245 (a year subsequent to the issue of the above mandate), the King directed John FitzGeffrey, then

Justiciary, to have his Hall in Dublin finished, and water conveyed thereto through a pipe from the city conduit, the work to be completed by the ensuing summer.

In the course of the year 1254, water from the Dodder was flowing into the conduit in High-street, which stood near the great gate of the priory of the Holy Trinity, and the *Liber Albus* of the corporation of Dublin contains copies of water grants made in that year to certain private citizens, and to some of the great ecclesiastical foundations, (among them) to the said priory, and to the church of the Holy Saviour, near the bridge of Dublin.

It is my privilege to bring before the Academy a hitherto unpublished,[1] and (I venture to think) unknown document, which makes us acquainted with some of the terms of an agreement, in connexion with this water supply, made between the city authorities and the Abbey of St. Thomas the Martyr, which stood in the western suburbs. There are no contemporary documents known to be in existence relating to these transactions, other than what have been above indicated, so that this additional evidence, only four years later in date than the period when the Dodder water was directly supplied to the city, is of peculiar interest and importance. The next document in point of date with which I am acquainted is some sixty years later.

Among the muniments preserved at Kilruddery is a parchment roll, containing the earliest grants (*circ.* 1177) connected with the foundation of St. Thomas' Abbey by King Henry II. Attached to the roll is an inquisition of 1258, taken in reference to the above agreement, and this document Lord Meath has most kindly permitted me to transcribe, with a view to submitting it to the Academy. These archives of Thomas Court have been handed down in the Brabazon family from the time of Sir William Brabazon, grantee in 1545 of its possessions.

The inquisition is as follows:—

Inq*uisitio* fact*a* a die Pasch*e* in tres septimanas anno r*egni* d*omi*ni R*egis* H*enrici* XLIII°. cor*am* d*omi*no galfrido de Forestel, tu*n*c locu*m* justiciarii Hib*erniæ* ten*ente* et aliis d*omi*ni Reg*is* et d*omi*ni Edwardi fidelib*us* p*er* br*eve* d*omi*ni Reg*is* et d*omi*ni Edwardi de t*ra*nsg*re*ssionib*us* f*act*is d*omi*no abb*a*ti et c*on*ventui s*anc*ti Thom*e* m*arti*ris jux*ta* Dubliñ

[1] It is not to be found in the *Register of St. Thomas'*, edited from the original in the Bodleian, by Sir John Gilbert. There is no copy in the Register of the abbey, preserved in the Library of this Academy, which I have examined.

p*er* major*em* et cives Dubliñ p*er* s*u*bsc*r*iptos, Haket fil*ium* Rob*er*ti, Augustinu*m*, fil*ium* Rog*er*i, Will*el*mu*m* Pilets, Mich*ael*em de Ang*u*lo, Milonem Chever, Will*el*m*um* Fichet, Henr*icum* Galuy, Ric*ard*um Levayt, Alex*andrum* pistore*m*, Robertu*m* Dispensatore*m*, Th*omam* de Athgo, Adam de Westoñ, El: Juvene*m*, Rog*er*u*m* Sumeter, Rob*er*tu*m* Tracy, Joh*ann*em le Poer, Milon*em* le porter, Will*el*m*um* Math, Joh*ann*em de Stachkony, Ph*ilipp*um Macy, Andrea*m* Tyrell, et Joh*ann*em, fil*ium* Barth*olomei*, Galfridu*m* de Dondrom, Th*omam* p*r*æpositum, Will*elmu*m forestariu*m*, Jordane*m* le Taylour, et Mich*ael*em de Stachkonny. Qui jur*ati* dicu*n*t sup*er* sacr*amentum* suu*m* q*uo*d sic co*n*venit p*r*ius int*er* abb*at*em s*anc*ti Th*om*e m*ar*t*i*ris jux*t*a Dubliñ et majore*m* et co*mmun*itatem ejusd*e*m civitatis p*er* mandatu*m* d*om*ini Maur*itii* fil*ii* Galfridi q*uo*d ta*n*tum cap*er*ent de aqua sua c*ur*rente de Dother q*ua*ntu*m* curreret per medium mole cuj*us*da*m* rote plaustri et non plus sine assensu co*n*ve*n*t*us* pro q*u*inq*ue* m*a*rc*is* fine f*a*c*t*o de quib*us* tres m*a*rcas solveru*n*t et pro una m*arca* annui reddit*us*, que*m*q*u*idem reddit*um* nu*n*q*ua*m recep*erunt*. Dicu*n*t ecia*m* q*uo*d p*r*ed*icti* cives facere debent murum lapideum sup*ra* aqua*m* de Doder ad custu*m* suu*m* p*r*op*r*iu*m* c*ir*ca cap*u*d d*ic*t*e* aque assu*m*pte et no*n*du*m* feceru*n*t. Et p*r*et*er*ea d*i*c*t*us abb*a*s d*ic*t*u*m muru*m* sustinere deberet p*ro* p*r*ed*icta* marca annui reddit*us* pro hac aut*em* co*n*ve*n*t*i*one om*n*es co*n*tent*i*ones inter d*ic*t*u*m ab*bat*em et cives d*ic*t*e* civitatis deb*er*ent sedari et pacificar*i*. Et dicu*n*t q*uo*d jam ducteru*n*t d*ic*t*am* aqua*m* ad duplu*m* vel amplius et hoc ad dampnu*m* molendinor*um* d*ic*t*orum* ab*bat*i*s* et co*n*vent*us* et molendinor*um* d*om*ini R*egis* qualibet septimana ad multura*m* unius molendini p*er* unum diem unde estimat*um* dampnu*m* d*ic*t*orum* ab*bat*i*s* et co*n*vent*us* ad XII libr*as* et dampnu*m* d*om*ini R*egis* sex marc*as*. Et dicu*n*t q*uo*d maior et p*r*ed*ic*t*i* cives vendideru*n*t aqua*m* p*r*ed*ic*t*am* p*r*iori et co*n*ventui s*anc*t*e* T*r*initat*is* Dubl*i*ñ, domu*m* s*anc*t*i* Joh*annis*, s*anc*t*i* Salvatoris et s*anc*t*i* Francisci, set sum*m*am vendit*i*onis p*e*cunie nesciu*n*t n*e*c reco*m*pensat*i*onem da*m*pni inde p*r*ove*n*ient*is*. It*e*m dicu*n*t q*uo*d p*r*ed*ic*t*i* maior et cives injuriant*ur* eisd*e*m sup*er* lib*er*tatib*us* suis ledendis de capt*i*one vadior*um* homi*n*u*m* suor*um* pro Alewyth, q*uo*d facere no*n* debent. Et dicu*nt* quod queda*m* insula de Donouř est de baron*ia* d*i*c*t*i abb*a*t*is* et no*n* p*er*tinet ad lib*er*tate*m* p*r*ed*ic*t*e* civitat*is* ubi vadia eor*um* sepe capt*a* fueru*n*t cont*ra* lib*er*tate*m* p*r*ed*ictorum* abb*at*i*s* et co*n*ve*n*t*us* p*er* p*r*ed*ic*t*o*s cives; dicu*n*t ecia*m* q*uo*d vicus int*er* eccl*es*iam s*anc*t*e* Kat*er*ine et foru*m* equor*um* est de lib*e*ra elemosina p*er*tine*n*s ad abbathia*m* s*anc*t*i* Th*ome*. Et ad istius inq*u*i*sitionis* certificat*i*onem om*n*es jur*atores* sup*ra*scripti p*re*senti inq*u*i*sitioni* sigill*a* sua apposueru*n*t.

From the foregoing, it is clear that the citizens of Dublin and St. Thomas' Abbey had had contests over the water supply derived from the Poddle, prior to the construction of the watercourse from the Dodder, and though, with the sanction of the Justiciary, a solemn agreement had been entered into between the parties, for the purpose of meeting such differences and difficulties as might arise under the new arrangements, the citizens appear to have violated their part of the compact, and infringed on the undoubted rights and privileges of Thomas Court. It is matter of history that, until the suppression of the Abbey, this and other subjects of controversy were frequent sources of litigation between the two bodies.

In 1258, King Henry the Third and his son Edward, as Lord of Ireland, issued a writ at suit of the Abbey, under which the foregoing inquisition was taken, and the findings of the inquisition may be briefly summed up as follows:—

The citizens were entitled to take from that portion of the Dodder water appropriated to the Abbey a fixed supply, but in reality they were drawing off double the stipulated quantity and even more. They were entitled to take what would run "per medium *mole* cujusdam rote plaustri," but as the word written "mole" (which might possibly be read *mete*, and which may originally have had a mark of contraction over it) is very indistinct, a perfectly satisfactory conclusion as to the precise meaning of the phrase cannot be arrived at.

At this early period, a more primitive mode of partitioning the water than that afterwards constructed at the Tongue, may have been used, and the clause in the inquisition may well have reference to this point in the course. In the absence of the agreement, however, and of a more specific description of the locality and surroundings of the spot where the contrivance for limiting the supply was fixed, the precise meaning of the expression must be matter of conjecture; but it seems plain that a cartwheel of a circumference agreed on (implied by the word, *cujusdam*) was to be the standard of an outlet for regulating the quantity of water to be drawn away.

A fine of five marks was to be paid for this accommodation, of which three had been discharged, and in addition, a yearly rent of one mark was fixed on, which, up to the date of the inquisition, had not been paid. The jurors assessed the damage sustained by St. Thomas' mills and those of the King, consequent on the excessive withdrawal of water, at £12 and six marks respectively, calculating at the rate of the multure[1] of one mill a day each week.

It may be well to explain here that the Dodder water, when diverted, was conveyed in an open course or channel to the Tongue (near Mount Argus), where by means of a stone pier, ending in an acute angle, the water was partitioned, two thirds being conveyed to the Liberty of Thomas Court and Donore, which supplied the mills and tenantry of St. Thomas' Abbey. One third was brought, *via* Dolphin's Barn to a large reservoir, which stood to the west of the Abbey gate. From this cistern, as it was called, the water was further led to the conduit in High-street, whence it was conducted by means of leaden pipes to the citizen's houses.

The jurors further found against the citizens on another count in the Abbey's indictment, namely, that they had failed to construct round the "head" (as it was termed) a stone wall, which when built (in consideration of the yearly rent before mentioned), the Abbey was under terms to keep up. This "head" was a dam or rampart of stone, strong enough to resist floods, which was erected at a place called Balrothery in the townland of Tallaght. When this was damaged by very serious floods, the mayor and bailiffs were bound to collect a number of the citizens and of those who had mills along the water, with a view to its speedy repair.

Another of the findings was to the effect that water had been sold by the city authorities to the following ecclesiastical foundations—namely, the priory of the Holy Trinity, the House of St. John, St. Saviour's and St. Francis'. In the *Liber Albus* of the corporation of Dublin are found entries of grants of water in 1254 to Holy Trinity and to the church of the Holy Saviour near the bridge of Dublin. St. John's was a poor house or hospital, outside the new gate, which opened to Thomas-street, and which was founded in 1188. St. Francis' must have been the house of Grey Friars, founded in 1235, which stood in what is still called Francis-street. St. Saviour's lay in Oxmantown, on the north side of the Liffey, occupying the site of the present Four Courts, so that the water had of necessity to be brought across the river; for this purpose the bridge had to be utilized, and the Friars bound themselves to carry out the works without injuring it.

As numerous water grants to citizens for specified sums of money are to be found in the *Liber Albus*, it is matter of conjecture why

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[1] Toll or fee which a miller takes for grinding corn.

the above special cases should have been proved against the city at suit of the Abbey. In the case of Holy Trinity, though an agreement is mentioned, no rent or payment is named, while the supply to St. Saviour's is expressly stated to have been bestowed as perpetual alms. St. Thomas' Abbey could hardly have objected to these grants, unless it had some claim to a share in the profits, save on the ground of the amount of water required to supply so many large establishments, which might seriously affect its own interests.

The next finding deals with infringement of the Abbey's rights by the city in taking pledges of their men for *alewyth*, in offering an explanation of which I am much indebted to the researches of the Deputy-Keeper of the Records, who is at present engaged in editing, under the Master of the Rolls, the Justiciary and Plea Rolls of Ireland, of the reign of King Edward I. Very little is known as to the jurisdiction of the courts here at this early period, more especially with regard to the practice of the inferior and petty courts, on the origin and growth of which the publication in question must necessarily throw much light.

The clause in our inquisition evidently refers to suits, prosecutions, and fines in the baronial court of the lord abbot of Thomas Court, for the liberty of Donore, which would be held at stated times by his seneschal, and to similar proceedings in the rival court of the mayor and citizens of Dublin. In those petty courts, as in the superior ones, when any one had cause of complaint, he came in during a sitting, stated his case and gave pledges for prosecution: in minor matters, some article of more or less value would be deposited, and in a case of greater magnitude, a friend or neighbour appeared as surety. These were in no sense courts of record and the proceedings were carried on without being committed to writing. On pledges being given, the court was bound to summon the defendant to appear and answer at a certain day, a summoner receiving instructions verbally from the court. In the present instance, it seems plain that the city court had been taking the pledges of the inhabitants within the jurisdiction of the abbot of St. Thomas, the cause of action lying in the island of Donore. I have no where else met with mention of any part of this district being called an island, but it must have been some lowlying portion of the large district and liberty of the name, insulated by the windings of the Poddle.

Gilbert's *Historic and Municipal Documents of Ireland* contains notices of appeals to the Justiciary of Ireland and to the King and council in England from St. Thomas' Abbey against the city for drawing to their court pleas of tenants of the former, which of right should have been pleaded in the barony court of the abbot.

Among the "Laws and Usages of the City of Dublin," enrolled in the *Chain Book* of the corporation, appears the following:—

DE CERUEISE.

Dautrepart, chescune ki aceresce paiera par an ij[s]. pur ceruoise quele vend par an si ele neyt grace des bailiffs.

Dautrepart, si ele ne face si bone cerueise come ele fere deust ne ne tient lassise come veisin et autre, ne si com est crie parmi la vile, ele est en la mercy de xv deniers.

As this enactment deals with women brewers, it is to be supposed that the bulk of the brewing in the neighbourhood was in small quantities, and that women were principally engaged in it.

In later times, the brewing trade was extensively carried on along the line of the Poddle and the city watercourse, the water being of a character peculiarly favourable for the purpose, and here the brewers, especially about Donore, would have been subject to the jurisdiction of the Abbey.

The saxon *wyte*, *wite*, *wytam* were equivalent to the Latin *mulcta*, fines, and the *alewyth* of the inquisition was, doubtless, the ale mulct or fine of 15 pence imposed on such as brewed bad ale or an article not up to the standard of the assise of ale. Complaints were frequent as to the assises of bread and ale not being strictly kept, and as to the assay not being sufficiently frequent. These old-time ale brewers would probably have had to give pledges in anticipation for payment of this fine, which some of them were certain to incur, and the city authorities were active in taking these, instead of allowing them to go to their rightful tribunal, the court of the abbot, as baron. In connexion with the subject of ale, it may be interesting to recall the fact that one of the most ancient privileges conferred on the Abbey of St. Thomas the Martyr, was the *Tolboll*, a custom of the tribute of one gallon and a-half of the best ale and mead to be rendered by every brewer in Dublin out of each large brew. This had been granted to Prince John, son of Henry the Second, and while lord of Ireland, before his accession to the throne of England, he made a gift of the imposition, in perpetual alms, to the abbey founded by his father.

The inquisition concludes with a finding that the street between St. Catherine's church and the horse market was of free alms, appertaining to St. Thomas' Abbey. The city, as it grew westward, began to encroach on the monastic precincts, for the Abbey, at its foundation, stood at a considerable distance from the walls, and some authoritative pronouncement on the extent and nature of the abbot's jurisdiction in this direction must have become necessary. Gilbert's *Calendar of Ancient Records of Dublin* (vol. ii.), under the year 1571, mentions houses built on the old horse market in St. Thomas-street, which street Speed's map (1610) shows as then running east of St. Catherine's, and it seems probable that this market lay nearer St. Francis-street and the New Gate. The same calendar (vol. i., p. 121) describes ground outside the New Gate, near the Franciscans' convent, the grant of which reserves a place for holding pleas annually during the time of the fair. Another grant is entered, wherein a curtilage in the city land where the fair was held, is mentioned as lying outside the New Gate, in St. Francis-street.

V.

AN ARABIC INSCRIPTION FROM RHODESIA.

By STANLEY LANE-POOLE, M.A., Litt.D.

(Plate I.)

[Read May 12, 1902.]

The Marble tablet represented on Plate I. is remarkable not only as the first Arabic inscription so far discovered in Rhodesia, but as a document relating to a very early settlement of Muslims in South Africa, unrecorded in any Arabic history. Much has been published during the past ten years on the ancient monuments of Rhodesia, and the thirteen sites which formed the basis of Bent's *Ruined Cities of Mashonaland* have now been multiplied by more recent exploration till they are estimated[1] at five hundred distinct groups of ruins, of which however scarcely half have been even partially surveyed, and none has yet received thorough investigation by trained archæologists. These interesting monuments, scattered over the immense stretch of country between the Zambesi and Limpopo rivers, and bearing strong points of resemblance to the remains of ancient buildings in Southern Arabia, have naturally attracted much attention, and their origin is one of the most curious problems that archæology has to solve. The hypothesis that they were the works of Sabæan miners of the period when the South Arabian kingdoms were at the height of their power, more than fifteen hundred years before the Christian era, and that the numerous ancient gold-workings connected with these monuments were really the source of the 'gold of Ophir' which the 'ships of Tarshish' brought for the adornment of Solomon's temple, as argued by Professor A. H. Keane[2] and others, has everything in its favour, except epigraphic proof, and it may still be hoped that further ex-

[1] Hall and Neal, *Ancient Ruins of Rhodesia*, 1902.

[2] *The Gold of Ophir, whence brought and by whom?* 1901.

ploration may reveal Himyaritic inscriptions. Nothing is more probable than that the sea-faring Arabs of the Yemen and Hadramawt should have been in close commercial relations with the east coast of Africa and have discovered the mineral resources of Rhodesia where numerous gold-mines still testify to very ancient workings.

What the ancient Himyarites probably did in almost prehistoric times, the mediæval Arabs undoubtedly carried on. There is every reason to believe that the predominant influence of Arab traders, and in some parts even of Arab rulers, was continuously maintained along the east coast of Africa as far south at least as Beira down to the arrival of the Portuguese at the close of the fifteenth century. When Vasco da Gama reached Sofāla, the mediæval port near Beira (towards which the ancient sites and gold routes of Rhodesia evidently converge), he found 'Moorish', *i.e.* Arab, traders employing natives to work the gold mines[1], and seized Arab dhows laden with gold dust. There is no doubt that this commerce had been going on for centuries, if not for some thousands of years. The references in the works of Arabic geographers and travellers, scanty and vague as they are, sufficiently prove that Sofāla was well-known as a port for the gold trade. El-Mas'ūdī, writing in the middle of the tenth century, mentions Sofāla (which is itself an Arabic word, meaning 'low-country') as the terminus of the voyages of the merchants of the Persian Gulf, and adds that 'the country of Sofāla and Wāḳ-Wāḳ produces quantities of gold and other marvels.'[2] El-Bīrūnī, Ibn-Sa'īd[3] and Yāḳūt refer to this trade, and el-Idrīsī says that in all the land of Sofāla gold is found in abundance, sometimes in nuggets of a (*raṭl*) pound's weight.[4]

Probably these commercial relations between Arabia and the east coast of Africa had been uninterruptedly maintained from ancient

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[1] J. de Barros, *Da Asia*, Dec. I, liv. x, cap. 1.

[2] Ed. Barbier de Meynard, i, 6, 7.

[3] Reinaud, *Fragm. Ar.*, 112; *Géogr. d'Aboulfeda*, Intr., 141.

[4] Jaubert, i, 66.

times; but when the Muslim Arabs first made settlements on the coast is not stated in any of the general Arabic histories. There was evidently no definite invasion at the time of the great Mohammadan expansion in the seventh century, or it would have been recorded. The only authority we possess, and that at second hand, is a 'chronicle of the kings of Quiloa' which was discovered when Francisco de Almeida, the Portuguese viceroy, took that island in 1505. An abstract of this history—the original is apparently lost,—appears in the celebrated *Da Asia* of João de Barros[1], who seems to have had the work at his disposal; and a modern Arabic MS. from Zanzibar in the British Museum (Or. 2666), entitled كتاب السلوة فى اخبار كلوة[2], contains a brief history of Kilwa (Quiloa) which has evidently been compiled from some such earlier source as the *Chronica dos Reys de Quiloa* cited by Barros. According to this solitary authority there were three independent settlements of Muslims on the Zanzibar coast. First a number of the schismatic sect of Zeydīs—whose leader, Zeyd ibn ʿAlī, a descendant of the prophet, was executed for proclaiming himself as the Mahdī in 740 by the Omayyad caliph Hishām[3],—emigrated to the African coast, somewhat north of the modern Zanzibar, to escape persecution. Barros calls them 'Emozaydij', which, as Mr. Arnold suggests[4], is probably a corruption of Umma Zeydīya, 'the people of Zeyd'. These were followed in the first half of the tenth century by a second (but orthodox) band of fugitives, who left their homes near the Bahreyn on the Arabian coast of the Persian Gulf in consequence of the oppression of the amīr of Laṣah (probably el-Haṣā), and settled at the same place as the Zeydīs, whom they drove into the interior. This second colony founded the great port of Maḳdashū (Magadaxo) which became the

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[1] Dec. I, liv. viii, cap. 4.

[2] Published by Mr. S. Arthur Strong in the *Journal of the R. Asiatic Society*, 1895, 385–430.

[3] Et-Ṭabarī, *Annales*, ed. de Goeje et alii, III, 1742 ff.

[4] Arnold, *The Preaching of Islam*, 278, 279.

metropolis of the Arabs on that coast.[1] The Morocco traveller Ibn-Baṭūṭa visited this city in 1332, and describes it as a vast town, with numerous mosques, and under the rule of a Mohammadan sultan called Sheykh Abū-Bekr ibn 'Omar. He mentions its trade with Egypt, and says that Magadaxo was fifteen days' sail from Zeyla' on the Red Sea.[2] It was situated about half-way between Zanzibar and Bāb-el-Mandeb. The third settlement of Muslims came early in the eleventh century from Shīrāz in Persia. Sailing from Hurmuz in the Persian Gulf, and avoiding orthodox Magadaxo—for the new-comers belonged to the Shī'a sect,—they proceeded further south to Kilwa (Quiloa), where they found a previous Muslim settlement and a mosque. Here they built a fort, and ruled until the coming of the Portuguese. This was the most important of all the Arab settlements, for the kings of Quiloa extended their sway north over Mombasa,[3] and south over Sofāla,[4] where they entered into relations with the native ruler, whom the Portuguese called the Monomotapa or Benomotapa, a name which Professor Keane explains as Bantu for 'lord of the mines', but which the Portuguese understood as meaning merely 'emperor'.[5]

Such is, in abstract, the little that we know about the Mohammadan settlements on the east coast of Africa. Although the Quiloa chronicle places the first arrival of Muslims not earlier than 740, it is permissible to assume that other Muslims had preceded them, since it is hardly probable that a band of persecuted fugitives would have fled to an unexplored land, where the natives had the reputation of cannibals, unless some others had shown them the way. That there was some such early settlement, not only earlier than the date

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[1] Cp. Rigby: *Report on Zanzibar Dom.*, 47, where the migration of Arabs of the tribe of el-Ḥārith from the Bahreyn to East Africa and the foundation of Magadaxo is placed about A.D. 924.

[2] Ed. Defrémery and Sanguinetti, ii, 180 ff.

[3] Strong, *J.R.A.S.*, 1895, 430.

[4] Barros, Dec. I, liv. viii, cap. 4; Wilson, *Monomotapa*, 109.

[5] Barros, Dec. I, liv. x, cap. 1; Keane, *Ophir*, 9.

when the Zeydīs established themselves north of Zanzibar, but also much further south, is implied by the inscription which has reached us from Rhodesia. The text, chiselled on a small slab of white marble, is quite legible :—

بسم الـــله الرحـــمن الرحـــيم
لا اله الا الله محمد رسول الله
صلي الله عليه وسلم وهذ القبر
سلام بن صلاة قـــد فارقت
الدنيا الى دار الاخرة وكان
هجرة نبى ا[لم]ومنين حمس وتسعين
سنه تـم الكـلام والله عـلـم
الله

(The pointing in the original is reproduced above. There are no points to خمس or to the ة of سنة or to عليم. المؤمنين omits the first م, and has superfluous dots under ن.)

Translation :—

> *In the name of God, the Compassionate, the Merciful.*
> *There is no god but God. Moḥammad is the apostle of God,*
> *God bless and save him! And this [is] the tomb*
> *of Sallām ibn Ṣalāh [who] had forsaken*
> *this world for the Last Abode, and was* [i.e. *after*]
> *the Hijra of the Prophet of the faithful five and ninety*
> *years. The sentence ends. And God is all-knowing.*
> *God.*

There are several grammatical errors in the text. هذ القبر should of course be هذا قبر. It has been suggested that it may be هذا لَقبر, 'this is indeed the tomb'; but I have never met with this classical form in an Arabic inscription, unless in Koran quotations. فَارَقَت, as third person feminine, does not agree with its masc. subject سلام. Possibly it is فَارَقْتَ, 'thou hadst forsaken'. In any case it is a very peculiar phrase. دار should be الدار. The phrase وكان هجرة نبي المؤمنين, etc., oddly as it is expressed, can only mean that the Hijra happened ninety-five years before. The formulas تم كلام and الله عليم call for special notice. تم الكلام, 'the sentence ends', equivalent to 'end of extract' or *finis*, may possibly imply that the inscription is copied from an earlier document.[1] الله عليم. 'God is All-knowing' or 'God knows best' is a phrase, like الله اعلم, that suggests some doubt on the part of the writer as to the accuracy of the statement. As to the names of the deceased, they may be read simply Salām ibn Ṣalāh, 'Peace (or security) son of Prayer' (for صلوة), which might possibly be names adopted by a native convert; or the first name should have teshdīd and should be read Sallām, a not unusual Muslim name in the first century of Islam, whilst the second may either be a mistake for صلة. Ṣilah, or possibly a form of the root صلت with the meaning of مِصْلَات, 'strong.'

We have therefore in this curious inscription an epitaph on a Muslim who is stated to have died in the year 95 of the Hijra,

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[1] Mr. A. G. Ellis, of the Department of Oriental Manuscripts in the British Museum, informs me, however, that this phrase is characteristically *West* African, and that he has seen it in a draft inscription in absurdly bad Arabic composed by a West African native for a memorial stone to soldiers who fell in the recent Ashanti expedition. He has also met with such names as Tawḥīd and Yā-sīn among West African negroes, which would be parallels to 'Peace' and 'Prayer' in the present inscription. That this inscription is not West African, however, is conclusively proved, not only by its provenance, but by the pointing of the *fē* and *ḳāfs*, which are differently pointed in the Maghrabi script.

or A.D. 713–714. There is nothing whatever to suggest that it is a forgery. Its history is perfectly straightforward. It was brought some eight or nine years ago from what appeared to be 'an ancient temple' in Matabeleland—unfortunately all inquiries have failed to trace the site—to Mr. P. Hanbury France, an agent of the Union Steamship Company at Cape Town. Mr. France attached no importance to it, and gave it as a curiosity to Dr. W. M. Russell, a surgeon on that line of steamers, who afterwards practised at Kimberley, and Dr. Russell passed it on to Mr. G. S. Cary, of Terenure, Co. Dublin, in whose possession it remains. No one in South Africa could have forged it, nor is there any motive for forgery. Moreover, forgers follow received types, and this inscription is peculiar in many ways. Nor do I believe that it was imported. The inscription is too unusual in diction to have been composed at any educated Mohammadan centre, but its peculiarities and grammatical errors are natural in such an out-of-the-way place as southern Rhodesia. I am told that there is no marble in Rhodesia, but this remains to be proved. Arabs do not carry tombstones about with them on their travels, nor can I imagine such an inscription entering the mind of an Arab of Arabia or a Muslim of Egypt: the language is too bizarre.

Assuming the inscription to have been engraved in Rhodesia and set up over the tomb of this Sallām son of Ṣalāh, the question remains, is it the original epitaph or merely a commemorative tablet erected in later times? The style of writing is no certain guide, since we possess no other specimens from the same region, and without dated examples epigraphic science cannot exist. The Arabic character varies so greatly at different places in different ages that it would be rash to draw conclusions from similar styles of inscriptional *naskhī* elsewhere. Still, judging roughly by the character, it is impossible to believe that it goes back so far as the eighth century, and having regard to the peculiar formulas 'the sentence (or record) ends', and 'God knows best', I incline to the belief that there was some doubt as to the actual site of the tomb of this Sallām ibn Ṣalāḥ—possibly a local saint,—and that some later Muslim put up the tablet, with all reserve, to commemorate the spot identified by local tradition. Such tablets are not uncommon in the East over the graves of holy men, and to erect them is a pious act which brings credit to the commemorator. There remains, however, the possibility that the century of the date has been omitted, but this I think improbable.

It will be seen that there are a good many problems connected with this tablet which are not easily solved. This much, however, may be laid down. If not actually a contemporary tombstone of a Muslim who died in southern Rhodesia in the beginning of the eighth century, it shows at least that there was a local tradition in regard to such a person strong enough to induce some one in later times to set up a commemorative tablet recording his name and date. As the solitary Arabic document from South Africa the inscription is valuable; but it is to be hoped that it will not long enjoy its unique eminence. A qualified archæological exploration of Rhodesia ought to bring to light other monuments of the Muslim and possibly far earlier periods, and decide many questions in regard to the ancient and mediæval history of South Africa which can never be settled until we have the evidence of trained explorers and thorough excavation of the numerous sites which so far have been scarcely more than looked at. Such an archæological survey should be undertaken without delay, and the results should be collected in the Museum of the Rhodesia Scientific Association at Bulawayo, whose members are fully alive to the importance of the subject.

VI.

SOME FURTHER NOTES ON ANCIENT HORIZONTAL WATER-MILLS, NATIVE AND FOREIGN. By JOSEPH P. O'REILLY, C.E.

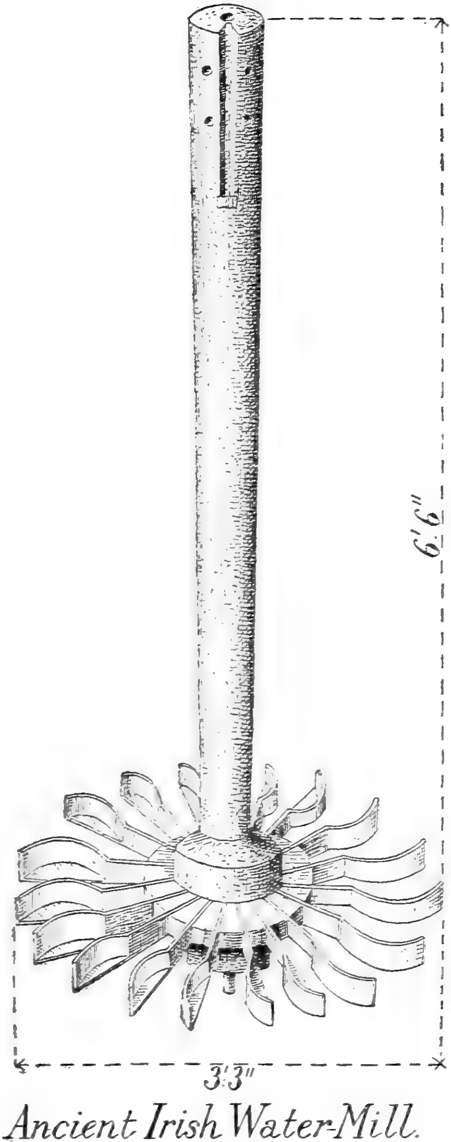
(Plates II., III., and IV.)

[Read April 14, 1902.]

In the paper on the "Milesian Colonization of Ireland considered in relation to Gold Mining," read before the Royal Irish Academy, January 22nd, 1900, I took occasion to cite from the work by Eugène Trutat on "The French Pyrenees" the names of the tools employed by the gold washers at Pamiers in the Comté de Foix, and their probable Celtic derivation, with a view to show the connexion that probably existed between the tribes or peoples engaged in the working of the precious metals in ancient times all over Europe, particularly in the mountainous regions, and the consequent similarity not only in the forms of the tools employed by them, but also in their names or designations. Convinced that this path of inquiry is capable of leading to very striking as well as useful results, as regards both Archæology and Philology, I have been expecting to meet with further opportunities of pursuing it, and beg to submit the following remarks as to the probable origin of certain ancient Irish water-mills. The subject was suggested to me by the article which appeared in the *Ulster Journal of Archæology*, vol. iv., 1856, p. 6, entitled "Ancient Water-Mills," from which the following details are worth citing:—

"The accompanying drawing represents accurately an ancient wooden water-wheel in the possession of Mr. James Bell, of Prospect, near Ballymoney, county Antrim, excepting only that such portions as are now imperfect, have been restored in the drawing to correspond with the others.

"It was found a number of years ago, in the bog of Moycraig, within one mile of Morsside, on a farm now occupied by William Hamill, and which is comprised in the district called 'The Grange of Drumtullogh.' The spot is low and flat, and no stream is at present visible near it.



Ancient Irish Water-Mill.

From the Ulster Journal of Archæology for; 1856; — Vol. 4, — p. 6.

"The wheel here represented is a horizontal one, and is the most perfect specimen yet found in Ireland. Portions of another of precisely similar construction are now in the Belfast Museum which were found in the county Down, near Killinchey, beside an artificial island, or water fastness, which is now occupied as a garden. The material of the wheel now figured is of oak, and when found was quite soft and spongy from long immersion in the bog; but on being dried, it recovered its hardness, and appeared perfectly sound. The water-wheel consists of a nave and upright axle, both cut out of one solid piece of wood, the entire length being 6 feet by 6 inches. Round the nave are inserted nineteen buckets or ladles, curved in the manner shown in the drawing, and which received the impulse of the stream of water. Ten of these still remain perfect. At the upper end of the axle is a deep groove 12 inches long, in which moves an oaken wedge, used evidently for the purpose of raising or lowering a small millstone which was placed above, or for what would be called now 'gristing the mill.' The whole mechanism was supported by a stone pivot or gudgeon secured by a wedge at the foot of the axle where it still remains. This pivot, no doubt, revolved upon another stone hollowed to fit it (a socket). A stone of this kind was in fact found near the water-wheel at Killinchey, and is preserved along with it in the Belfast Museum, bearing evident marks of having been deeply perforated by some pivot constantly revolving in it" (p. 7): "The buckets are ingeniously fastened into the nave by mortising, and are firmly secured by an oaken pin driven in a sloping direction, from the outer circumference of the nave, in such a manner as to pass through the inner ends of three, and at equal distances, each bucket in the wheel had three pins passing through it, thus securing it completely to the two adjoining ones and to the nave.

"No tradition now remains among the people respecting the use of water-mills of this construction in the country, but there is evidence (which I give further on) to prove that they were common at least in Ulster three centuries ago. However, down to that period and even later, the use of the quern or hand-mill was quite general throughout Ireland and its use is not yet given up in some of the western islands of Scotland. So early as the thirteenth century legal means were adopted in Scotland to compel the people to abandon the use of the hand-mill for the larger water-mills then introduced. In 1284, in the reign of Alexander III., it was enacted that 'No man sall presume to grind quheit, maishlock, or rye, with hand mylne, except he be compelled be storm, or be lack of mills, quhilk sould grind the samer; and in this case, gif a man grinds at handmylnes, he sall give the threttein measure as multer; and gif anie man contraveins this our prohibition he sall tine his hand-myleres perpetuallie.' Yet in 1819, M'Culloch (*Western Isles*, vol. ii., p. 30) states that the quern is found in every house in St. Kilda, and the statistical account of Scotland, published in 1845, mentions that in the parish of Sandsting in Shetland, there are 'querns or hand mills without number.'

"There seems to be reason, however, for believing that water-mills were not unknown in Ireland at a very early period. Dr. O'Donovan, in an article in the *Dublin Penny Journal*, has quoted several passages from the Brehon laws, which are of great antiquity, stating the damages to which the miller and the millwright shall be respectively liable in case of an accident occurring in a *mill turned by water*. He also gives references to many of the lives of Irish Saints, in which water-mills are expressly mentioned as having been erected by *ecclesiastics*, proving that they were in use not long after the introduction of Christianity.

"Mr. Getty, in his account of Torry Island (*Ulster Journal of Archæology*, vol. i., pp. 143, 146), mentions the curious circumstance of a very ancient stone cross being fastened at its base into a *millstone*; and notes the tradition of the islanders, that all ancient buildings there have a millstone in their foundations.

"In the notes to the translation of the *Annals of Ulster* (now in course of publication in this Journal) at A.D. 587, it is stated from the Breviary of Aberdeen, that Constantine, a King of Damnonia in Britain, 'having abdicated his throne, repaired to Ireland and became miller to a monastery.' It is well known that a mill was almost always in connexion with religious houses of the Cistercian Order.

"In the *Annals of Tighernach*, one of the most trustworthy of our old Irish chronicles, there is a curious passage at the year 561, where mention is made of the slaughter of the sons of Blathmac, King of Ireland, in the *mill* of Maclodran; and a verse is quoted from an ancient poem, in which the Bard fancifully addresses the mill thus: 'O mill! what hast thou ground? precious wheat? Thou hast ground not oats, but the sons of Cerbhall,' &c. (O'Connor, Rerum. Hibern. Scriptores, vol. ii, 198). The writers of the historical notes to the Ordnance Survey of Londonderry gave quotations from the Book of Kells (MS. Trinity College), and the *Registry of Clonmacnoise* (Clarendon MSS., Brit. Museum), in which grants of mills to monasteries in the eleventh century are mentioned; and various passages may be found scattered through our Irish Annals, in which allusion is made to mills. Most writers who have mentioned the subject seem to take it for granted that water-mills must have been introduced into Ireland by Roman ecclesiastics, or at all events from some country subject to Roman sway, especially as it is pretty well ascertained that a mill of some kind was usually at each Roman station in Britain; and a decisive evidence seemed to be afforded by the similarity or rather identity of the Irish and Latin names for a mill. A little further examination of the question may perhaps show that this is not so certain, at least so far as the North of Ireland is concerned." The writer then examines the philological argument first. He cites Cormac's Glossary, and discusses the derivation of the Irish term *Muilean.* The forms in which it appears in the modern languages which are known to be directly descended from the Latin, such as the Italian, Spanish, French, Walloon, &c., are *mulino* (It.); *molino* (Sp.); *moulin* (Fr.); *molin* (Walloon). "But," he continues, "if we examine further, we shall find the very same root, little more changed than in the above examples in a variety of other languages, which can claim an origin as independent as the Latin, and are spoken by nations who were never influenced by Roman sway." He then gives a table of the equivalents for the word 'mill' as used in the chief languages of Europe, exclusive of the four already mentioned, twenty-eight in all. In each case the name given is a slight modification of the word 'mill.' This slightly modified name is found in countries extending from the shores of the Mediterranean to the far North, and from the coasts of Spain and Ireland to the extremity of Russia. To complete the chain we have only to note further, that in Persian *mâl* is 'to grind,' and that in Sanskrit, the old language of India, *malana* signifies 'rubbing or grinding.' The root is therefore common to all the extensive class of languages known as the Indo-European family, as well as to several outlying districts not included among them. There can be little doubt, therefore, that it is one of extreme antiquity, and cannot be claimed exclusively by the Latin any more than by the Celtic."

(p. 9.)—He then discusses the probability of the Romans having introduced the water-mill into the British Isles. He shows that the hand-mill was no doubt in extensive use from a remote period, not only in Italy, but all over Europe and the East. It must have been well known to the Gauls and Britons in Cæsar's time, as he speaks of their "*molita cibaria,*" or ground breadstuffs.

(p. 10.)—"The water-mill does not appear to have been a Roman invention. Strabo mentions that a mill of this kind was erected in Pontus (in Asia) at the palace of King Mithridates (Strabo, xii., 3, § 30), which is the earliest of which we have any record. Indeed, we have it on Roman authority that water-mills were not introduced in Italy before the time of Julius Cæsar (who died B.C. 44), and were then only used by a few individuals (Vitruvius x., 5, 2). Pliny's slight notice of them, which only occurs in one sentence of his entire great work, shows that they were by no means common in his day (Plin. lib. xviii., c. 10). He died A.D. 79. The earliest mentions of public water-mills is about the year 398, under the Emperors Arcadius and Honorius; and the manner in which they are referred to in the laws of the period shows that they were then a novelty (Code Teod. 14, 15). Now it was at this very time that the Romans finally abandoned Britain. It appears therefore that the Romans never used water-mills to any great extent, nor have we any satisfactory proof that they established such mills at each of their military stations in Britain. Many small millstones, indeed, belonging to the Roman *hand*-mills, have been discovered on the sites of the Roman stations, but so far as I am aware only a few doubtful cases have been brought forward to prove the existence of water-mills at those places.

"For the foregoing reasons and from the consideration that there never was a friendly intercourse maintained between Ireland and the Roman province, it seems unlikely that water-mills were introduced into this country from Roman Britain. We must therefore seek for their origin in some other quarter, and, in my opinion, the weight of probability rests on the North of Europe. Although the Danes and Norwegians did not effect their conquest of Ireland for many centuries after the departure of the Romans from their British province, they, and the other maritime tribes in the neighbourhood of the Baltic had maintained an intercourse with these islands for an indefinite period. The details of this intercourse is unknown to us further than what may be gathered from scanty allusions in old Irish Annals and Icelandic sagas. But there seems to be little doubt that during the obscure period alluded to these Gothic tribes had been gradually colonizing the east and north of Scotland, and of course bringing within them whatever arts of civilization they possessed, which there is reason to believe were greatly superior to those existing in their new colonies. A people who could send out fleets of well-equipped vessels and armies of mailed warriors, sweeping the coasts of Europe, and conquering wherever they appeared, must have possessed considerable mechanical skill, and were not likely to be without water-mills for grinding their corn. Their native hills abounded in cascades suggesting the employment of water-power, and their forests furnished the materials for their *mill-wheels.*"

(p. 11.)—"Now it so happens that the poetical account of the first water-mill ever erected in Ireland (written by a bard who died A.D. 1024) and the popular tradition state the millwright who constructed it was brought from Scotland. This was in the third century, when, as the poet relates, the Monarch Cormac, desirous of saving a beautiful bond-maid the labour of grinding corn daily in a quern, sent across the sea for a millwright who erected a mill on the stream of Nith near Tara (Poem of Cuan O'Lochain, quoted in the historical notes to the Ordnance Survey of Londonderry). We have no description of this mill to assist us in forming a conception of its form or construction, but we may assume that it was of wood, and of a simple form, probably not very different from the one which is the subject of the present article. This traditional story, at all events, points to the quarter from whence the invention was believed to have come. Now, if on examination, we should find that mills quite similar to our specimen were in use, or are actually still in use, in a number of districts in the British Islands and the islands adjoining, known to have been peculiarly Scandinavian, and for centuries under the government of the Northmen, it would be difficult to avoid the inference that these machines were introduced thither by them. This I am enabled to show from various independent authorities, whose several notices of mills I now place together for comparison."

1. *In the Faröe Islands.*—"The construction of a water-mill in Faröe is exceedingly simple. The building for the most part consists merely of wood, the roof being supported by four posts or pillars; but, to save timber, these pillars are sometimes built of stone, mixed with mud; it is entirely open below, so that the water can have a free course through it. On the ground is placed a loose beam, having in the middle a piece of iron, with a small hole in it, which, however, does not pass through the beam. This hole is made to receive the gudgeon of a perpendicular axle, which proceeds up to the millstone, and this axle supplies the place of a crown wheel and spindle. To the upper end of the axle is fixed a round rod of iron, which passes through the lower stone, and which supports the iron cross that bears the upper millstone. At the lower end of the axle there are eight leaves or boards mortised into it, about 18 inches in length, a foot in breadth, and from 1 to 1¼ inch in thickness. These leaves, which perform the part of a water-wheel, do not stand exactly in a perpendicular, but with

a somewhat oblique direction, so as to turn their flat sides towards the water which falls upon them; and the spout, which must give the water a sudden fall, is placed with its lower end close to these leaves. From one end of the beam lying on the ground, which supports the axle and the upper millstone, a piece of wood rises in a perpendicular direction towards the millwork, where it rests on wedges, and by pushing in or drawing out these wedges the upper stone can be raised or lowered at pleasure. The millstone makes a hundred revolutions in a minute; but, as the stones in general are small, and have no furrows in them, they grind slowly, and are not calculated for the preparation of grits or barley.—Landt's 'Faröe Islands,' 1810, p. 293."

(p. 12.)—2. *In the Shetland Islands.*—"In skirting along the harbour ('Rigseller Voe, in Shetland') numerous slender rills were observed ambling down the dales to pay their tribute to the Voe. These occasionally served to supply some small mill, the presence of which was signified by a low shed of unhewn stones that stretched across a diminutive streamlet, over which it was possible in many places to stride. Compared with a water-mill of Scotland or England, the grinding apparatus of Shetland seemed designed for a race of pigmies. The millstones are commonly formed of a micaceous gneiss, being from 30 to 36 inches in diameter. Under the framework by which they are supported is a sort of horizontal wheel of the same diameter as the millstones, named '*Tirl*,' which consists of a stout cylindrical post of wood, about 4 feet long, into which are mortised twelve small float boards, placed in a slanting direction, or at an oblique angle. It has a pivot at its under end which runs in a hollowed iron plate fixed in a beam. A strong iron spindle, attached to the upper end of the '*Tirl*,' passes through a hole in the under millstone, and is firmly wedged in the upper one. A trough conducts the water that falls from the hill, upon the feathers of the '*Tirl*,' at an inclination of 40° or 45°, which, giving motion to the upper millstone, turns it slowly round. Such is a description of this exquisite piece of machinery, the invention of which is *probably* as old as the time of Harold Harfagre."

3. *In the Hebrides.*—"The mills at Lewis are probably the greatest curiosity a stranger can meet with on the island. There is scarcely a stream along the coast, or any part of the island, on which a mill is not to be seen. These mills are of very small size and of a very simple construction. The water passes through their middle, where the wheel, a solid piece of wood, generally 18 inches in diameter,

stands perpendicularly. A bar of iron runs through the centre of this wheel. This bar of iron, or axle, rests on a point of steel, which is fixed on a plank, the one end of which is fixed in the mill wall, the other in the end of a piece of plank, which stands at right angles with the plank on which the wheel rests. The upper end of the axle fits into a cross-bar of iron, which is fitted into the upper millstone, which is rested upon wooden beams or long stones. There is a purchase upon the end of the said perpendicular beam or plank by which the upper millstone can be raised or lowered (p. 13). There are nine pieces of board, 8 inches broad and $1\frac{1}{2}$ feet long, fixed in the wheel, parallel and at equal distance from each other, upon which the water is brought to bear; which, together with a few sticks for roof and some heather for hatch, constitutes a Lewis mill."—"New Statistical Account of Scotland," 1845.

M'Culloch states that the quern was found in every house in St. Kilda, and recommends the establishment of a water-mill to supersede it. He then gives a description of a water-mill almost identical with those already described, and says: "It would not be easy to construct the horizontal mill on cheaper terms."—M'Culloch's "Western Isles of Scotland," vol. ii., p. 30.

4. *Isle of Man.*—"Many of the rivers (or rather rivulets) not having sufficient water to drive a mill the greatest part of the year, necessity has put them on an invention of a cheap sort of mill, which, as it costs very little, is no great loss, though it stands idle six months in the year. The water-wheel, about 6 feet in diameter, lies horizontal, consisting of a great many hollow ladles, against which the water, brought down in a trough, strikes forcibly, and gives motion to the upper stone, which, by a beam and iron is joined to the centre of the water-wheel."—"Gibson's Camden" (Isle of Man), vol. ii., p. 1448.

5. *Ulster.*—I conclude with a few remarks more, viz.:—"That from the said long bogg (beside Newtownards, Co. Down), issue many rills and streams, which make small brooks (some of them almost dry in ye summer) that run to the sea on each side of ye upper half-barony, and on them each townland almost had a little milln for grinding oats, dryed in potts, or singed and leazed in ye straw, which was ye old Irish custom, the mealle whereof, called '*greddane*,' was very coarse. The mills are called 'Danish,' or ladle millies; the axle-tree stood upright and ye small stones or querns (such as are turned with hands) on ye top thereof; the water-wheel was fixed at ye lower end of ye axle-tree, and did run horizontally among ye water, a small force

driving it. I have seen of them in ye Isle of Man, where the Danes domineered, as well as here in Ireland, and left their customs behind them."—"Montgomery MSS.," p. 321.

(p. 14.)—"Anyone by comparing the foregoing separate descriptions will at once perceive that the several mills mentioned are identical, in principle and construction, with the one described in the present paper, while differing in a few details, such as the number of buckets or paddles. It will also be noted that the districts in which they are described as being commonly used form, when taken together, a geographical chain, leading directly from the country of the Northmen through the old seats of their dominion in these countries, and terminating on the eastern coast of our own province.

"It will be seen likewise that the last of the extracts alludes specially to the popular tradition, both in Ulster and in the Isle of Man that these mills were Danish. The same passage, written about the year 1698, shows also that in the county Down a short time previously such mills were quite common. It is only remarkable that more of these remains have not been discovered, but this has arisen no doubt from the perishable nature of their materials."—Robert M'Adam.

To these citations may be added one from the "Encyclopædia Brit." (9th ed.), vol. ix., p. 344, article "Flour Mills." The nature of the water-mills, which were formerly common in Great Britain and Ireland, and which continued in use well into the present century (nineteenth), may be gathered from the following description of one visited by Sir Walter Scott during his voyage in the Shetland Islands, &c., in 1814. ("Lockhart's Life"):—"In our return, pass the upper end of the little lake of Cleik-him-in, which is divided by a rude causeway from another small loch, communicating with it, however, by a sluice for the purpose of driving a mill; but such a mill! The wheel is horizontal, with the cogs turned diagonally to the water; the beam stands upright, and is inserted in a stone quern of the old-fashioned construction. This simple machine is enclosed in a hovel about the size of a pigstye, and there is the mill! There are about 500 such mills in Shetland, each incapable of grinding more than a sack at a time."

That mills, mechanically worked, were known and erected in Ireland in the thirteenth century appears from the following entry in the Calendar of State Papers, Ireland 1171-1251, p. liv. (2941), June

3rd, 1248. Mandate from the Justiciary of Ireland to assign to the abbot and monks of St. Mary's, near Dublin, land or annual rent of 10 marks in compensation for the injury done to them by the erection of the King's mills near the Castle of Dublin. That the hand-mills were in common use at that time appears from the first entries in that calendar, p. 1, entry 1, "Barth. de Glanville and others render their account for 468 equippers (eskiperii), six hand-mills (manumolendina)."

Similar mentions occur in the entries 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16.

It would seem from these different citations that while the hand-mill was in common usage all over Europe during ancient times, and in the northern countries down to quite recently, water-mills, though not so common, were also in use, particularly in these northern countries, and that they presented generally, the peculiarity of construction detailed in the before-mentioned descriptions, that is, were horizontal wheels, with paddles of peculiar form, adapted to receive the impulse of a small stream of water having a certain volocity, that is, a certain sufficient head. Mr. M'Adam's conclusion that the origin of this style of mill must be referred to the Danish or Norse people seemed plausible enough, granting his assumptions, and taking as ascertained, that no other such mills were known elsewhere in Europe or in the East, but Mr. M'Adam does not appear to have made the necessary research in this respect, and hence it is desirable to examine if there be any evidence for the existence in past or present times of such mills in the countries of Europe and of the East which have still remaining either monuments or records.

A priori, one might expect that the Chinese knew of water-mills, as of many other mechanical appliances, long before any other nation in the East, and in Chambers' Encyclopedia, under the heading, "*Water-power*," p. 365, it is stated: "Notably, amongst eastern nations, the Chinese were conversant with water-motors from a very early period."

"The first attempt to produce hydraulic machinery proper, as the term is now understood, were made in the Greek schools at Alexandria, which flourished under the Ptolemies, under whose regime Ctesibius and Hiero invented the fountain of compression, the siphon, and the force-pump about 120 B.C." That water-mills were invented or introduced into Europe as early as that period would appear from the following paragraph taken from Smith's "Dictionary of Greek and Roman Antiquities," 2nd edition, 1859, under the heading "Mola," mill and water-mill (*mola aquaria*). The first water-mill of which any record is preserved was connected with the palace of Mithridates in Pontus (Strabo, xii. 3, § 30). "At Cabeira (in Pontus) was the palace of Mithridates (the Great, 120 B.C.), the water-mill, the park for keeping the wild animals, the hunting ground in the neighbourhood, and the mines." That water-mills were used at Rome is manifest from the description of the them by Vitruvius (x. 5, edition Schneider):—"A cogged wheel, attached to the axis of the water-wheel, turned another which was attached to the axis of the upper millstone, the corn to be ground fell between the stones out of a hopper (infundibilium) which was fixed above them." (See Palladio de Re rustica, 1, 42). Ausonius mentions their existence on the river near Treves, and Venantius Fortunatus, describing a castle built in the sixth century on the banks of the Moselle, makes distinct mention of a tail race, by which "the tortuous stream is conducted in a straight channel."

It is to be remarked that the water-wheel above described from Vitruvius' work, was evidently a *vertical wheel* with *horizontal axis*, the cog-wheel placed on this, communicating its movement to the *vertical* axis carrying the millstone, by means of another cog-wheel. It was therefore *not* of the same description as the wheels forming the subject of this paper; rather indeed of the same style as those modern forms so common in these countries in modern times, and which are those generally mentioned in the various encyclopedias under the heading *Water-mill.* It is very difficult to find any historical description or mention of the *horizontal* water-wheel in question in these works, although the *turbines*, which they really are a rude form of, are described, but as of quite modern invention. It can therefore be only incidentally that such a description may be met with, and as such I have come across the following in the "Lettres sur la Grèce, l'Hellespont, et Constantinople (1811) première partie," by A. L. Castellan. Of this writer and artist the following short account is given in the "Biographie Universelle":—

"(Antoine Louis Castellan, peintre, graveur, and architecte français; né à Montpelier en 1772: mort à Paris, 2 Avril, 1838. Il se voua d'abord à la peinture, entra in 1788 dans l'atelier de Valenciennes; il acquit bientôt pour le paysage une réputation méritée. Voyagea dans le Levant, visita Constantinople, la Grèce, les Îles, l'Italie, et la Suisse; recueillant partout un grand nombre de documents, de dessins, et puisant dans ces riches contrées, un goût d'autant plus sur, qu'il ne se laissait pas aller à un enthusiâsme irreflechi. Fixé à Paris des 1804, il s'occupa de publier, divers ouvrages pleins d'intérêt où se trouvent consignés les résultats de ses voyages et de ses observations. Ils sont accompagnés de nombreuses ves dessinées et gravées par l'auteur; tels sont. 'Lettres sur la Morée et les Îles de Cerigo, Hydra, et Zante,' 1 vol. in 8vo, Paris, 1808: 'Lettres sur Constantinople,' &c., in 8vo, Paris, 1811.)"

At p. 87 of this last work he speaks as follows:—

"En Grèce, on retrouve à chaque pas la tradition des usages antiques, et particulièrement dans les arts mécaniques. Il est bon d'observer que la plupart des machines dont on se sert dans ce pays, sont d'une simplicité qui, bien loin de marquer l'enfance de l'art, semble au contraire ne pouvoir être que le résultat de la réflexion, aidée d'une longue expérience.

"Si l'on entend par mécanique, l'art d'augmenter les effets en simplifiant les causes, on pourrait croire que les anciens l'entendaient mieux que nous, surtout si l'on en juge d'après les entreprises gigantesques qu'ils ont exécutées avec des machines qu'on peut appeler primitives ou élémentaires, et dont les nôtres ne sont que la complication."

(p. 90.) "Nous avons dit que le besoin seul était le véhicule des anciens dans l'invention des machines. En effet, celle des moulins à moudre le grain ne remonte qu'au siècle d'Auguste. Avant cette époque, on s'était contenté de moulins à bras, semblables à ceux qu'on voit encore en Sicile (Voyage pittoresque de Sicile par M. Houel, 1782–87) (p. 91), et qui ne sont que de simples instruments de ménage. Ces moulins étaient portatifs, occupaient les moins d'espace possible, et devaient fournir à peu de frais, assez de farine pour nourrir une famille. On pouvait même employer à ce travail jusques aux enfants, et dans les maisons des riches, l'on en chargait les esclaves.

"Mais lorsque le luxe s'introduisit à Rome, et que les besoins augmentèrent en proportion des richesses de quelques particuliers, tandis que le peuple s'appauvrissait d'autant, les grands dont, l'ambition était de gouverner, imaginèrent pour conquerir l'opinion publique, de donner des fêtes magnifiques accompagnées de distributions de vivres et de pain."

(p. 92.)—"C'est alors que les moulins à bras dévinrent insuffisants. On fût forcé d'avoir recours à des entrepreneurs pour fournir à ces immenses distributions. Ces hommes avides, étant dans l'obligation de payer un grand nombre d'esclaves, et qui même employaient des moyens criminals pour s'en procurer (Théodose fit en 389 une loi pour reprimer ces désordres qui duraient encore de son temps (Lebeau, 'Histoire du Bas-Empire,' livre 24), cherchèrent à diminuer le nombre des bras en y suppléant par les agents plus puissants et moins coûteux, que devait leur fournir la mécanique, et l'on inventa les moulins à eau.)

"L'époque de cette découverte est fixée d'une manière précise par l'epigramme suivante, faite à cette occasion (Anthologie manuscrite de la Bibliothèque impériale et mémoires de l'Académie des Inscriptions et belles lettres, vol. ii. p. 408. Edit^{n} en 8vo.) 'Femmes, occupées à moudre le blé, cessez de fatiguer vos bras; vous pouvez dormir à votre aise et laisser chanter les oiseaux dont la voix annonce le retour d'aurore. Cérès ordonne aux Naïades de faire ce qui faisaient vos mains; elles obéissent, elles s'élancent jusqu'en haut d'une roue et font tourner un essieu. L'essieu, par la moyen de rayons qui l'entourent, fait tournir avec violence, la pesanteur des meules creuses qu'il entraîne. Nous voilà, revenus à la vie heureuse de nos premiers pères, et à récueillir sans peine les fuits des travaux de Cérès.'

"Il parait d'après cette épigramme d'Antipater, que l'usage des moulins à eau n'a commençé que du temps d'Auguste, et Vitruve, son contemporain, fait dans son dixième livre la description de ces moulins, qui peut même servir de commentaire à l'épigramme Grèque. Strabon (lib. 12) remarque aussi une machine alors fort rare, et dont il parle comme d'une singularité, à l'occasion de la ville de Cabires et du palais de Mithridate. Il n'est pas douteux que les moulins qu'on voit encore dans l'Asie mineure et dans toute la Grèce ne soient des copies de moulins antiques, et par cela il est intéressant de les faire connaître. D'ailleurs il est probable que ces mêmes machines nous ont été transmises par la fréquentation que nous avons eue avec ces pays. On peut croire aussi que leur établissement chez nous, ne remonte qu'au-temps des Croisades, et qu'auparavant nous ne connaissions pas les moulins à eau, les moulins à vent, et les puits à roue," &c.

(p. 94.)—"Les croisés, au retour de leurs expéditions d'outre-mer, introdusirent dans leur patrie ces machines et bien d'autres, qui se sont perpétuées et perfectionées en raison de nos besoins et de nos lumières. Il n'en est pas moins curieux de voir d'où l'on est parti, ce que nous devons aux peuples orientaux, et ce que nous avons ajouté à leurs inventions.

"J'ai déjà donné le dessin d'un puits grèc (Lettres sur la Morée, &c., 2nd partie, p. 41) qui m'a paru remplir, à peu de frais, le même object que des machines beaucoup plus compliquées. Je pourrai en dire autant de deux sortes de moulins que j'ai dessiné à Lampsaki; ils sont d'une telle simplicité, que l'inspection seule des dessins doit suffire pour en faire comprendre le mécanisme. (Plate II.)

"Ce mécanisme dans le premier moulin (pl. 5) ne consiste qu'en une roue horizontale devisée en rayons creusés de manière à recevoir et à opposer le plus de résistance possible à l'eau. L'axe en fer de cette roue traverse la meule inférieure, se fixe, au moyen d'un tenon en forme de hache, dont parle Vitruve, au centre de la meule supérieure qu'il met en mouvement. [Note.—Ce fer que les Latins appelent *subscus* est nommé *Cothb* par les Arabes; ils ont aussi donné ce nom aux pôles du monde, et se figurent que les sphères des cieux tournent sur eux et à l'entour d'eux, comme sur des pivôts, &c. (D'Herbelot au mot *Cothb*)].

"Jusque là il n'y a rien de fort ingénieux dans ce mécanisme; mais cequi paraît l'être davantage, c'est d'avoir profité non seulement avec discernement, du peu d'eau dont on peut disposer, mais encore d'en avoir doublé l'action. Si l'on avait eu de l'eau eu abondance et dans tous les temps, sa chute seule aurait suffi pour faire mouvoir une roue verticale, comme celle de nos moulins; mais il s'agissait d'obvier à sa rarité dans de certains temps, et de se débarasser sans peine de sa trop grande affluence dans d'autres temps. À cet effet le canal est construit de manière à ne contenir que la portion d'eau strictement nécessaire. Le trop plain se déverse avant d'arriver à son extremité, au moyen de vannes indiquées dans mon dessin.

"À cette extremité du canal on a adapté une longue caisse en forme de pyramide renversée; elle est formée de planches épaisses, assemblées et rétenues par de fortes traverses. Les joints sont garnis d'étoupes et goudronnés, suivant l'expression de Vitruve, comme les navires. Cette caisse embrasse la largeur du canal. Son autre bout, qui penètre dans le mur du moulin, se rétrécit beaucoup, et n'a qu'une fort petite ouverture dirigée vers les rayons de la roue horizontale. L'eau se précipite dans cette caisse, qui lui offre un plan incliné d'à peu près 45°, et ne pouvant s'échapper que par cette étroite ouverture on peut juger de la violence avec laquelle elle sort. En effet, la cumulation du poids de l'eau, augmentée par la hauteur de sa chute, jointe à son volume qui se trouve doublé en quelque sorte par le retrécissement des parois du canal, doit donner une très forte impulsion au jet qui s'échappe de cette sorte d'entonnoir, son action se portant toute entière sur les rayons qu'elle prend en flanc, et qui sont disposés horizontalement et creusés de manière à le recevoir directement, ce jet, dis-je, doit faire tourner la roue avec une rapidité suffisante et peut être même plus grande que celle produite par une complication de rouages."

(p. 97.)—" Nous avons vu un autre moulin où l'on a suivi le même système de force motrice et le même mécanisme à quelques modifications près.

" Au premier coup d'œil elles paraissent peu avantageuses, et n'en remplissent pas moins l'objet des constructeurs. Le canal ou aqueduc y est élevé à plusieurs pieds audessus du niveau de la roue : mais le conduit dans laquelle l'eau tombe, au lieu de représenter une pyramide renversée et posée diagonalement, offre un cône tronqué et vertical.

" L'eau y entre par le retrécissement du sommet, et après avoir rempli l'ampleur de la base s'en échappe par un tuyau percé horizontalement et qui se trouve de niveau avec la roue. De plus, au lieu de perdre, comme dans le précédent moulin, la surabondance, ou la crûe des eaux, on l'a rendue utile en divisant le courant de manière à faire tourner les roues des deux moulins jumeaux et accolés l'un à l'autre. À cet effet l'aqueduc s'élargit à son extrémité qui est divisée en deux parties égales par une cloison en planches épaisses ; ce qui forme deux canaux parallèles, garnis de leurs vannes ; et qui aboutissent aux deux cônes où l'eau se précipitant en même temps, fait agir le double mécanisme."

[TRANSLATION.]

In Greece is met with at every step the tradition of ancient usages, and particularly of those of the mechanical arts. It is worth observing that the greater part of the machines made use of in this country are of a simplicity such, that far from thus marking the first efforts of art, they seem on the contrary to be but the result of reflexion, assisted by a long experience. If by mechanics is to be understood the art of increasing certain effects while simplifying the causes, it might be believed that the ancients understood it better than we do, particularly if one is to judge after the gigantic enterprises which they have executed, with the aid of machines which might be called primitive or elementary, and of which ours are but the complicated form.

(p. 90.)—We have said that necessity alone was the guide of the ancients on the invention of machinery. Thus, that of mills for grinding corn only goes back to the century of Augustus. Before this period people were content with hand-mills, similar to those to be still seen in Sicily (see Picturesque Tour in Sicily, by M. Houel, p. 91 (1782-87)), and which are but simple household instruments. These mills were quite portable, occupied but little space, and were capable of producing at but slight expense enough flour for the food of a family. There might even be employed for this work the labour of children, and in the dwellings of the rich slaves were charged therewith. But when luxury became introduced into Rome, and that the requirements became greater in proportion to the riches of certain individuals, whilst the people became poorer by so much, the great, whose ambition it was to govern, set themselves to dominate public opinion by giving magnificent festivals, with distributions of goods and bread.

(p. 92.)—It was then that hand-mills became insufficient. People were obliged to have recourse to undertakers in order to be able to supply these immense distributions. These men, covetous of gain, were under the necessity of paying a great number of slaves, and even employed criminal means to procure them. (Thedosius in 389 passed a law to repress these disorders, which persisted even to his time (Lebeau, History of the Low Empire, liv. 24), seeking the means of diminishing the number of hands by the use of agents more powerful and less costly, such as machinery could furnish, and thus water-mills were invented.)

The period of this invention is fixed in a precise manner by the following epigram, made on account of it (see MS. Anthologia of the Imperial Library and Memoirs of the Academy of Inscriptions and Belles Lettres, vol. ii., p. 408, edition in 8vo). "Girls, occupied in grinding the corn, cease thus fatiguing your arms; you may sleep as you list, and leave the birds to sing, announcing thus the return of morning. Ceres has commanded the Naiads to do the work you were engaged on: obediently they leap up to the top of a wheel, and cause to turn an axle. The axle, by means of the spokes which surround it, causes it to turn rapidly the weight of the hollow millstones which it draws with it. Thus are we brought back to the happy times of our primitive fathers, and gather, without labour, the fruits of the works of Ceres."

It would seem from this epigram of Antipater that the use of water-mills had not commenced until the time of Augustus, and Vitruvius, his contemporary, gives in his tenth book a description of these mills, which might even serve as a commentary on the Greek epigram. Strabo (Book 12) remarks also on a machine at that time very rare, and of which he speaks as a singularity, when describing the town of Cabires and the palace of Mithridates. It is not doubtful that the mills which are yet to be seen in Asia Minor and all through Greece are copies of these ancient mills, and for that reason it is of interest to describe them. Moreover, it is probable that these same machines have been transmitted to us by reason of the intercourse we have had with these countries. It may even be believed that their establishment with us does not go farther back than the time of the Crusaders, and that previously we had no knowledge of water-mills, wind-mills, or wells with chains of buckets.

(p. 94).—The Crusaders, on their return from their foreign expeditions, brought home with them these and many other machines, which have been perpetuated and perfected by reason of our requirements and our learning. It is not the less curious to see from whence they come, how much we owe to the Eastern peoples, and what we have added to their inventions.

I have already given (in the Letters on the Morea, &c., 2nd part, p. 41) a drawing of a well which seemed to me to fulfil cheaply the same object as machines of much more complicated design. I may say the same of two sorts of mills which I had occasion to sketch at Lampsaki: they are of such great simplicity that the mere inspection of the drawing should be enough to make the mechanism intelligible.

This mechanism in the first mill in question (pl. 5) merely consists of a horizontal wheel divided into rays or spokes, hollowed out so as receive and to oppose the greatest resistance to the water. The iron axis of this wheel passes through the lower millstone, fixes itself by means of a tenant in the form of a H, of which Vitruvius speaks, to the centre of the upper millstone which it puts in movement. [Note.—This iron, which the Latins called "*subscus*," is called "*Cothb*" by the Arabs: they have also given this name to the poles of the world, and they imagine that the sphere of the heavens turns on them and round them as if upon pivots (D'Herbelot, *voce* "Cothb").]

So far there is nothing particularly ingenious in the mechanism, but that which really appears to be so is the care taken, not only to take advantage of the small supply of water, with great skill, but even to double, as it were, its action. If water had been abundant in supply and at all periods, its fall alone would have been sufficient to furnish the movement to a vertical wheel, such as that of our mills; but it was requisite to meet the difficulty of its insufficiency at certain times, and also to get rid of its excess at other periods. For this purpose the canal is so built as to contain or carry the quantity of water strictly necessary. The excess overflows, before reaching the end of the canal by means of a sluice-gate indicated in the drawing.

To this end of the canal has been adapted a long box, having the form of a reversed pyramid; made of planks sufficiently thick, adjusted and held together by means of strong ties. The joints are caulked and pitched in the same manner, as Vitruvius says, as a vessel's seams. This box extends over the breadth of the canal. Its other extremity, which passes through the wall of the mill, is much narrowed, and has but a small opening at its lower extremity, directed towards the spokes or paddles of the horizontal wheel. The water precipitates itself into this box, which presents a plane inclined at about 45°, and finding its only outlet, this narrow opening, rushes out with a violence that can be easily conceived. In fact the accumulated weight of the water increased in action by the height of the fall, added to its volume, which becomes, as it were, doubled by the narrowing of the walls of the canal, should give a very strong impulse to the jet as it escapes from this sort of funnel, its action exercising itself entirely on the spokes or buckets which it acts upon from the side, and which are arranged horizontally, and hollowed out so as to receive normally this jet, which must, therefore, cause the wheel to revolve with sufficient rapidity, and, perhaps, with more than could be furnished by a complication of wheel-work.

(p. 97).—We had an opportunity of examining another mill, wherein the same system of motive-power and the same mechanism have been employed with slight modifications.

At first sight they seem to offer few advantages, but yet fulfil the intentions of the builders. The canal or watercourse is raised several feet above the level of the wheel; but the conduit into which the water falls, instead of offering the form of a reversed pyramid and being disposed diagonally, presents a frustum of cone and is placed vertically.

The water enters it by a narrow orifice at the summit, and filling the column—broad at its base—escapes from it by a tube which penetrates it horizontally, and which is placed at the level of the wheel. Moreover, instead of allowing the surplus supply, as in the previous example, to run to waste, it is utilized by dividing the current so as to make the water give motion to two wheels, thus twinned and joined one to the other. With this object the water-course is enlarged towards its extremity, and divided into two equal-sectioned channels by a diaphragm, or division of thick planks, each fitted with a sluice, and which are in connexion with the two cones into which the water precipitates itself at the same time, thus putting in motion the double mechanism.

From this very complete description given by Castellan it will be evident that the mill he speaks of is of precisely the same nature as that described by M'Adam, and shown by him to be of common occurrence on several of the countries of northern Europe.

Moreover, it is to be noted that he speaks of those mills being prevalent over all Greece, and to be found in Asia Minor; lastly, they are in Greece, at least in the example described by him, more carefully constructed and more skilfully disposed than in those northern examples already described. Unfortunately, as to the origin of the mechanism or the historical side of the question, there is nothing but what may be interpreted from the epigram of Antipater; and although the wording of this would allow of its being understood to refer to a water-mill with *horizontal* buckets, such as described by Castellan, the terms employed are not sufficiently clear, nor sufficiently technical, to prevent them being equally applicable to a mill-wheel with *horizontal axis and buckets*, such as are usually employed at present in these countries. Two further points are also worth calling attention to: 1st, that occurring in the citation from the Montgomery MSS., p. 321, given by M'Adam, where it is said: "*the water-wheel was fixed at ye lower end of ye axle-tree, and did run horizontally among ye water, a small force driving it.*" This most important remark proves that the former users of this form of water-mill had ascertained by experience the advantage it presents in being able to work *when drowned*, that is when completely covered by water. Now this is precisely one of the advantages claimed for the most modern and most perfect forms of turbine, working as they do with remarkably small heads of water. 2ndly, in the citation from Lockhart's "Life of Sir Walter Scott," describing his tour in the Shetland Islands, he describes the conditions affecting the rude mill he meets with at Loch Cleik-him-in. "It is divided," he says, "by a rude causeway from another small lough, communicating with it, however, by a sluice for the purpose of driving a mill; but such a mill!" Now it is evident that the upper lake was taken advantage of to retain or pond a head of water, while the lower lake, being allowed to find its own level, gave thus rise to a difference of level or head of water utilized for driving the mill, the sluice being established to allow the overflow of floods or high waters. It is evident, therefore, that the ancient users of these mills knew how to create the necessary head of water, simply by cutting off a part of a lake or other surface of water by a dam or wall, taking care to insert a sluice to meet the requirements of the necessary occasiona overflow. But this simple device, so easily understood in the case of a lough, is equally applicable in the case of small tidal estuaries or inlets, such as occur with great frequency on the northern or Cantabrian coast of Spain, where I had occasion to sketch such a mill and to witness the most simple, practical, and ingenious use of the tidal force, a problem often talked of in scientific journals in these countries, but as a matter of fact never yet here realized, to my knowledge, up to the present. Anyone acquainted with that Cantabrian coast, or who even consults the Admiralty map of the Bay of Biscay, knows, or can learn, that it is very bold, rocky, and accessible, for even small shipping, in only a few points. It is penetrated by a number of small inlets narrow and rocky, which receive the many streams coming from the foot ranges of the Pyrenees, and which, therefore, can be traversed by a wall of no great length, and consequently of not excessive cost of construction. Such conditions present themselves both to the east and to the west of Comillas, a fishing-village about 22 miles west of Santander (and not even mentioned in any of the modern gazetteers).

At a distance of about 2 miles to the west of Comillas there occurs such a small inlet, relatively narrow, and presenting high banks on either side; across this, at a short distance from low-water mark, a wall had been thrown, so as to retain the waters of a high tide, and thus create a water power; on the seaside was found established one of these corn-mills (Plate III.), with horizontal wheel and radiating buckets or arms, quite similar to those described and represented in general appearance by the accompanying sketch taken on the spot, during the course of an excursion made to the locality in the summer of the year 1857–58, or thereabouts. A sluice established in the dam wall allowed of the intake of the tide, and its being retained for the purpose of working the little mill when necessary. These mills correspond in the simplicity of their structural arrangements with what has been described of the Shetland and other Scotch mills, so completely that nothing further need be added than a reference to the sketch. They are mostly intended for purely local and even personal wants, and one would rarely see more corn coming at a time to be ground than can be carried on an ass's back. The great interest of them lies in their adaptation to the tidal rise and fall, and the suggestion they convey to other people, is sufficiently important to be taken notice of. It is probable that further research in these countries would determine the existence of many other such mills, and perhaps allow of some information being gathered, as to the period of their introduction, which the ignorant peasantry would, in most cases, be inclined to attribute to the "Moors." I am obliged to admit, however, that I have never yet come across mention of them in any of the several works on Spain that I have read, with the exception of

Townsend's "Travels,"[1] in the second volume of which the following occurs :—

(pp. 59, 60).—"*Journey from the Asturias to the Escurial.*—As we approached the confines of the principality the scene changed greatly; for, instead of soft and swelling hills, covered with grass or clothed with woods, scarcely anything was to be seen but stupendous rocks of limestone—some in long ridges, rising perpendicular to the height of two or three hundred feet, others cragged and broken into a thousand forms. In this route the way winds chiefly by the side of little rivers, brooks, or torrents, till it has passed the summit of that vast chain of mountains which separates the Asturias from Old Castille; yet in the midst of these stupendous mountains a few rich valleys intervene, each with its little village, in size proportioned to the extent of land susceptible of cultivation. In the ravines through which we passed I observed that all the mills have horizontal water-wheels. These grind the corn very slowly, being fed by single grains; but then to compensate for this defect, they place many near together, and the same little stream, having communicated motion to one wheel, passes in succession to the rest. These are well suited to a country abounding with stone for building, where water runs with rapidity down a steep descent, and where despatch is not required": since, however, Comillas is hardly known to geography, its environs and the coast along may be equally ignored by travellers.

From those different examples of this class of water-mill it may be fairly concluded that their origin can hardly be ascribed to the Danes, finding them, as we do still, on the Cantabrian coast and in Greece. On the other hand, nothing so far gives us any clue to their origin or introduction into the Mediterranean countries. There is fair grounds for presuming that they really come from the East or from Asia Minor, where all the arts were developed to so high a degree from the very earliest times known to history, and that their remains or presence in these countries and in the north of Spain and in these isles may be regarded as offering testimony of the frequency and continuity of the commercial relations between the southern trading peoples and the "Hyperboreans" or northern races inhabiting these islands, Holland and Scandinavia. Ground is therefore furnished for research in that direction, and, mayhap, it would be neither fruitless or uninteresting. It may at once be pointed out that the *Senchus-Mór* contains some notices of mills which are worth quotation. In vol. i., p. 125,

[1] Three volumes. Published in London, 1791.

the eight parts of the mill are referred to under the heading "*Distress*," "for the eight parts which constitute the mill, the 'spring,' the mill-race, 'the land of the pond,' the stone, 'the shaft,' 'the supporting stone,' 'the shaft stone,' 'the paddle wheel,' 'the axis,' 'the hopper (cup comla),' *so called* because *originally* the bond-maid was bound to mind it." These different parts as mentioned fit in fairly with those pertaining to the *mills with horizontal wheel* already described.

At p. 141 this is commented on as follows:—"*For the eight parts which constitute the mill, i.e.* about the eight parts which are necessary to the mill, as we shall explain hereafter. '*The spring*,' *i.e.* from which water comes, *i.e.* the water which is drawn from the spring rests on the land of the pond. '*The millrace*,' *i.e.* from the spring to the pond, '*The land of the pond*,' *i.e. they are* the first requisite, *i.e.* which is at the head of the 'en,' *i.e.* the water. '*The stone*, *i.e.* the second requisite, *i.e.* the upper stone. '*The shaft*,' (mol), *i.e.* the third, *i.e. this is* its own *proper name*. The '*supporting stone*,' *i.e.* the fourth, *i.e.* the lower stone. The '*shaft stone*,' *i.e.* the fifth, *i.e.* the little stone which is under the head of the shaft, and on which the shaft turns. '*The paddle wheel*' ('*circel*'), *i.e.* the sixth, *i.e.* ('*dar a cel*') over its paddle the water flows. '*The axis*,' *i.e.* the seventh, the burden of the shaft is on it, *i.e.* the '*ganuel*.' '*The hopper*' (cup) *i.e.* the eighth, because it drops the corn out of itself into the upper stone, *i.e.* the '*tual*,' *i.e.* the perforated iron. The '*Comla*,' *i.e.* they are all *in place of* a bond-maid to a person, *i.e.* the *whole* mill, *i.e. the mill* common to them all. *For the bond-maid was bound to mind it*, *i.e.* for she was bound to mind everything of these which a person wished; or everything that one has, which is worth a '*cumhal*,' is entitled to a gate ('*Comla*') to protect it, *i.e.* the whole mill, *i.e.* by a gate ('*Comla*'), the restitution of which should have a stay of one day; because the bond-maid ('*Cumhal*') is bound to protect it, and one of its parts has a stay of one day, *i.e.* by a gate ('*Comla*'), the value of which is four pennies for every man in the place. If both are not supplied, it is full honour price; if less, it is half honour price." There are several entries in vol. iii. relative to "*mills*" of which the following is interesting, p. 391:—"And when a man has the site of a kiln, or of a mill of rightful land, or when he shall purchase, *such* it makes a native freeman of him."

Also similar entries in vol. iv., but not bearing on the question of construction or form.

In the preface to volume i. of this work (1864) the origin and antiquity of it is elucidated and commented on, and it may be gathered therefrom that certain parts of it were of high antiquity, "such as the first judgment respecting distress," by Sean, son of Aighe, who is supposed to have flourished about 100 B.C. It is reasonable to assume that the matters forming the subjects of the laws were themselves still more ancient, and that the mills referred to therein were of this class, and, consequently, it may be inferred that water-mills of the style to which the "eight parts" already mentioned may be considered as belonging were already ancient in Ireland 100 B.C. This inference would certainly be in harmony with the details contained in Messrs. Bennett & Elton's "History of Cornmilling," vol. ii. (1899), "Water-mills and Wind-mills."

They examine and discuss the references to be found in the classical authors with reference to water-mills, including the epigram of Antipater of Thessalonica (to whom they assigned a date of 85 B.C., while Smith, in his "Dictionary of Greek and Roman Biography," places him between 10 B.C. and 38 A.D.; and Hafer in the "Nouvelle Biographie générale" indicates merely that he lived under Augustus and Tiberius, *i.e.* between 63 B.C. and 37 A.D. They state (p. 5), "The extended researches of modern times have, perhaps, brought us into closer view of actual facts; the sum and substance of these, as will be shown, establishing water-milling as of Greek origin, at a period only shortly preceding the birth of Christ." At p. 6 they describe the Greek mill, *horizontal type,* and cite the epigram of Antipater as the earliest known allusion thereto. They give two translations thereof, one by Tennant, in verse, as follows:—

> "Ye maids, who toiled so faithful at the mill,
> Now cease your work and from those toils be still.
> Sleep now till dawn, and let the birds with glee,
> Sing to the ruddy morn, on bush and tree.
> For what your hands performed so long and true,
> Ceres has charged the water-nymphs to do."

"The epigram is to be taken as recording the invention of water-milling about 85 B.C."

They also examine and discuss the mention made by Strabo as to the water-mill having existed at Cabira in the time of Mithridates of Pontus, and called by him "hudraletes" without further description, and which word is agreed on by commentators to indicate a water-mill. [They add as a note, "In some Latin translations of Strabo this word is stated to be omitted, as in that of Jansen" (Amsterdam, 1652, ii., 196).]

Strabo does not distinctly claim it as a novelty, nor yet as a Cappadocian invention. Page 8, they examine the mention made in Pliny's Natural Hist. xviii. 23, and point out how doubtful is the true meaning of the passage. Page 9, they say, "In classic times no evidence occurs indicative of the nature of the Greek water-mills; and in modern ages its existence has been almost entirely overlooked. Still, there are at hand abundant means not only of proving its existence as above, but of judging, from other sources, of its form and construction." Page 10, "Its use spread throughout Europe, till about the eighth century it was generally superseded by the larger and more powerful Roman water-mill, and at the present day in Europe and Asia either the mill itself is found in use, or its prehistoric relics testify to its former existence. In Greece it survived till late in the Middle Ages. The sixteenth century French naturalist and traveller, Belon, saw at Mount Athos, in Greece, mills driven by streams no thicker than a man's arm, the wheel small, and 'made in a different manner to ours,' but, nevertheless, capable of turning millstones as large as might be desired. 'In this mountain-mill overlooking the Ægean Sea, with its water-wheel differing from that of the French mills, we may, doubtless, recognise the still perpetuated, primitive little machine which evoked the wonder and inspired the ode of Antipater of Thessalonica.'"

As on Mount Athos, so in the Holy Land, on Mount Lebanon, and Mount Carmel, the same little mill was seen in 1668 by D'Arvieux, the politician and traveller. "The mills on Lebanon and Carmel bear a great resemblance to those found in many parts of Italy. They are exceedingly simple and cost little. The millstone and wheel are fastened on the same axis. The wheel (if it can be so called) consists of eight hollow boards, shaped like a shovel, placed across the axis."

"Italy also is thus seen using the mill as in the time of Pliny." (p. 11.)—In France the mill is described by Paul Henzer in 1588 (Itin. Gall. 56, 262): "On the Garonne they have a curiously made mill, in which the wheel is much smaller than in ours, and has a shaft inserted in the centre of the floats or vanes, which revolve with great rapidity." "The wheel is not set perpendicularly upon the water, but moves horizontally in it. The millstones are much larger than ours, and are composed of so many pieces, skillfully joined together, that one stone is estimated to be worth a thousand crowns."

At p. 12, they give details as to the "*Norse mill.*" In Northern and Western Europe, and in Asia, the primitive mill, with its horizontal water-wheel of Greek type, has been in general use from prehistoric times and in some places survives still. The mill had early become established in Britain. There seems to be no remaining evidence of its use in England; but there can be no doubt that when the mill was equally common in Scotland, the Isle of Man, and Ireland, it was also ordinary in this part of the kingdom.

(p. 13.)—In Ireland, over half a century ago, the discovery of relics of water-mills of remarkable form led to a systematic exploration, which eventually established the fact that the Norse horizontal mill had been extensively in use there from, at all events, the seventh to the eleventh century. The Irish laws ascribed to King Cormac, of the third century, as well as certain traditions of the same king, seem to refer to these mills; but the actual date, both of enactments and legends, is so extremely doubtful as scarcely to warrant their acceptance as evidence of any Irish mills existing in the third century. The Kilkenny Archæological Society, under whose auspices the investigations were carried out, found the black oaken remains of these ancient machines in the dried-up channels of old streams, covered sometimes with turf, and sometimes with beds of clay from 6 to 10 feet thick, the clay having evidently been purposely placed upon the mill, in some time of rapine, to conceal them from marauders.

At Ballymartin was found, at a depth of 6 feet below the surface, a framework of black oak, placed across traces of an ancient water-course. It measured 11 feet by 6 feet, and supported a flooring of boards 2 inches thick, and some of them 3 feet wide—all having been evidently dressed with the adze. At Bramblestown, near Gowran, in deepening a river-course, a similar platform framework, together with fragments of millstones, was exposed. One of the latter had been 2 feet 5 inches in diameter, and the marks of the position of the rynd on the upper stone was still apparent. (Kilk. Archæolog. Soc., i. 154.)

(p. 14.)—Discoveries at Bantry and Mallow revealed the same general features; but here also were found water-troughs of black oak, about 12 feet in length, which had evidently been used for the purpose of conveying water to the mills to create a fall. The oaken shaft or spindle was also found. In the neighbourhood of these discoveries is one of the raths or enclosed prehistoric camps. Two pair of millstones here were neatly finished and well faced, the upper being 2 feet in diameter, and 1½-inch thick at the eye at the centre. The stream was very small, and had a fall of only 5 feet. At Shannacashel, Co. Cork, the mill seemed to have been burned down; but on the floor were a pair of millstones, a wooden shovel, and the shaft of a wheel. The upper stone was 8 inches thick and 2 feet in diameter, the understone being only 3 inches thick at the centre. The shaft, about 6 feet in length, was rather of an ornamental character, and contained at the lower end a series of mortises for the reception of the water-vanes. The mill was found buried deeply under turf. In 1838 three relics of the floats or vanes of a Norse mill-wheel were discovered at Banagher, Co. Derry, all (except one of yew) being of black oak. They were of scoop-like shape, the dished-end serving to catch the force of the stream more effectively than a flat board. Each float was 14 inches in length, perforated and fitted with a projecting ledge at the narrow end for fixing into the shaft.

(p. 15.)—One of the most complete relics was described, in 1856, by Mr. M'Adam (*Ulster Journal of Archæology*, 1856, p. 6).

(p. 16.)—In Scotland the mill has long been known under the designation "Norse mill." In the Islands of Colonsay and Oronsay the small meal-mills built across streams, and now driven by ordinary vertical wheels, were anciently worked by horizontal Norse-wheels, and known under the term "*Muilean-dubh,*" or black mills. One of them has been pointed out at the farm of Ballerdomin-mor. The sides of the small stream had been built up with dry stone-walling for a length of 8 or 10 feet to a height of about 4 feet, with a circular recess, in which the horizontal wheel turned. The stream was bridged by four or five long undressed stones, upon which the mill hurst had been constructed, and in one of these remained a portion of the hole through which the spindle from the wheel beneath had passed to the millstone. Other ruins are mentioned at Machrines, Bulnahard, Uragang, and Ardskinnish. No information could be obtained as to these latter water-mills having been utilized for grinding meal during living memory, though it was said they had been to some extent utilized for bruising malt for making smuggled spirits. Throughout the district the Norse-mill, either in use or in ruins, abounds. Wherever a small stream runs rapidly down to the sea may be found a series of these little mills at no great distance from one another (Soc. Scot. Antiq., 1883, 292). In some instances a double millrace running under the structure with a wheel and pair of stones at each end of it, the mill, of course, possessing no cog-gearing, and a separate wheel being thus always required for each pair of stones.

(p. 19.)—In Lewis and the Shetlands the Norse-mill is still common, being continued, says Professor Mitchell, rather from choice than from necessity or ignorance. The same authority has given an excellent description of these curious survivals of bygone times. The mills are small and entail no great expenditure either of building or working. They are convenient and easy to operate, and, though grinding but slowly, are amply able to meet the small wants of the country-side. "Many of the people who build these mills know as well as any of us the general superiority of an overshot water-mill and the unfitness of the wheel they use to do anything more than the small amount of work which they require of it, and not a few of them thoroughly understand the waste of power in the mill; but, to use the words of one of the crofters, 'If I get all the power I need from the burn, as it flows past, where is the foolishness in leaving the rest unused?'"—"Past and Present," Mitchell, 1876, 39.

At p. 20 is given an illustration of a Shetland mill (exterior view), as shown in Mitchell's sketches, the little hurst of timber, roofed with thatch or turf, is of merely sufficient size to contain the mill. There is no resident miller. The door usually stands open to all comers, precisely as in the ancient laws of Bohemia, together with the Church, the Court, and the Hall, is stated always to do.

(p. 22.)—The same type of mill is described in a paper read by Mr. James Jardine to the Hawick Archæological Society, to have abounded in that district, a list of no fewer than fifty-one being enumerated within a radius of about eight miles. The usual diameter of the stones was from 2½ to 3 feet, and the upper was usually concave on the lower side. When the controversy as to the identity of the early Hibernian mills was in progress, Mr. R. Chambers, who had then recently visited Norway, recognised the type as that of the horizontal mills of that country, and published the fact in "*A Tour in Norway*," in his popular *Journal*. The Norwegian Norse-mill is still to be found in ordinary use, "housed in structures as rude as may have been that seen by Antipater nearly 2000 years ago."

(p. 23.)—Mr. E. C. Hart (Robinson & Son, Rochdale) remarks of the Norwegian mills:—"In western Norway we find many of these little mills, in all sorts of places. The spindle is made out of a pine tree, with vertical teeth, there being paddle-blades at one end, and stones at the other."

(p. 24.)—In Roumania (valley of the Danube) they have been seen recently at work by Mr. Wilson Marriage, of Colchester, who entertains a high opinion of their value for the kind of work required from them. Mr. Marriage, in a contribution to *Milling*, accompanied by a photograph, says: "The Norwegian mill bears a striking resemblance to the mills one sees in the Carpathians; and I should think that the mills of Norway and Roumania are almost identical in the method of working. A wooden upright has a home-made turbine at the foot, and drives a single pair of stones. The mill is started by shifting the wooden flume conveying the water of the mountain stream on to the wheel. I saw several of these mills at work with no attendant. The owner brings a supply of grain, fills the hopper, sets the mill going, locks the door, and does not need to return for a day or two. It is a far cry from Norway to the Carpathians, yet we see here two mills which might have been constructed by the same workman, so similar are they in almost every detail, from the foundation of rough stones to the 'log cabin' mode of building."

(p. 26.)—In the "Great West" of China the same horizontal mills were seen in frequent use, within the last two or three years, 1895 to 1899, by the traveller, Mrs. Bishop (Isabella L. Bird), F.R.G.S., who, in a recent communication to us, states that she saw them in large nnmbers, especially on the great Ching-tu plain, where no doubt they have been in continuous use from very primitive times.

Starting in the present paper with the occurrence of this form of horizontal water-mill in Ireland, during ancient times, and following the descriptions of the different authors cited, it has been found to exist or to have existed and been in use in Scotland, the Shetland and Orkney Islands, in Sweden and Norway, in France, in Spain (on the northern coast), in Italy, in Roumania (in the Carpathians), in the Morea, the Holy Land, and Asia Minor, and, finally, it is last seen in western China, by Mrs. Bishop, a most intelligent and observing traveller. The writers last cited, Messrs. Bennet and Elton, seem to rely much on the epigram of Antipater, as placing the invention of this form of water-mill in Greece, and seem disposed to date the invention at about 85 B.C. But taking into consideration the wide extent of Europe and Asia, over which its former and recent presence has been determined, and the still more important fact that it has been frequently met with by Mrs. Bishop on the western plains of China in her very recent travels in that country, that these plains adjoin the great central plateau of Asia, from which it is generally admitted the earliest emigrations of a civilized race proceeded towards the west, it is not exceeding the limits of the probable in presuming that the water-mill in question formed part of the industrial appliances developed by the people who inhabited the central plateau and its dependencies, and that it passed with the successive hordes of emigrants in their slow march towards the west, and must therefore be considered of very high antiquity, much more ancient than even the introduction of the arts into Greece. To substantiate this presumed antiquity, it would be necessary to bring forward further examples from the three eastern countries, and thus prove the connexion of the different links of the chain. Meanwhile every new example, if carefully described, helps in the elucidation of this very interesting problem, and must be considered as having a certain historical value. As bearing on the question, and as tending to illustrate one of the details, there is submitted herewith a stone in which has been mechanically worked a conical cavity, and which has all the characters of a socket-stone of one of these water-mills. It is the property of the Rev. P. A. O'Reilly, c.c., at present administrator of the parish of Killala, County Mayo, and he has very kindly entrusted it to the author of the paper, giving at the same time the following details :—"The stone was found about eight years ago at Ardmore, in the Mullet, about three miles from Belmullet, at the bottom of a cut-away bog, that is to say on the gravel." It has been in Father O'Reilly's possession for the last four years. I had the occasion of seeing it in 1898, and was much puzzled to account for the fineness of the lines of wear at that time. Sir John Evans also saw it, and pronounced it to be a socket of a water-mill, and subsequent consideration of the whole question leads me to the same conclusion. I have therefore prepared photos of it, and made a section to accompany the present paper. (Plate IV.) The material of the stone is pure white crystalline quartz, and the shape shows that it is a water-worn pebble or cobble, such as might be found on a sea-shore or in the bed of a mountain torrent.

VII.

THE CISTS, DOLMENS, AND PILLARS, IN THE EASTERN HALF OF THE COUNTY OF CLARE. By THOMAS JOHNSON WESTROPP, M.A.

[Plates V. and VI.]

[Read April 14, 1902.]

So important are methodical field surveys to antiquaries, and so few persons have even attempted to treat exhaustively the early remains of any of the counties of Ireland, that I venture again to trespass on the time of the Academy by further notes on the dolmens of the county Clare. The present paper is an attempt to give the position and description of all the oldest sepulchral remains, cists and pillars of rough stone, in the baronies of Upper and Lower Bunratty. I do not anticipate that it will prove exhaustive; it is still probable that other cists may be found in the northern portion of upper Bunratty. There, among a network of fields with rocks and boulders (very like dolmens when seen at a little distance), some actual cists may even yet be found. It is an undulating country difficult to examine without passing through every valley, if not through nearly every field, and on this account this paper only claims to contain descriptions (or notes where the monuments have perished undescribed) of the eleven dolmens in Upper Bunratty, and seven in Lower Bunratty, as marked on the maps of the Ordnance Survey of 1843, together with ten which I have been able to add to the list of the first barony during a series of researches from 1870, but more especially since 1892. I hope to continue these notes to include the other dolmens of Clare.

This paper is a continuation, or rather an expansion, of one—"The Distribution of Cromlechs in the County of Clare"—read before the Academy in May, 1897, and (as any detailed descriptions of the Bunratty dolmens in Mr. Wm. Copeland Borlase's book, "The Dolmens of Ireland," were from my notes), I must here ask forgiveness for any repetitions needful for the completion of this paper.

Sections 1 and 2—The Baronies of Bunratty.

The dolmens in the district of Bunratty have been strangely neglected by previous antiquaries. None have been noted in the Ordnance Survey letters; in either of Miss M. Stokes' lists of Irish dolmens, or in Canon Dwyer's "Diocese of Killaloe." Mr. James Frost only notes Croaghane and its destroyed neighbour.[1] Mr. Borlase gives my notes and illustrations of the remains at Caheraphuca, Caherloghan (with the cists wrongly located as in Moymore in the barony of Upper Tulla), Rylane, Knappoge, and Ballinphunta. Plans are given of the three last.

The baronies of Bunratty extend from the borders of Galway to the Shannon. The northern extremity is a grassy and hilly district abounding in small lakes, and the frequent occurrence of the place-names of "Derry" and "Durra" confirm the allusions in early history, showing that it was for the most part wild and wooded. South of this lie large tracts of bog, then a region of crags or grassy districts (in part well cultivated) with many forts of earth and stone. Along the south lie the rich corcasses of the Shannon.

is conventionally divided from the barony of Tulla, but for archæological purposes the whole district may be counted as one from the Fergus to the hills of Slieve Bernagh and Slieve Aughty.

The tribal arrangements even as recorded in the earliest legend and history are probably too late to have any bearing on the dolmens.[2] We may briefly note that Lower Bunratty nearly corresponds to the ancient Tradree (Tradraighe), and is clearly marked by the two streams—the Rine or Gissagh[3] flowing into Latoon creek to the north, and the Owennagarnagh or Raite to the east. This ract, as noted

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[1] "History and Topography of Clare" (ed. 1893), p. 11.

[2] The age of the smaller cists is very doubtful. Some may be post-Christian. The "Tripartite Life of St. Patrick" (ed. W. Stokes, p. 123) mentions a "Giant's Grave" 120 feet long, dating 100 years before the Saint's mission. According to the Leabhar na hUidhre (*Revue Celtique*, vol. xiii., 1892, p. 64) Fothaidh Airgtheach, King of Erin, killed by Caeilte in A.D. 285, was buried in a cairn in "a chest of stone." The alleged erection of the Clochogle dolmen, near Ballina, in the sixth century, is not supported by the original narrative, and in any case could only imply a secondary burial. See Mr. H. T. Knox in Journal of Royal Society of Antiquaries of Ireland, vol. xxvii. (1893), p. 430, and vol. xxviii., p. 284.

[3] The name is "Misagh" in MSS., R.I.A., 24 D 10, a poem "on the Franciscan Monastery (Quin) on the Misagh." The stream is "the Gissagh at Quin" in Hugh Norton's account of Clare, 1695, MSS. T.C.D., I. 1, 2, p. 235. He calls the Sixmilebridge river "the Kney." The "Gossogh" and "Gosseogh" appear in early seventeenth-century maps.

before, was the first portion of county Clare overrun by the Dalcassians under Lughad Meann, King of Munster, before A.D. 370, and so formed the mensal land of the kings of Thomond, the O'Briens as named in later times. Probably on this account it was seized by the Norsemen in the tenth century, and by the Normans in the thirteenth. It remained the special appanage of the Earls of Thomond till 1712, and was then sold in fee-farm to various English families. No dolmen remains, probably from Tradree having been so long under cultivation.

The northern portion of this barony (with portions of the upper barony, and of the barony of Tulla) forms a rather bleak plain, "the beautiful cold Magh Adhair."[1] It was a legendary settlement of a clan of the Huamorian Firbolgs; and its name contracted from a district to a townland (Tuanamoyri[2] in 1584 and 1685), then to two fields "Moyri," or "Moyross Parks" in 1839, and to a single field "Moyars Park" at the present time.

The oldest allusion to any dolmen in Clare is to that of Knockalappa, or "hill's bed," by Thomas Dyneley in 1680;[3] there is, as already noted, no detailed description of any in eastern Clare till 1897.

The dolmens are here described topographically, and, where possible, in groups; the townland names are always given, and are followed by the sheets of the Ordnance Survey maps, which, with the sections of each sheet on that of 25 inches to the mile, are given in brackets.

We may classify the remains in the baronies of Bunratty as—(1) simple cists—Kilvoydan, Toonagh (three), Caherloghan (six), Ballyhickey, Monanoe (site), Ballymacloon, Knocknalappa, Drumullan (northern), Ballysheen (site); (2) cists, with two or more chambers—Caheraphuca, Ballymaconna (?), Rylane (western), Ballinphunta; (3) dolmen with enclosure—Knappoge; (4) long dolmens—Ballyogan (two, one removed); (5) circle—Clooney (eastern); (6) enclosures of blocks—Dooneen, Clooney (western); (7) doubtful and destroyed—Rylane (eastern), Clooney (blocks), Drumullan (southern) (site), Kilcornan (perhaps multiple chambered), Brickhill (site), Lacht (?) (site); (8) pillars—Knocknafearbreaga (five), Magh Adhair. None of the stones to my knowledge exhibit any sign of dressing, and only one

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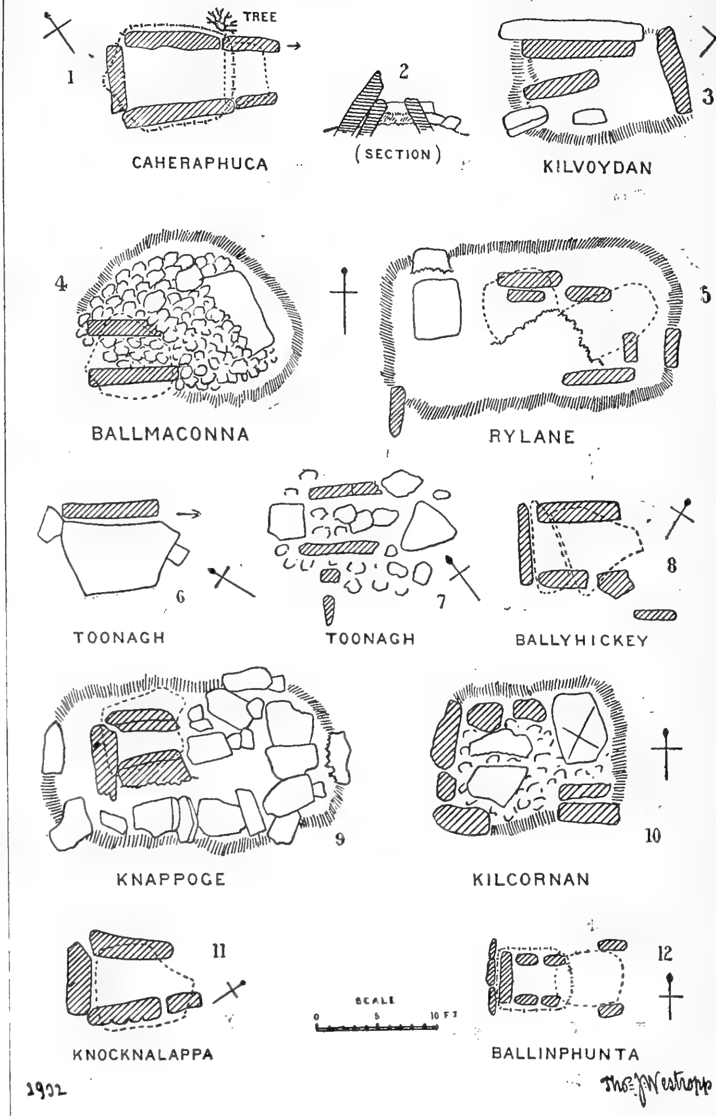
[1] "Circuit of Ireland," A.D. 941, by Cormacan Eigeas, p. 43.

[2] Tuanamoyre in "Castle List," 1584, MSS. T.C.D., Tuanamoree, 1655, Petty's Survey (Vallancey's copy Tuanamoret).

[3] Royal Hist. and Archæol. Assoc. Ireland, vol. ix. (1867), p. 176, repeated by Mr. Frost in "History and Topography of County Clare," p. 543.



Plans of Dolmens in the Baronies of Bunratty, County Clare.

(at Kilcornan) of scribing, whereas hammer-dressing occurs in several of those made of limestone slabs in the districts of Burren and Inchiquin.

(1). Caheraphuca, Inchicronan Parish (O. S. Sheet 26, No. 2).—A very perfect double-chambered cist made of five side stones and two covers lies close to the north west of the main road from Ennis to Gort, not far to the south of the village of Crusheen. It is in perfect preservation, and is a most interesting specimen; but, like every other dolmen (except the closely similar Ballinphunta), known to me in this county, it has been opened. There seem to be slight traces of the earth mound in which it was once embedded. It is of the usual type, getting narrower and lower towards the last. Its axis (as is usual) lies E.S.E. and W.N.W.; and the main chamber, which is exactly 8 feet long inside, tapers from 5 feet 5 inches to 4 feet 4 inches. The sides are

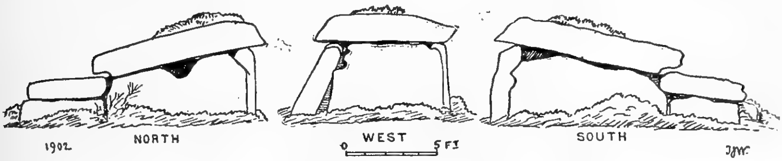


Fig. 13.—Caheraphuca.

4 feet high to the west and 2 feet 7 inches to the east, the lesser and lower chamber being only 18 inches high at its eastern end and 4 feet long. The block closing the western end measures 5 feet 3 inches by 4 feet 2 inches by 12 inches. The north block of the larger chamber, 7 feet 3 inches by 13 inches thick; the southern, 8 feet long, 4 feet to 2 feet 7 inches high, by 13 inches thick. The blocks are of the coarse and irregular gritstone of the district and exhibit no dressing. A fine and picturesque hawthorn springs at the north side near the junction of the two chambers, and is, I fear, slowly overturning the structure. The dolmen has been illustrated by Mr. Borlase.[1] Of the defaced Caher, which gives its name to the townland, I have failed to find any legend. It is possible that it was deserted at an early date, and the people (before the townland name was fixed) believed that it was haunted by the phuca—that mischievous goblin pony or goat which, even in this age of unbelief, is still a reality to some of the peasantry. This connexion of the phuca with forts and

[1] "Dolmens of Ireland," vol. i., p. 82. See plan, p. 88, fig. 1, *supra*, and Plate V., fig. 1.

rocks is sufficiently marked in other places; as at Carrigaphuca, in Cork, Clochaunaphuca in Kerry, the Dun of Clopoke in the Queen's County, and the dolmen of Poulaphuca in the Burren, and other examples might be cited.

(2). Kilvoydan, Inchicronan Parish (O. S. Sheet 26, No. 14).—A defaced dolmen, which occupies a beautiful position on the summit of an abrupt grassy hill, with a fine view of two lakes and the ivied peel-tower called O'Brien's Castle. To the north, at the foot of the hill and near Durra House, are the very ancient graveyard of Kilvoydan,[1] with a large basin stone and a dry holy well, and the remains of a ring fort.

The dolmen is to all appearance an example of the very curious (though scarcely credible) type which occurs near Louisburg, in Mayo, as figured by Mr. G. H. Kinahan, of which, as Mr. Borlase points out, examples occur in Portugal. These structures are formed of sloping blocks overlapping till they nearly meet at the top, and then roofed with small slabs. The section of the Kilvoydan cist closely resembles this type, as may be seen in the illustration (p. 88, fig. 2, *supra*); but after careful consideration it seems more probable that the slipping inward of the sides tilted the massive cover over the north side, against which it now leans. The cell is 12 feet long, with single blocks to the north and south. These measure, respectively, 9 feet 6 inches by 18 inches thick and 5 feet by 20 inches thick, being at present only about 3 feet high. The cover measures 11 feet 8 inches long, about 6 feet wide, and 22 inches thick. All the slabs are of massive gritstone or conglomerate.[2]

(3). Ballymaconna, Kilraghtis Parish (O. S. Sheet 26, No. 10).—Not far to the west of Kilvoydan three other monuments lie near Kilraghtis church, and with the first named may be called the Kilraghtis group. The district is diversified and interesting, formed by a group of low rounded hills with a curious fortress-like outcrop of stratified rock at Dromgloon. The church was called "Kilrathusa" in the Papal taxation of 1302, and is at present a plain building of the later fifteenth century.[3]

The cist lies in the remains of a cairn on the slope of the hill to

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[1] Not the Kilvoydan near Corofin described by Dr. MacNamara in Journal R.S.A.I., vol. xxx. (1900).

[2] See section and plan, p. 88, figs. 2 and 3, *supra.*

[3] The fields in which these dolmens stand (we were told) were a few years ago covered by an assembly of myriads of rats. The great meeting was held for several days, and then broke up, and marched eastward in squadrons which must have dispersed as they went, for they could only be traced for a couple of miles.

the north of the church. It seems to have two chambers, but is much buried in the cairn. The principal cell is formed of two massive blocks rising 3 feet above the stones and 7 feet long, being about 3 feet apart and tapering eastward. The cover is nearly level, and is a strong slab of gritstone, over a foot in thickness and about 7 feet square. Both the north side and the east end are deeply buried in small stones, which nearly fill the interior.[1]

A large slab 6 feet 6 inches long protrudes from the cairn about 9 feet from the end of the cist, and may be the top of a second chamber; it does not seem to rest on side blocks. The dolmen is locally called the "Lobba." The names of Dermot and Grania seem to have passed out of local memory at this place.

(4). BALLYOGAN,[2] Kilraghtis Parish (O.S. Sheet 26, No. 10).—On the eastern slope of the same hill, in the adjoining townland of Ballyogan, lie the foundations of a large and massive stone ring-wall called Cahereiny; it has the remains of a souterrain, but is most completely defaced. A fort-like knoll of rock juts up not far away, rising from a cultivated field.

(*a*) The bohereen to the west of the caher did not exist when the O. S. survey of 1840 took place; but the older labourers remember its construction, and state that this led to the removal of a "Giant's Grave" very similar to and not far from the existing monument. It was a "long grave," as we learned from two independent descriptions, each side consisted of five or six blocks, across the middle of which rested a large slab 5 feet or 6 feet each way. There had once been "two other covers," but few remembered them at the time of the demolition. Only for the positive statements of the men and the corroborative recollections of the late Mr. Pierce O'Brien of Durra (who gave me much kind aid when studying the dolmens of his neighbourhood), I should have suspected some confusion with the existing "giant's grave" which it so closely resembled. I was shown the approximate site a couple of fields from the latter and to the north-west. No antiquities were unearthed in the removal.

(*b*) The existing "long grave" lies nearly covered with grass

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[1] See plan, p. 88, fig. 4, *supra*.

[2] Ballyogan, in 1640–1668, was the residence of Maoilin M'Brody (MacBruodin) and his wife, Margaret Molony, whose son, the well-known monastic historian, Anthony "Bruodinus," was born there. It is called Gortnefunchin in the 1675 Book of Survey at Edenvale. "Ashgrove" in the townland is probably a mistranslation of this name. We may note that the adjoining townland Bearnafunshin is also called Ballyfinshan in the 1703 estate-maps of the Earl of Thomond.

and stones in a tilled field to the north of the second bohereen. Its axis lies N.N.E. and S.S.W., and it consisted of four rows of stones. The complete portion is 24 feet long, and tapers eastward from 7 feet 4 inches to 5 feet 4 inches over all. The end slab remains to the west. Rows of stones stood about 3 feet from and parallel to each side of the central enclosure. Only two remain to the north and three to the south. It is even possible that the most western of the latter belonged to the inner row. The longest slab remaining is 7 feet 6 inches long. If the minute sketch-plan on the Ordnance Survey map of 1840 may be trusted, two long blocks projected from the southern side, and (apparently) a cover remained *in situ.* It is still called, as on the maps, "the Giant's Grave," but no fuller legend survives.

This monument is one of a very interesting and wide-spread type, though of less frequent occurrence than the cist type so common among the dolmens of Ireland, Portugal, and Spain.[1] The long graves are closely akin to (in some case identical with) the allées couvertes of France, and to passages in the tumuli in Scandinavia and other parts of Europe, as far south as Sardinia. For comparison with the Ballyogan grave, we select a few others—Lachtneill, Cork, 12 feet long, 3 feet wide inside; Slieve-owen, Cork, 20 feet long, 3 feet to 1 foot wide, with parallel rows of slabs at each side; Burren, Cavan, two graves, respectively, 29 feet by 5 feet to 4 feet, and 17 feet 6 inches by 4 feet 9 inches to 3 feet 2 inches; Carryglass, Tyrone, 40 feet by 4 feet to 2 feet 3 inches, with parallel rows of slabs at each side; Coolbuck, Fermanagh, 33 feet by 4 feet to 3 feet; Proleck, Louth, 22 feet 6 inches long, 6 feet to 2 feet 6 inches wide; and Moiglisha, near Arklow, in Wicklow. With these we may compare the "Hun's Beds" (Hünebed), in the district of Drenthe, in Holland, which consist of long chambers, outside of which are parallel rows. Mr. Ferguson says these differ from those of France and Ireland by having closed ends; but this is not the case,

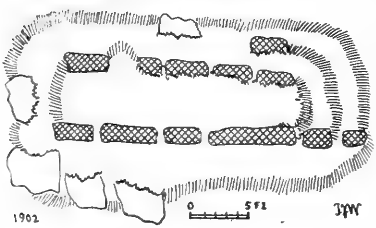

Fig. 14.—Ballyogan.

[1] "Dolmens of Ireland," vol. i., pp. 29, 31, 202, 214, 324, 317, 414; vol. ii. p. 639. Ferguson "Rude Stone Monuments of all Countries, their age and uses" (Ed. 1872), pp. 320, 356.

as we have learned, even from the defaced "long grave" of Ballyogan. Similar structures have been also found under long barrows, as at Kerlescant, which is 52 feet long and 5 feet wide, with rows of stones parallel to its sides. The nearest example to Ballyogan is probably the much more perfect long grave of Formoylemore on the brow of that steep hill, up which runs the road from Broadford to Limerick.

I was much interested to see "microlithic" representatives of these "long graves" in certain churchyards in Kerry, where slabs set on edge and covered with other slabs enclose the coffin. They rise above the level of the churchyard, and are covered by miniature cairns.

(5). RYLANE, Clooney Parish (O.S. Sheet 96, No. 16).—The two dolmens at this place are not named on the map of 1840, but may be found marked by two small squares to the south-west of a rath, and near a second fort directly above the "E" of the parish name. They were first noted by Mr. Arthur Gethin Creagh, of Fiaghmore, to whom I am also indebted for particulars about the destroyed burial-place and the hearths at Coolosluasta Lake.

(*a*) The more southern monument is called the "Labba." It is a cist about 23 feet long, and 11 feet 6 inches wide, and had at least three, if not four, chambers. It has been illustrated and described from my notes by Mr. Borlase. It probably consisted of a parallel-sided enclosure, with an outer line of slabs round it. The eastern end is nearly perfect.[1]

(*b*) The second "Giant's Grave," as it is called, is greatly defaced. It is of larger blocks than the "Lobba." Its south side lies east and west by compass, and it tapered eastward. It lies in a circular patch of stones and mounds, much overgrown, and evidently the base of a cairn or tumulus. Some of the blocks are 5 to 6 feet long and 4 feet high. Near it is the almost levelled ring of a small rath; while a much more perfect and larger earth fort occupies the summit of a low green hill to the north-west. It is girt with a deep fosse, which frequently contains water.

Not far away to the north-east, in a field at the Donoghue's house, and about 500 yards from Maghera cross roads, was found (on February 4th, 1897)[2] an interesting early burial-place. The field was dug up for the first time in human memory. Scarcely 2 feet

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[1] "Dolmens of Ireland," vol. i., p. 82; see plan, p. 88, fig. 5, *supra*.

[2] Journal R.S.A.I., vol. xxvii. (1897), p. 178.

below the surface lay a passage 10 feet long and 2 feet 6 inches wide, of rather small dry masonry roofed with thick sandstone flags. The passage ran N.N.W. and S.S.E. At its southern end was a small circular cell, domed in the usual way by courses overlapping till the space could be closed with a slab. Another slab was laid outside the flank of the dome, as if to ease the pressure of the earth at that point. Fragments of a human skull, including a portion of the lower jaw with six teeth, lay at the north-west end of the grave; and a few vertebræ in the last stage of decay lay along the passage. Around the remains lay charcoal and burned earth, while other traces of a fierce fire were apparent on the side walls. Nothing was found in the round cell, nor were there any traces of either metal or pottery. On the top of the covering slabs lay portions of the skull of a horse and "bones of a goat or pig." Similarly, in an early cairn-burial near St. Cernin de l'Arche, near Brive, in France, the bones of a horse lay outside a cist covered by a cairn. In another cairn lay the skeleton of a woman, the upper part of which was partly cremated. An oval hearth of sandstone blocks, including a portion of a quern, lay 1 foot 2 inches south of the Clare grave, and 4 feet higher than its floor. It was about 2 feet 6 inches under the surface of the field. Mr. Creagh at once wrote to me; but when I next was able to visit Clare, in the following April, the whole structure had been removed and stacked against the fence of the field, and corn was sprouting in the slight depression that marked its site.

Some years before this, discoveries of some interest were made at the little bog-pool of Coolosluasta Lough.[1] The peat had evidently grown in and greatly diminished the lake, and the Carrahan drainage works considerably lowered its waters. Mr. Creagh found several planks under 4 feet of good peat, which had been covered by about 6 feet of water. One plank was worn along the edges as if by a rope. It was 5 feet long, and had a round hole cut in it. The other boards were in fragments, and so soft that the hand sank into them. All

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[1] Journal R.S.A.I., vol. xxv. (1895), p. 179. Fich and Coolsluosty appear in Petty's "Book of Distribution" (1655), p. 2. The latter is noted by Canon Dwyer from King's "Church History of Ireland.' Suppl. vol., p. 1047. "O'Sluaisti from Cill Osluaisti"; and others, "these were they who stole the horses, the mules, and the asses of the Cardinal who came from Rome to instruct in the time of Domhnall Mór O'Brien, King of Munster; and it was on that account the Cowarba (*i.e.* the successor) of Peter sold the rent and right of Erin to the Saxon." If so this little marshy spot is one of the most historic sites in the world, but the story needs far better authority to support it.

around and under the plants was a mass of deer's bones, recalling the popular interpretation of the townland name Fiaghmore, "the big deer." Directly beneath were found three human skulls, "two females and one male." All the teeth were sound but much worn. The lower jaws were, it is said, still in the sockets, and the arm-bones with the shoulder-blades. Among these bones lay two long oak poles, one neatly shaped with a sharp implement. No metal was found, but it may have sunk in the deep peat below.

A fragment of a very neat gritstone quern is preserved; it was about 20 inches it diameter, with a ring 8 inches wide and a central hole, with three concentric and rounded edges, each an inch wide. A straight band crossed these, and girdled a small handle-hole, which did not pass through the slab. I could not ascertain the locality of this "find."

Around the margin of the lake were found some twenty hearths of gritstones; they measured about 6 feet across, with wonderfully fresh charcoal and remains of pigs and goats, the long bones were broken for the marrow. Great stems and roots of bog-deal lay everywhere; all had fallen towards the east; the tops, and in some cases the roots, had been burned, or in a few cases cut.

(6). Clooney, Clooney Parish (O. S. Sheet 34, No. 7).—In the picturesque demesne of Mr. Joseph Hall, and at no great distance from the fifteenth-century castle and church, are two remarkable remains.

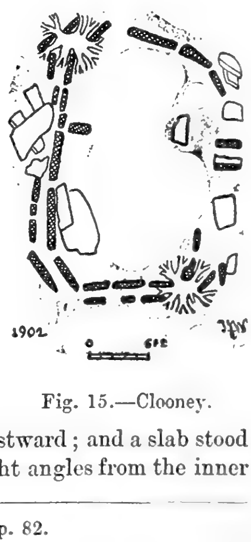

Fig. 15.—Clooney.

(*a*) The first is of a type not very common in Ireland; it occupies the summit of a low natural mound near a stream, and is much overthrown. Enough, fortunately, remains to show the plan. The late Mr. Borlase[1] (who had not seen it) considered it a "boat-shaped enclosure"; but, as I pointed out to him when sending the plan, the structure is a nearly straight-sided but not rectangular oblong inclosure, with the angles cut off. It is formed of two rows of slabs, equidistant and about a foot apart. The "southern" side actually points E.S.E. and W.N.W., and is 10 feet long; the northern is 12 feet, and the remaining sides about 20 feet each. A small entrance, with two side-blocks, opened eastward; and a slab stood in line with its northern jamb projecting at right angles from the inner

[1] "Dolmens of Ireland," vol. i., p. 82.

face of the "western" side. Thirteen slabs of the inner and seven of the outer row are in position, many others remain out of place. I repeat the plan from the earlier paper.[1] The enclosure and knoll are thickly planted, and there is no trace of a cist or any other structure in the garth.

(*b*) A second monument lies nearly eastward from the last in a grove of fine beech-trees. It was a circle, once probably double, and is much defaced. The western portion is, however, partly preserved. Beginning at the south, and going westward, there are four outer blocks, measuring respectively 12 feet 6 inches long by 8 feet by 25 inches, 9 feet 3 inches by 6 feet 6 inches by 24 inches to 30 inches thick, 4 feet 2 inches by 3 feet by 11 inches, and 3 feet by 2 feet 4 inches by 12 inches. Inside there are two fallen blocks, one 5 feet 6 inches long. A single fallen and nearly buried block lies to the north, and another, 5 feet by 4 feet by 21 inches, to the south. At some distance outside the grove another set block suggests a third ring.

(*c*) Three blocks are set in line, N.N.E. and S.S.W., in another grove, and possibly represent the remains of a third monument.

(7). Knocknafearbreaga, Clooney Parish (O.S. Sheet 34, No. 3).—Near Classagh House, but in the townland of Knockanoura, is a low cultivated hill, called Knocknafearbreaga. On it stands a line of five pillars, lying N.N.E, and S.S.W. Noting these from the north they measure respectively—the first, 4 feet 10 inches high by 3 feet 8 inches by 1 foot 2 inches; the second, 4 feet 5 inches by 11 inches by 17 inches; the third, 5 feet 2 inches by 3 feet 10 inches by 10 inches; the fourth is broken, the stump being only 1 foot 6 inches high; and the fifth leans towards the north-west, and is 6 feet 2 inches by 2 feet 3 inches by 10 inches. There are said to have been two others in human memory.[2]

Such alignments of pillars are not unknown in Ireland, Scotland, France, and elsewhere. Examples occur in Caithness, Wiltshire, and Brittany, varying from a single line to the great group of Carnac. The Rev. S. Baring Gould, in his interesting account of those on Dartmoor, advances the ingenious theory that they are tribal monuments, the stones varying from under 3 to over 6 feet; and, on this supposition, varying according to the number or individual strength of each family.[3]

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[1] Proc. R.I.A., vol. iv., ser. iii., p. 546.

[2] See Plate VI., fig. 1.

[3] "Book of Dartmoor" (1900), pp. 60, &c.

In Ireland, we may note, for comparison, the alignment near Lough Gur, in Limerick, and that in the townland of Reenaree and parish of Kilnamartry, Cork. The rows in the latter case are 4 feet apart, and the highest gallan is 5 feet 6 inches high.[1]

Local tradition states that the Clare pillars were seven robbers who "kept about the place in old ancient times." Now there was a saint (possibly Mochulla) at Tulla who was building the church there; and he was so busy, "he had no time to cook his food." The holy man fortunately possessed "a blessed bull," and used to send it with bags to Ennis Abbey, where the monks used to pack a supply of cooked provisions for the church-builder. Hearing of this, the robbers waylaid the faithful animal, and proceeded to ravage the bags. The bull thereupon roared so loudly that he was heard at Tulla; and the saint stopped building, "and he prayed and cursed at the one that was hurting his bull." Rapid was the retribution—in the twinkling of an eye, the seven robbers were "struck and turned into fearbreags," or sham-men, on the spot where they stood.

The legend is late in form, but has ancient equivalents in all ages and counties; we need only note some Irish and Scottish forms. We find at Iona, a "Portanfhirbhreig," so called from a tall rock, supposed to resemble a man's figure.[2] Another late Scottish legend, "Fionn's Enchantment,"[3] tells how Fionn and his lads had been hunting in a snow-storm, and, while waiting for their "bird-stew" to be cooked, a hare ran into the house and kicked up the ashes. All the men ran out after her, and followed her to a hut, which proved to be the abode of a giant magician, named "Yellow Face," who lived on enchanted boars and human flesh. The giant called in the intruders to help him, and, on their crossing the threshold, struck them with his rod of magic, and "they became pillars of stone; and he set them on the north side of the door to stop the sleety wind" (like the shelter slabs at the doors of clochauns in Corcaguiney). The curing of Fionn, whose legs had been burned off, and the disenchantment of the petrified youths, do not bear directly on the subject of Fearbreags. St. Brendan is said (in an Irish legend) to have saved a young man from murderers by changing him into a pillar, and a pillar into his form. The villains

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[1] "Cork Historical and Archæological Society's Journal," vol. iv., ser. ii., p. 289.

[2] Adamnan's "Life of S. Columba" (ed. Dr. Reeves), p. 429.

[3] *Revue Celtique*, vol. i. (1870), p. 196.

stabbed the pillar and cut off its head, and carried it away to another place, "and still that stone remains."

At Kilross, in Sligo, two men endeavoured to steal a magician's cow; but the owner pursued, and, striking them with a wand, turned them into stones, which are still shown. It is possible that the "cow-stone" and "thief-stone," near Gallerus, in Kerry, commemorate some such legend. In the "Book of Feenagh," when the Druids of Fergna "do corrguineacht" against St. Caillin, Aedh Dubh, son of Fergna, orders his soldiers to attack them. "No," said Caillin, "we will not exercise human power upon them; but it is my will (if it be the will of my God of Heaven and Earth) that the Druids may be changed into stones forthwith." Thereupon the Druids were immediately turned into forms of stone. Fergna, in his wrath at his son's defection, and because "his Druids were transformed into the shape of stone columns," brings on himself the vengeance of Heaven, and dies. The whole subject of Fearbreags, as John Windele has long since noted, is much in want of elucidation. It crops up in Monaghan, Cork, Clare, Tipperary, and, as we have seen, in Iona and elsewhere in Scotland. The name is applied to a stone circle near Kimalta (Keeper Hill), in Tipperary, and to a cairn at Kilcolman, in Cork.[1]

Natural rocks, called Fearbreags, occur at Fanygalvan, in the Burren, in the hills near Broadford, and at other places in Clare.

Mr. Borlase notes its connexion with the name and legend of the wolf (breag) and were-wolf, and that wolf-names are connected with cairns and tumuli in Germany (as, *e.g.*, the wolf hügel) and Bohemia, as well as in Ireland.[2]

It is, however, possible that the pillars at Classagh, like those not far from the Fearbrega Rock of Fanygalvan, form some long-forgotten tribal boundary rather than sepulchral monuments, though, in the historic period, they seem to have coincided only with townland borders. It will be remembered how Cuchullain, when mortally wounded in battle, went to drink at a lake. "Now a great mearing went westward from the lake, and his eye lit on it; and he went to a pillar-stone which is in the plain, and he put his breast-girdle round

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[1] "Brendaniana, or St. Brendan the Voyager in Story and Legend," Rev. Denis O'Donoghue (ed. 1893), pp. 16, 17. See also "Battle of Moy Leana," p. 31 n.; "Traces of the Elder Faiths of Ireland," Col. Wood-Martin, vol. ii., p. 214; and "The Book of Feenagh" (ed. W. Hennessy and D. H. Kelly, 1875), p. 117.

[2] "Dolmens of Ireland," vol iii., pp. 912–915. See also some valuable notes on the name in Dr. Joyce's "Irish Names of Places." Series ii., pp. 411, 412.

it that he might not die seated or lying down."[1] "Cormac's Glossary" also has a sentence: "They are not neighbours till their properties are meared with boundaries of pillar-stones." A manuscript in the Library of Trinity College, Dublin, says: "Land is secured by the joint memorial of two territories—*i.e.*, the ogam on the gallan." Unfortunately the Classagh pillars are uninscribed.[2]

(8). MAGH ADHAIR, Clooney Parish (O. S. Sheet 34, No. 12).—Near this fully-described[3] place of inauguration, at the opposite side of the stream from the moat, cairn, and basin-stone, and in the townland of Corbally, is a rude limestone pillar. It measures 6 feet 3 inches high, by 3 feet to 2 feet 6 inches wide, and 10 inches thick. It stands in line with the mote and its sloping descent and the cairn. Between it and the stream is a shattered block set firmly in the ground, and possibly the base of another pillar. Another stone lies near Drumbaun fort, two fields to the west of Moyars Park.

(9). TOONAGH, Clooney Parish (O. S. Sheet 34, No. 8).—Not far to the north-east of Magh Adhair, near the same rivulet, is a group of defaced cists. They are not marked even on the new map, but were shown me by the Rev. J. B. Greer, of Tulla. They lie on the 1899 map at the apex of a practically equilateral triangle, resting on the main road from Clooney to Tulla, between the bench-marks 121 and 120·4, and south of the road. The remains of two, if not of three, defaced cists lie in a furzy hollow near a small brook.

(*a*) Of the western cist only the sides remain; the northern is still standing, a coarse gritstone block, 7 feet 6 inches long and 4 feet 8 inches by 20 inches; beside it lies a slab (the fallen south side 10 feet by 4 feet 3 inches by 20 inches); the axis of the standing slab lies S.S.E. and N.N.W.

(*b*) Another thick block, 5 feet long and 16 inches thick, set north and south, lies at a short distance to the north-east, and may be the west end of a cist.

(*c*) On higher ground, to the north of the last, are the remains of a little cist. The south side lies north-west and south-east, and is about 6 feet long, 32 inches high, and 12 inches thick. The north side has been much broken, and lies from 4 feet 4 inches to 4 feet

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[1] *Revue Celtique*, vol. iii., p. 182. From the "Book of Leinster," p. 178.

[2] "Cormac's Glossary" (ed. W. Stokes), p. 84, MSS., T.C.D., H. 3, 18, p. 230. For "meer stones" see Notes on the Landnamabok (by Rev. E. T. Ellwood), p. 59.

[3] R.S.A.I., vol. xxxi. (1891, p. 463 n.), with illustrations. Proc. R.I.A., vol. iv., ser. iii., p. 55.

3 inches away; only 4 feet 6 inches remain—the rest is broken to the ground. The west end is 4 feet 4 inches long and 3 feet high; the cist tapers eastward to 3 feet 9 inches internally, and the broken cover lies near it.[1] A short distance from the east end is a large round cairn of mossy stones overgrown with bushes. In this, near its northern edge, a large block is set east and west.

A line of slabs 3 feet to 6 feet long is set in the ground southward from the northern cist to a small pillar 22 inches square, 9 feet to the west of which lie a fallen slab and traces of an old-looking curved earthwork.

(10). Caherloghan, Clooney Parish (O. S. Sheet 35, No. 8 and No. 12).—This townland adjoins the barony of Tulla; and its monuments group naturally with the once numerous cists of Milltown and Moymore. Our plan of adhering to the lines of the map necessitates their separation. The group of four small cists were (by a mistake of my own as to the townland bounds) given as in Moymore by Mr. Borlase. They were shown to me by the Rev. J. B. Greer, and lie near a farmhouse between the Moymore bridges, being marked on the new survey, whose officers were careful to insert any unmarked monuments pointed out to them; but unfortunately (so far as I know) only Dr. George U. Macnamara and I took any trouble with the marking of pre-historic remains of Clare on the new maps.

(*a*) The first or southern cist hardly rises over the field; its cover only measures 4 feet by 2 feet 3 inches by 12 inches; it rests on three other blocks, one being 3 feet square. There is no trace of a mound or cairn about it.

(*b*) Two blocks of similar character lie side by side; but it is not certain that they formed a cist.

(*c*) In the north wall of the field is set a block 4 feet by 2 feet 8 inches by 12 inches, and is said to have been part of a "Lobba," of which the other portions were used for the wall.

(*d* and *e*) Beyond this are two small cists entire: the northern resembles a demi-dolmen; its cover measures 6 feet east and west, and 6 feet 8 inches north and south, being about 12 inches thick. The standing-block, supporting it to the east, measures 33 inches by 14 inches, and rises only a foot above the ground. The neighbouring cist has an irregular top slab 4 feet 4 inches to 7 feet 3 inches east and west, and 4 feet 2 inches north and south, and is 16 inches thick. The sides are nearly buried.

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[1] See plan, p. 88, figs. 6 and 7, *supra*.

(*f*) There are remains of a cairn, with a small and defaced cist of four blocks, in a patch of bushes, near (but outside) the west wall of the field. The cist was about 4 feet square.

It may be noted that, both in size and in the lack of definite orientation, these tiny cists differ greatly from the usual type in Clare, whether of the huge dolmens of Poulnabrone, Ballyganner, or Fanygalvan, or the little cists at Poulaphuca, Parknabinnia, or Toonagh, which taper eastward, and are identical in every respect save size.

(*g*) The remains of a larger dolmen are found at the opposite (southern) edge of the townland, beside the road to Magh Adhair. In human memory, it was "a great box of stones"; but unfortunately a farmer overthrew it when clearing the field. He removed the sides, but found the top too heavy; and (unable or afraid to blast it, though popular belief does not extend its protection to dolmens or cahers as it does to earthen forts) he set it up on edge, where it remains propped by lesser stones, and measuring 8 feet by 5 feet by 12 inches to 15 inches thick.

(11). BALLYHICKEY, Clooney Parish (O. S. 34, No. 15).—This small cist of coarse gritstones is quite perfect, and is unusual in having parallel sides and level cover. The axis lies E.N.E. The north side is of one block 6 feet 8 inches long and 16 inches thick. The south side has two, parallel to which, and about 3 feet away, is another and thinner slab. The west end is 7 feet 2 inches long and 8 inches to 9 inches thick. The cist is 8 feet 1 inch long, and the interior 7 feet 4 inches east and west by 4 feet 2 inches north and south. The cover is somewhat pear-shaped; and, broken into two, it does not overlap the west end.[1] It lies in a plantation to the side of Hazelwood House, and is shown correctly in a little sketch on the map of 1840.

Fig. 16.—Dooneen.

(12). DOONEEN, Doora Parish (O. S. Sheet 34, No. 6).—There are only two dolmens in Doora parish, much of which (as its name implies) is swampy. The Dooneen monument is called a "Giant's Grave," and is not recognized as a "Lobba"; it lies in a field to the north of the road from Moyreisk

[1] See plan, p. 88, fig. 8, *supra*.

Cross, past Maryfield House. It is a defaced enclosure of deep-set slabs from 9 feet to 6 feet long, and measures internally 22 feet 8 inches east and west, and 13 feet north and south. The two largest slabs at the eastern end make a slight angle. Of the other side blocks only one remains to the west, one to the north, and two to the south. It has been considerably defaced since I first saw it. Ferguson figures a somewhat similar Continental example at Eginlar.

(13). Monanoe, Doora Parish (O. S. Sheet 34, No. 10).—A small cist stood on a gravel hill not far from a large stone-faced earth fort. I failed to find it on my earlier visits, owing to an altered bohereen and field-bounds. When aided by the new map of 1894, I found the place the monument had been removed and its very site deeply dug out for gravel.

(14). Ballymacloon, Quin Parish (O. S. Sheet 42, No. 4).—This parish—one of the most historic parts of Clare—only possesses two dolmens. One stands near a small lake in a field with outcrops of rock in Ballymacloon. It is entirely overthrown, but was of rude and massive slabs of gritstone. One measures 7 feet, east and west, by 5 feet 3 inches. It is shown on the map of 1840 as a massive block, resting on three lesser stones. Near it is a dolmen-like slab resting on a large boulder, but probably natural, and certainly bearing no marks of human workmanship.

(15). Knappoge,[1] Quin Parish (O. S. Sheet 42, No. 8).—This cist lies south of the road from Knappoge Castle to Kilkishen, and has suffered from the hands of the "improver," having been partly removed and blasted, the blocks still bearing marks of the crowbar. Its western end defied the vandals, and still rests on the end and two side blocks. It is hard in its present condition to speak with confidence as to its original design. The cist appears to have stood in an oval earthen mound with a kerbing of blocks round the base. The cover measures 8 feet north and south, 4 feet 7 inches east and west, and is about 10 inches thick. The west end is 5 feet by 1 foot thick, and rises 18 inches over the mound. The north is 6 feet long by 12 inches; some ten blocks of the ring seem to lie in position. My drawing and a rough sketch-plan are figured by Mr. Borlase.[2]

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[1] Or Knoppoge.

[2] "Dolmens of Ireland," vol. i., p. 84. See also plan, p. 88, fig. 9, *supra*.

BUNRATTY LOWER.

It is noteworthy that in the ancient Tradree[1] from Latoon and the Fergus to the Shannon and Owen na Gearna no dolmens occur. This probably arises from the district having been (as pointed out) in an unusual state of cultivation and clearance as the special appanage of the native princes. It is only between the Lakes of Rossroe and Mountcashel that any monuments remain, for the dolmens at Croaghane really belong to the group on the Slieve Bernagh Hills.

(16). KNOCKNALAPPA, Kilmurry na Gall Parish (O. S. Sheet 43, No. 11).—This is named in Dineley's sketch of Rossroe, in 1680, as "Knockalappa, *anglice* the Hill's Bed,"[2] but is not drawn. It rests on a low green hill, at the foot of which stands the massive ivied tower of Rossroe Castle, and the large lake called after it.

The cist is of large blocks, less shapely than most other "Lobbas" in this county. It is at present 11 feet long, and tapers eastward from 4 feet 7 inches to 3 feet internally. A single block, 6 feet 3 inches long, and 2 feet 8 inches thick, remains; a second was, I hear, blown up; and other stones bear marks of crowbars. For some reason not stated, the destruction is stopped; and there is no present intention of removal. The west end is 5 feet 7 inches long, and from 17 inches to 24 inches thick. The cover is irregular, about 8 feet 6 inches by 8 feet, and of varying thickness.[3]

Close beside the "Lobba" was found a gold fibula, described to me as about 3 inches across and as thick as a cedar pencil, with, however, slightly expanded ends, but without cups; my informant roughly sketched it for me. I could not learn to whom it was sold.

(17). DRUMMULLAN, Kilmurry na Gall Parish (O. S. Sheet 43, No. 9). —There were two cists in this townland. One lies north of the road to Fenloe. It is so rude and defaced that, only for the orientation and tapering of its side blocks, it would be hard to believe it a dolmen at all. Indeed, despite this and the 1840 map, I am scarcely satisfied that the blocks are not a split rock. Each slab is about 10 feet long; the northern is much broken. Two lesser blocks lie at the opposite

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[1] Tratraighe of the Firbolg Race, Mac Firbis: see "Irish Nennius," p. 266.

[2] Journal R.S.A.I. (R.H.A.A.I.), vol. ix. (1867), p. 176.

[3] See plan, p. 88, fig. 11, and Plate VI., fig. 2.

side of the fence in which it is embedded. Another dolmen lay near Knockacunag Lake, and has been entirely removed since 1839. It is shown as a small, square cist on the 1840 map.

(18) Kilcornan, Kilmurry na Gall Parish (O. S. Sheet 43, No. 5, No. 6).—A greatly defaced but massive and interesting monument lies within a ring of lakes, and has a pleasing view of the long-wooded ridge of Cullaun, crowned with its turret. The grave is covered with earth, stones, and tangled masses of hazel scrub. It was hard to understand its nature until a plan was made; when it became evident as a group of some three or four compartments, an arrangement not unexampled in other Irish monuments, but, I think, otherwise unknown in Clare. To the north-west angle is a block 5 feet long, lying north and south; near its northern end are blocks at right angles to the last and 6 feet long. To the east of this lies a cover of irregular shape, 4 feet 8 inches by 4 feet, deeply marked by the narrow lines of a large cross. The graving must be of no little age, as the edges are worn and the grooves mossed. South of this are two parallel blocks, 4 feet 6 inches long and 9 inches apart; and west of these, in line with them and its west end—also in line with the north-west block—is a large irregular stone about 5 feet long. Iti s called a "Giant's Grave."[1]

(19). Ballysheenbeg, Kilfinaghty Parish (O. S. Sheet 52, No. 4).—Major Walton, of Ballysheen, informs me that it was a small box-like cist. It was destroyed about 1852. It is shown by two small marks on some maps of the 1840 Survey.

(20). Brickhill, Kilfintinan Parish (O.S. Sheet 62, No. 2).—This lay to the west of the dolmen of Ballinphunta and Croaghane Church. At least one large block remained in 1839; but I only found a low green mound of earth and stones on the site, which may or may not conceal the slab.

At no great distance is a place called Lacht, where I found no remains of a cist. However, "Lobba," and not "Lacht," is the received local name for a dolmen.

(21). Ballinphunta or Croaghane, Kilfintinan Parish (O.S. Sheet 52, No. 2).—One of the most perfect cists in the county stands in the tilled field south of the defaced church of Croaghane, in full sight of

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[1] See plan, p. 88, fig. 10, *supra.*

passengers on the railway which runs along an embankment directly east of the remains. It is now much buried in field rubbish, and overgrown with brambles and ash-plants. However, as this may add to its chance of survival in its endangered position, we may the less regret the fact. It was (so far as I could find when making its plan in 1887) unopened. In naming this to local antiquaries we suggest great caution and consideration in any action to be taken.

Having given to Mr. Borlase (and here repeating) the plans and elevations, I need only note that this cist is double, lying east and west. The west chamber has a large end-slab, with two stones to

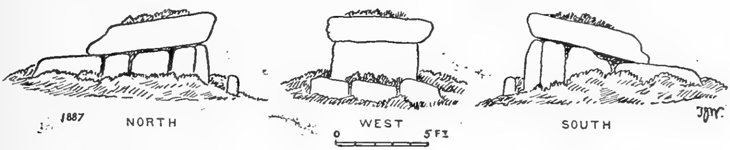

Fig. 17.

each side, and three low stones parallel to the end, which, with two others near the east end, show that this dolmen had a kerbing of smaller blocks around it.

The cover measures 6 feet 7 inches by 5 feet 6 inches by 10 to 13 inches thick. The eastern chamber is far lower, so that its slab is partly overlapped by the western cover. It measures 4 feet 8 inches by 4 feet 2 inches. It was nearly buried even when I first remember it in about 1881.[1]

This, to our present knowledge, completes the survey of the dolmens in the baronies of Bunratty. The problems raised must be reserved for solution till the subject is more advanced. Much as the ground has been cleared by Mr. Borlase's great work, much more remains to be done. We want field-work, spade-work, and folklore at present. Later on we may proceed to clearer light than is afforded by the theoretical portion of our only general survey. Till a map can be prepared of each Irish district (not necessarily a county), little progress can be made; and as one short step towards this map, this paper is offered to the Academy. We are at present bewildered in

[1] See plan, p. 88, fig. 12, *supra*. "Dolmens of Ireland," vol. i., p. 86.

mist and darkness; but every district completed is at least a step towards the light.[1]

[NOTE.—The group in each parish is marked off by a broader space.]

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[1] Of the dolmens named in this paper there are photographs of the following in the photographic collection of the Royal Society of Antiquaries of Ireland:—Caheraphuca, Ballymaconna, Kilvoydan, Clooney Circle, Ballymacloon, Knappogue, Knocknalappa, and Ballinphunta.

VIII.

THE CISTS, DOLMENS, AND PILLARS IN THE EASTERN HALF OF THE COUNTY OF CLARE. By THOMAS JOHNSON WESTROPP, M.A.

[Plates VII. and VIII.]

[Read June 23rd, 1902.]

Sections 3 and 4—The Baronies of Tulla.

The baronies of Upper and Lower Tulla form, with those of Bunratty, the well-marked eastern half of Clare. It seems desirable to take them next in order to the district of which I gave a survey of the early monuments of rough stone in a paper read before this Academy in last April. The barony of Upper Tulla corresponds to part of the ancient Hy Caisin and Hy Ronghaile, with Tuath Echtghe (or Feakle parish) and Cinel Donghaile (the O'Grady's country). Lower Tulla covers Hymbloid, Hy Turlough, and some obscure little states along the edge of the hills. As in the Bunratty districts, it is probable that none of these arrangements extend far enough into the past to affect the dolmens or cists. Topographically the divisions are equally defective; eastern Clare falls naturally into the plain land and the hills of Slieve Echtghe and Slieve Bernagh. In this paper we are obliged to refer strictly to the conventional divisions and the maps of the Ordnance Survey, which show the sites, but do not always mark the dolmens.

The earlier writers have, as usual, passed by the prehistoric monuments without any detailed description—indeed, rarely with even casual mention. In 1839 O'Donovan and O'Curry described, not very clearly, two monuments at Miltown and two at Ballycroum. Beyond this they barely allude to the "Broken Giants' Graves" of Drummin and Ballykelly. The maps of 1840 omit four at Miltown, two each at Fomerla, Kiltanon, and Dromandoora, and one each at Tyredagh, Ballycroum, Maryfort, Derrymore, Elmhill, and Cloonyconry. Mr. M. Brogan described the upper dolmen of Dromandoora to this Academy in 1865. Miss Stokes, in both her lists of dolmens, omits all the monuments (even those marked on the maps) to the east of the Fergus. Canon

Dwyer and Mr. Frost, in their histories and topographies of the district, are equally silent.

At last, in 1897, Mr. W. Copeland Borlase published several descriptions and a fairly complete list in "The Dolmens of Ireland." He gives his own notes on ones at Miltown, Newgrove, Cloonyconry, and Formoyle; Mr. M. Brogan's notes on Dromandoora; O'Curry's notes on Miltown (2) and Ballycroum (2), and my notes on Tyredagh (2), Miltown, Maryfort, Rosslara, Elmhill, and Ardnataggle. The only other contributions are two short descriptions of Tyredagh Upper and the lower dolmen of Corbehagh in 1897, and a paper on the three monuments at Ballycroum in 1900—both in the Proceedings of this Academy.

Though these descriptions need only be noted briefly in the present paper, it is necessary to repeat the plans for comparative study.

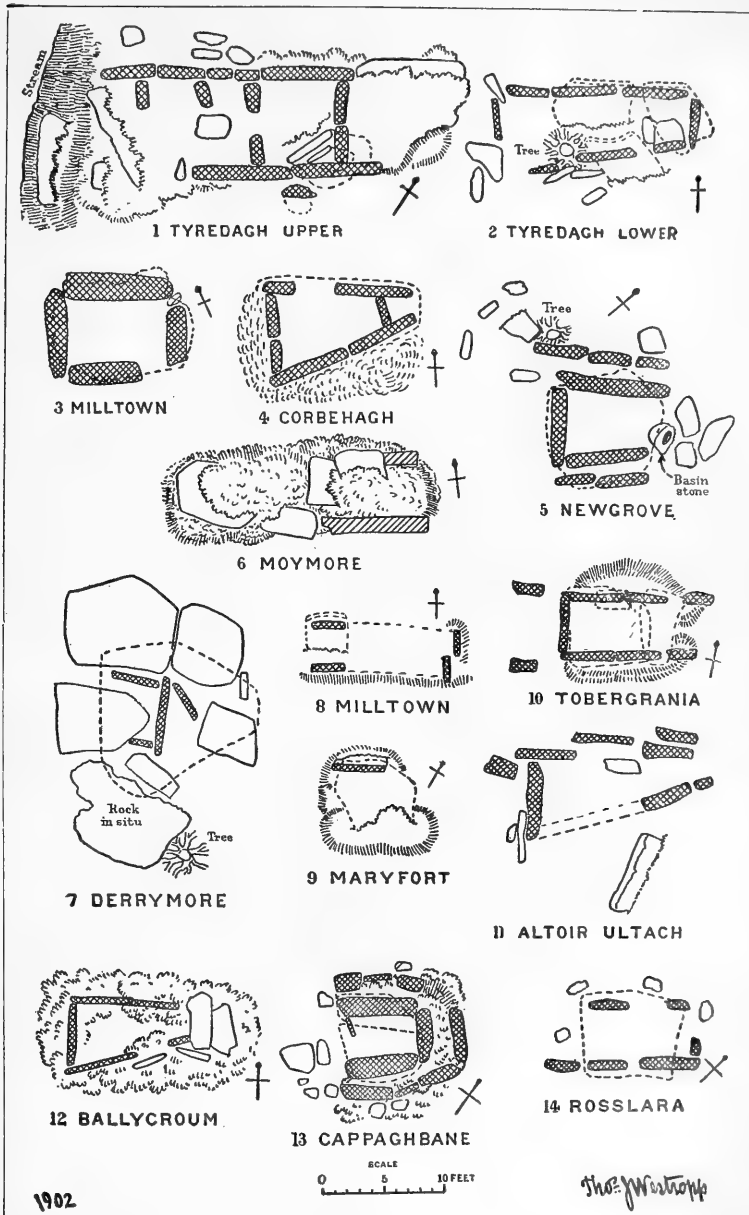
The Barony of Tulla Upper.

In the following survey I give the name of the townland and parish, the sheet of the Ordnance Survey of 25 inches to the mile, and the description (if the structure is hitherto undescribed) at some length.

Tulla.

(22). Tyredagh Upper, Tulla Parish (O. S. Sheet 27, No. 13).—This townland, the Tir Aodha of 1390,[1] contains a very remarkable monument not marked on the maps of 1840. It lies in a pleasant little recess or shallow valley, hemmed in to the north-east by low but picturesque cliffs. A little stream flows past and has undermined its west end; one block has fallen down the bank. It has been fully described, and the plan and view of it published from my notes by Mr. Borlase. We may briefly note that it is of five compartments, with an extension to the north-east; that it tapers slightly eastward; that the covers have fallen; that it measures at present 27 feet

[1] "Tiresheeda" in the list of lands in the termon of Tulla Church, 1397, copied (it appears) from the ancient "Black Book of St. Mochulla" into the Inquisition taken at Ennis in 1611. The termon comprised:—Tulla, Killeen, Lisoffin, Cloonteen, Dromlig (Knockdrumleague), Moymore, Fomerla, Kiltanon, Tiresheeda, Dromcaha, or Kildonalballagh (Ardbooly, according to a Molony and Westropp deed of November 1720), Ballyore, Cregancryan, Dromaghmartin, Bonavorey, Furhee, Loghan, Cutteen or Cahercutteen, and (apparently) Rine. O'Curry, without citing any ancient writing, says the name is "properly Tir Riada." It is pronounced "Tir'eeda."



Dolmens in the Barony of Upper Tulla.

east and west, and that it tapers eastward from 7 feet 6 inches to 6 feet 6 inches in 20 feet. The axis lies north-east and south-west.[1]

(23). TYREDAGH LOWER, Tulla Parish (O. S. Sheet 27, No. 13).—Not far away from the last in the adjoining townland, separated from Tyredagh Upper by the road from Carrahan to Tulla, is a large dolmen lying in one of the back yards of Tyredagh House. Borlase has published very roughly a view and sketch-plan from my notes. The dolmen is from 16 feet to 19 feet long, and tapers eastward from 5 feet 10 inches to 3 feet 11 inches internally, the sides sloping in the same direction. A fine horse-chestnut tree growing in the enclosure has helped to destroy the western end. Three of the side blocks remain respectively to the north and south, with two others projecting from them, and two end blocks to the west and one to the east. Three large slabs of the broken and rather thin cover remain.[2]

In the adjoining field are the reputed remains of another dolmen, being two rows of rather small blocks lying east and west, and nearly parallel. No cover remains; and I am more than doubtful as to the nature of the structure.

In a plantation to the east, beyond the yards and garden, is a small earthen ring-mound, far too small to be a rath. One can only recall the tomb of Dathi at Rathcroghan and the passage in Keating's "Three Bitter Shafts of Death"[3] (1620), where it is stated that the pagans were laid facing the east, and a small rath raised round with a leacht or cairn, or an earthen rath without a monument. No stones remain in the Tyredagh ring.

In the field still farther eastward is a pillar slab, 9 feet high, made of a very thin flag of limestone, tapering upwards from 31 inches to 24 inches wide[4] and 5 inches broad.[5] A graveyard lies near it to the north, and north of the latter, at the opposite side of the road and in line with Tyredagh Castle, lies a large sandstone boulder with a bullaun or basin ground into it.

The dolmens in the two townlands have been described from my

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[1] Plan, p. 109, fig. 1, *supra*.

[2] Plan, p. 109, fig. 2, *supra*.

[3] See note in "The Battle of Gabhra" (edited by N. O'Kearney) in the publications of the Ossianic Society; also Kilkenny and South-East of Ireland Society (R. S. A. I.) Journal, 1854, for "Tulachs" or burial-mounds.

[4] Misprinted 5 *feet* in Proceedings of the Royal Irish Academy, *ut infra*.

[5] "Dolmens of Ireland," i., p. 88, sketches and plans; the sketch of the dolmen of Tyredagh Lower being very rude and defective. Proc. R. I. A., Ser. iii., vol, iv., Plate IX., p. 546.

notes by Mr. Borlase, and that in Tyredagh Upper is noted in these Proceedings."

(24). KILTANON (O. S. Sheet 27, No. 13), Tulla Parish.—The remains are greatly defaced, and are not marked on the maps. Four stones stand in line, side by side, lying east and west on a low mound among hawthorns to the south-east of the outer bridge on the front avenue; it is probably the remains of a small dolmen. The blocks measure 4 feet by 30 inches to 24 inches by 7 inches; the second and third are each 4 feet 4 inches wide; other dimensions similar. Another similar slab lies to the west on the slope of the mound, which is 18 feet long.

South of Kiltanon House, in a grove of trees, lies a sandstone block resting on a slab, 3 feet by 4 feet. It has a bullaun, 13 inches across, ground in it. This has been illustrated elsewhere in these pages.[1] Three other slabs lie in the grove. The side of an undoubted dolmen stands in a disused burial-place for children, at no great distance from the last remains. It tapers upwards from 9 feet to 5 feet 9 inches long, and is 3 feet 8 inches high and 16 inches thick, of good sandstone, and belonged, the old people say, to a "box" cist.

(25). MILTOWN or BALLYVOLLEN, Tulla Parish (O. S. Sheet 35, No. 1).—Miltown is separated from Kiltanon by the Affock river running through the range of caverns called the Toomines, so bombastically described by John Lloyd in 1778;[2] but which form an interesting and picturesque natural gallery, lit by openings hung with ferns and ivy, and with a gravelly strand beside the stream. The English name of the townland is a mistranslation, as the place was O'Moylan's town, and is called Baile ui Maoilin, from the family of O'Moylan or Mullens, in the Macnamara's rental, 1390. It is named Ballyworryn (Ballyvollyn) in the Inquisition *post mortem* of Donat Macnamara Reagh in 1591, and Ballymoilin in the Edenvale "Survey of Clare" about 1675.

One of the finest groups of cists in Munster existed in human memory among the craggy fields of Miltown. Unfortunately, the majority have been "improved off the face of the earth," and only one remains perfect. I can faintly remember two others that have since been destroyed, but which stood nearly perfect some twenty-five years ago. The others were all in existence so late as 1839, though some are not marked on the maps of the Ordnance Survey of 1840.

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[1] Proc., R.I.A., Ser. iii., vol. iv., Plate IX., p. 547.

[2] "An Impartial Tour in Clare."

(*a*) Not far north of the picturesque and ivied peel-tower of Miltown lies among the crags a large, rugged block of limestone, supported on lesser stones. It is apparently artificial, and formed a cist of different and ruder type than the others in the townland.

(*b*) In the Kennedy's farms, to the west of the side road, stood in my recollection a fine dolmen. It has been described to me by a farmer, who remembered it as "the tallest labba in the place; a great table of a rock on top of four other stones as high as your shoulder" (say over 5 feet high). "It was open below; the top slab was very thick, and it stood on the highest point of the field some distance from the fence." My sister, Mrs. O'Callaghan, says that it closely resembled the perfect one on Mr. Sheehan's farm, and was of four thick blocks, with a large cover, being over 5 feet high, and partly covered with thick ivy. These descriptions are independent of each other, and, as will be seen, closely correspond. My own recollections of this monument are very vague. It is called "Dermot and Grania's Bed" on the map. Unfortunately, I cannot find that any sketch or measurement is preserved; and it is only shown as a cist on the O. S. map, and lies E.N.E. and W.S.W. It was removed about twenty years ago.

(*c*) In what is now the same field are the mutilated remains of two smaller dolmens. In the more northern (so far as I could examine it through a thick overgrowth of sloe-bushes and brambles), the top slab is from 31 inches to 36 inches thick, and has crushed down the south side which lies under it—if, indeed, these are not the remnants of the destroyed monument last described; though I was told that this was not the case.

(*d*) In the ditch south of the same field is a defaced little cist, 12 feet long and 4 feet 9 inches wide. The sides and ends remain; and a cover-slab, now partly buried, lies on the north-west slab. The south side lies E.N.E. and W.S.W.[1]

(*e*) Another cist, facing north-west and south-east, lay south-west from the last group towards the Newgrove Bridge.[2] It has been long removed; and I could not get any very clear description, or the date of its destruction; but it seems to have been a ruined "box" of slabs.

(*f*) To the east of the side road was another dolmen, which I sketched about 1883. Unfortunately, the many opportunities of visiting Miltown led to my postponing my intended survey of its remains

[1] Plan, p. 109, fig. 8, *supra*.

[2] It is marked over the I of the townland name on the 1840 map.

till too late, for this dolmen was blown up by the tenant of the farm in July, 1890. So far as I remember it and my sketch shows, the cist was a small box of three slabs and a cover, and sloped towards the south; it lay east and west.

(*g*) South from the last, in the angle made by the two roads through Miltown, lay three monuments marked on the map of 1839.

The first is called "Giant's Grave" on the Survey of 1840, and has been noted by Eugene O'Curry in the Ordnance Survey Letters.[1] It lay to the north-east of the perfect one on the Sheehan's farm, and was in "the form of an ordinary grave (coffin), measuring 19 feet 6 inches in length, 4 feet 5 inches in breadth at the foot, and 6 feet 4 inches in breadth at the head, the thickness of the stones all round being included in the measurement. This was enclosed by a number of large stones placed at a few feet distance, and following the form of the grave." He continues: "The grave of Sliabh Gearr, near Glen Cullen, in the county Dublin, is of the same form with this, as are some more in the eastern parishes of Clare. These long coffin-like graves can hardly be supposed to belong to the same period of time as the square chest-like and sometimes irregularly formed monuments, to be met with in several parts of the Barony of Burren, &c."

The long and enclosed type also occurs at Faunaroosca and Iskancullin,[2] in the Burren. I do not know of any extant example in "the eastern parishes of county Clare." Not a trace of this monument is now to be found, nor do I remember any in 1877. The site lies near a nearly levelled rath.

(*h*) Another undescribed dolmen lay near the last; it has been removed.

(*i*) Another monument, further to the west, has shared the same fate; it is shown as a cist, called "Dermot and Grania's Bed," lying in the field near the junction of the by-road and the Tulla road, and to the east of the former.

(*j*) I was told that certain blocks on a little mound near the road are the sides of a labba. If so, they are possibly not *in situ*, and may have belonged to the neighbouring dolmen.

(*k*) The sole intact survivor of this once fine group stands near the last ones to the south of the main road from Newgrove to Tulla, on the Sheehan's farm, near the old lead and silver mine. It is thus noticed

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[1] MSS. R.I.A., 14 B 24, p. 255.

[2] See Journal of Royal Society of Antiquaries of Ireland, vol. xxxi. (1901), pp. 277–285.

by O'Curry in the Ordnance Survey Letters: "There are seven giants' graves in Miltown (Baile Ui Mhaoilin, O'Mullen's town), one of them near Green's House,[1] in perfect preservation, of an irregular square fōrm, serving as a pig-sty, with a rick of turf built over it at present." Then after describing the giant's grave already given, he adds: "The other graves in this townland deserve no particular description." Students will regret that this feeling towards prehistoric remains dominates the Letters on Clare, and deprives us of much valuable information, then easily accessible and recoverable.

In this case the house and yards have disappeared, leaving no trace, while the cromlech remains. It is a low, clumsy cist, of five massive gritstone blocks, and is capped with a deep heap of earth, covered with a rich growth of shamrocks and flowers. The cell measures 9 feet 6 inches by 5 feet 6 inches to 5 feet, tapering eastward. The west, north, south, and east blocks are, respectively, 7 feet by 2 feet by $1\frac{1}{2}$ feet; 9 feet 6 inches by 2 feet 9 inches by 1 foot 9 inches; $5\frac{1}{2}$ feet by 2 feet 9 inches by 18 inches, and 5 feet by 1 foot 3 inches by 18 inches. Its axis lies slightly to the south of last. It has been described and illustrated by Mr. Borlase from his own notes.[2]

There are some large slabs in the fence of a field south of the road, some distance to the west of the last.

(26). Newgrove or Ballyslattery, Tulla Parish (O. S. Sheet 34, No. 4).—This townland was assigned by the Mac Shanes to the O'Slatterys (from whom it takes its Irish name) in 1493, by a deed published in the *Transactions* of this Academy.[3] It adjoins Kiltanon and Tyredagh, lying across the Affock river from Miltown. The "giant's grave," as it was called in 1839, lies in the demesne to the west of the avenue; it is now called "Lobba 'yiermudh." It is nearly perfect, and is a large cist about 5 feet by 9 feet internally, with a bullaun ground in a block at the east end, and a surrounding fence of slabs set on end, like the demolished "giant's grave" in Miltown and others. Three are still standing to the north and two to the south. The cover measures 9 feet by 9 feet 6 inches by 18 inches thick. The basin stone found with this and other Irish dolmens is a very interesting feature. Similar basins occur with dolmens outside

[1] Colonel O'Callaghan, the owner, tells me that Green's holding is now the Sheehan's farms. The leases are now at Maryfort. This clearly identifies the monument described by O'Curry.

[2] "Dolmens of Ireland," vol. i., p. 91, plan and view. Also plan, p. 109, fig. 3, *supra*.

[3] Transactions R. I. A., vol. xv. (Antiquities), p. 52.

our islands, as at Mont d'Algeda, in Portugal, and at dolmens in Syria and Moab. Basins are found near overturned dolmens near the site of Dan. Other basins are found in Palestine,[1] possibly marking the sites of sacred pillars, stone circles, and dolmens, destroyed by Israelitish reformers when they "removed the high places and brake the pillars." The Newgrove monument has been described and figured by Mr. Borlase, and also by me in these *Proceedings*.[2] In the plantation near the river stands a pillar marking the mearing with Tyredagh.

(27). Fomerla (O. S. Sheet, No. 34).—Two little cists lay, I am told, near the stream not far from the remains of Fomerla Castle. I could not find them; but believe that, at any rate, one exists.

(28). Moymore, Tulla Parish (O. S. Sheet 35, No. 5).—A small cist of four stones and a cover, called "Dermot and Grania's Bed," lay near the north-east angle of the townland, but has been removed since 1839.

Another cist is intact, but buried in field rubbish, and with a hawthorn growing on it; it was also called "Dermot and Grania's Bed" on the Survey of 1840. It is 10 feet long and 6 feet 8 inches wide externally, and 5 feet 4 inches internally, at the east end. The north block (so far as I could measure) is 6 feet 4 inches long, and 8 inches thick; the south the same length, and 14 inches thick. Several cover blocks lie on the top, the most western being 4 feet north and south, and 3 feet east and west, the most eastern 6 feet 4 inches by 6 feet across.[3] Across the stream, near Moymore Bridge, the group of small cists, already described,[4] lie in Caherloghan.

(29). Maryfort[5] or Lismehan, Tulla Parish (O. S. Sheet 35, No. 3).—The townland frequently appears in notices of the Macnamara lands and castles, but it bears the name of the

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[1] Conder's "Heth and Moab," pp. 230–249. Cups and circles appear on rude stone monuments even in Fiji.

[2] "Dolmens of Ireland," vol. i., pp. 89, 90, plan and illustration, Proc. R.I.A., ser. iii., vol. iv., p. 547, Plate ix., illustration. Also plan, p. 109, fig. 5, *supra*.

[3] Plan, p. 109, fig. 6, *supra*.

[4] Plan, p. 109, *supra*.

[5] The castle is said to have been built by Mahon Mac Shane Macnamara early in the fifteenth century (S. H. O'Grady's Catalogue of Irish MSS. in the British Museum, p. 73). The modern name was given to the house about 1760 by Ralph Westropp, of Lismehan, in honour of his wife Mary Johnson, and, following (it is said) the bad example of Robert Westropp, who renamed Fertane as "Fort-Anne," after his wife Anna, some fifty years earlier.

O'Meehans, who were possibly its earlier owners. Lios mioðacain appears in the Macnamara rental of *circa* 1390.[1] The fragments of the destroyed castle, built about 1440, lie on what seems to have been an earlier entrenchment. Two other lisses are on the rising ground to the south; a third on the beautifully wooded hill behind Maryfort House. The slight remains of a double earth-fort lie in the marsh near the castle; and on the higher field, east of the castle, where the trace of an old road crosses the avenue, is a small cist. It stands on a grassy knoll in the remains of a mound. The ends are gone, the south side has fallen, and only one block, the north side, and the cover, still leaning upon it, can be measured. They are two limestone blocks; the cover is 5 feet 6 inches east and west, 6 feet 3 inches north and south, by 9 inches; the side measures 4 feet 8 inches by 3 feet 6 inches by 3 inches, and lies E.N.E. and W.S.W. It has been illustrated by Mr. Borlase[2] from my sketch; but the background has got rather altered in the engraver's hands.

(30). Rosslara, Tulla Parish (O. S. Sheet 27, No. 16).—This, when I sketched and planned it, was a fine and fairly perfect dolmen, on a low, grassy hill, overlooking the Castle Lake and Maryfort Lake, overhung by the wooded hill already named, and with an open view to the hills behind Feakle. It was not far from the "rude ribs of the ancient castle" of Fertanemore or Rosslara. It fell naturally in the spring of 1898. Its blocks lie untouched and almost overgrown in the bushes beside the fence and hedge along the top of the hill. The cover measures 9 feet to 7 feet 6 inches by 6 feet 6 inches by 14 inches to 16 inches. It was supported by two stones to the south and three to the north, forming a cist 12 feet 6 inches long, and 4 feet 8 inches to 4 feet wide, and about 4 feet high. The ends were removed, which, with the lowering of the field (so frequently noticeable at dolmens), led to the settlement and collapse of the monument. It is figured and described from my notes by Mr. Borlase,[3] but, as usual, the views have suffered in re-sketching.

This completes, so far as I am aware, the dolmens in the parish of Tulla. Lewis's "Topographical Dictionary," however, mentions

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[1] There is a charter of Tiege i Meadchain, son of Conor, to the Macnamaras, dated 1517 (Catalogue of Irish MSS. in the British Museum, S. H. O'Grady, p. 155; Egerton Charters, No. 97).

[2] "Dolmens of Ireland," vol. i., p. p. 94, view. Plan, p. 109, fig. 9, *supra*.

[3] *Ibid.*, vol. i. p. 93, view, plan and elevations. Also plan, p. 109, fig. 14, *supra*.

another lying on the hill of Tulla, of which I can find no trace, and which is not on the maps, though this, of course, disproves nothing.

KILNOE.

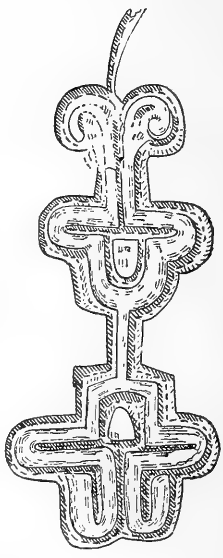
(31.) CLOGHER OR DERRYMORE, Kilnoe Parish (O. S. Sheet 35, No. 5).—This townland was called Clogher before 1651, and derives its name from the many great limestone blocks and outcrops of crag rising in its fields. It is, however, best known as Derrymore, as it forms that very picturesque demesne lying along the winding shores of Lough Breeda. That the place was inhabited by more than wandering hunters in early times is shown by various defaced forts and two crannoges on the lake.

The dolmen is one of the most curious, and I think the most massive, examples among the monuments of the county. My attention was first called to it by Mrs. Gore, of Derrymore, it being apparently a mere natural block. It lies in a grove of trees south of the first turn on the older (northern) avenue. At the opposite side of the avenue we notice a great block similar to the cover of the dolmen. This is embedded in a bank of drift about 6 feet above the level of the foot of the bank; and the gravel underneath has been partly hollowed out. This fact and the appearance of similar blocks (lying near it on low ridges of drift and gravel) lead us to suppose that the dolmen cover also rested on such a mound, under which the grave-makers ran a tunnel, inserting upright blocks underneath so as to form a cist; this was double-walled to provide against the pressure of the cover. Eventually—whether soon after the interment or at some other time during the long subsequent centuries—the cover "kicked out" the outer slabs and crushed and splintered the weaker inner ones. The broken and fallen blocks, however, still bore up the mass sufficiently to allow one to explore and make a plan of the structure. The cover is a massive irregular slab of rough limestone, 12 feet 7 inches east and west, 10 feet 6 inches north and south, and from 3 feet and 3 feet 6 inches at the ends to 4 feet 6 inches in the middle. The west face is 6 feet long, the south-west 8 feet 7 inches, the eastern 7 feet 6 inches, the remaining edges 3 feet and 5 feet. Underneath, as may be seen by the plan, was a cist 9 feet 5 inches by 7 feet 4 inches, with double lines of slabs to the sides. The east end slab is 7 feet 4 inches long, the northern innerside is 8 feet; the southern is broken; they are 9 inches to 10 inches thick. The outer north slabs are more massive, 7 feet 6 inches by 7 feet 5 inches by 12 inches to 18 inches, and 5 feet

4 inches by 7 feet 9 inches. The axis of the cist lies north-west and south-east. The dolmen is not marked on the maps.[1]

FEAKLE.

Feakle parish lies for the most part among the hills round Lough Graney. It is a place almost devoid of history and of ancient buildings of the historical period, having been, it appears, densely wooded. However, a few cahers and earth forts, together with six dolmens, show that it was inhabited in a few spots. A curious plate of gold was found near the village of Feakle about 80 years ago, and is described in the sixth volume of the Academy's *Transactions* in the following words: "A few years ago Mr. Samuel Johns, a working silversmith in Limerick, bought a very curious piece of thin gold of this shape" [a figure with concave sides and straight ends is shown], "and of an exceeding fine quality, supposed to be a shield or breastplate. He got it from a labourer, who found it in the parish of Feakle and county Clare; it weighed upwards of 12 ounces. He gave £3 8*s.* 3*d.* per ounce for it, and sold it afterwards to Mr. William D. Moore, goldsmith, in Dublin, for £4 an ounce.[2] The dolmens, except the wrecked one at Corracloonbeg, have been fully described, but must be briefly noted here.


Rock-Carving, Corbehagh.

(32.) CORBEHAGH or DRUMANDOORA, Feakle Parish (O. S. Sheet 19, No. 3).—The upper Labba and the rock-markings have been described by Mr. Brogan[3] in these *Proceedings*. The Labba on the ridge consisted, in 1866, of an enclosure tapering eastward. It measured internally 5 feet to 3 feet 6 inches by 15 feet 6 inches. A cover rested on the western end, and another lay near the N.E. corner. The ends were nearly intact. It had, besides the end blocks, threel ong ones to the east; and to the west the middle was removed. The lower "lobba" lies in a tilled field,

[1] Plan, p. 109, fig. 7, *supra*; Plate VI., 2.

[2] Trans. R.I.A., vol. vi., p. 32.

[3] Proc. R.I.A., vol. x. (1864–1866), p. 440, Plate XXIX., views of upper dolmen and carvings; plan of the first. The view of the carving been re-sketched inaccurately.

and is a low massive cist of seven blocks, measuring internally 8 feet 2 inches long and 6 feet 5 inches to 3 feet 3 inches, and beyond the end slab to 1 feet 8 inches wide, tapering boldly eastward, with a cover block 11 feet long, 8 feet 2 inches to 2 feet 2 inches wide, and 16 inches thick.[1] Not far away, the outline of a footstep and a curiously combined ornament, formed of spirals, loops, and curved ends, are incised in the natural rocks. I have described the remains and given a sketch in a previous volume of the *Proceedings*.[2]

(33). BALLYCROUM, Feakle Parish (O. S. Sheet 19, No. 16).—This important group stands in the basin of a mountain bog, and consists of the long dolmen Altoir Ultach; the cist Tobergrania,[3] once considered to be a holy well and a long cist found by me, near the first. The first two are marked on the O. S. maps of 1840, and described, though vaguely and incorrectly, by O'Curry. This account was published by Mr. Borlase, who did not visit them. They are noted at some length in the *Proceedings* of this Academy for 1900.[4] I repeat the plans.

(34). CORRACLOONBEG, Feakle Parish (O. S. Sheet, 20, No. 14).—A steep ridge (crowned with a small table of rock, closely resembling a dolmen, but natural) rises 629 feet above the sea, and commands a broad view to the Shannon, the Fergus, and Lough Derg, and across the lake-studded plain to Slieve Bernagh. Towards the north, we look up the valley to Lough Graney and the woods of Caher, and, down the slope, but on the brow of a bluff, we see the defaced dolmen.

A few shattered blocks and a row of three slabs (each 3 feet long, and a fourth, 5 feet long, set deeply in the ground, and running east and west for 14 feet) alone remain. Two loose blocks, 6 feet 6 inches by 2 feet, and 3 feet 3 inches by 1 foot 3 inches by 5 inches, lie near. It is shown as a line of scattered blocks on the survey of 1840.

TOMGRANEY.

(35). CLOGHLEA, Tomgraney Parish (O. S Sheet 28, No. 12).—South of the road, on the bounds of the rectory grounds, stands a pillar called Cloghlea. The slab is 6 feet 7 inches high, and about 4 feet

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[1] Plan, p 109, fig. 4, *supra*.

[2] Proc. R.I.A., ser. iii., vol. iv., p. 546. (Inaccurate). They seem to have been independently discovered and a query inserted in the Journal R.S.A.I., vol. xxi., p. 86, in 1890, by Rev. J. Halpin, of Scariff. They are now marked on the Ordnance Survey maps.

[3] There is actually a holy well, Tobergrania, in Drummaneen, near Crusheen.

[4] "Dolmens of Ireland," vol. i., p. 96; Proc. R.I.A., ser. iii., vol. v., p. 85. Illustration and three plans. See also plans, p. 109, figs. 10, 11, 12, *supra*.

2 inches wide; but it has split into two layers, each 10 inches to 7 inches thick. It is thickly ivied, and may have been adopted or erected by the monks of the neighbouring very ancient monastery, to mark the bounds of their lands.

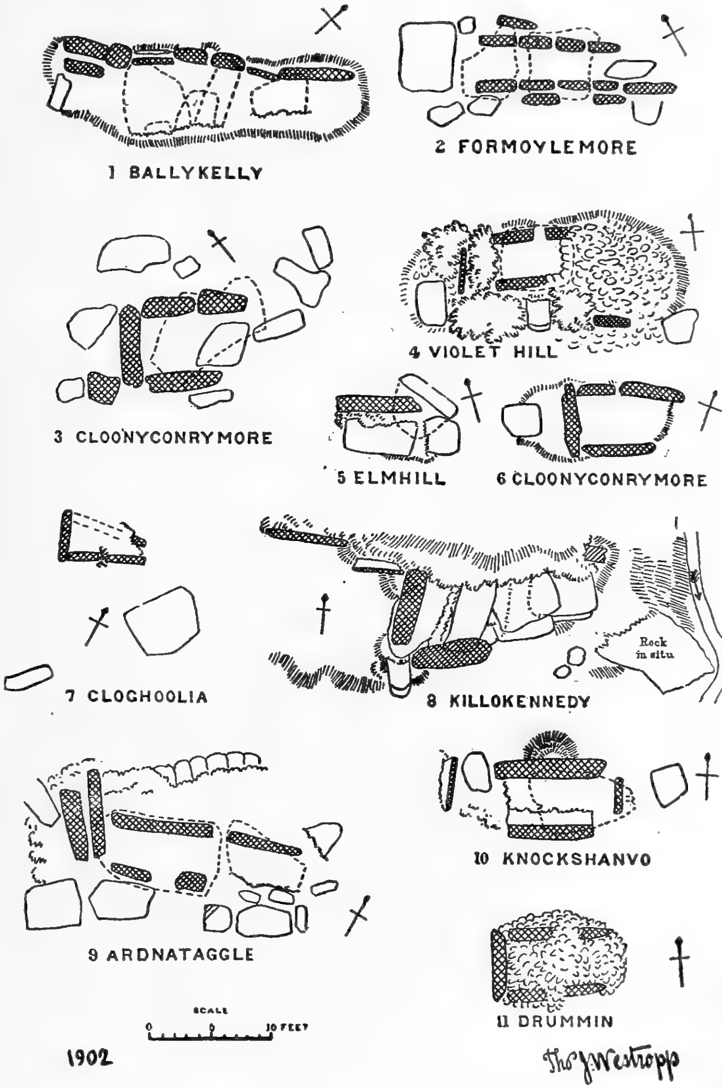
Moynoe.

(36). Cappaghabaun Mountain or Cappaghbane,[1] Moynoe Parish (O. S. Sheet 21, No. 5).—This dolmen lies near the bounds of Clare and Galway, in a secluded nook in the hills above Lough Derg. It is shown in the maps of 1839 as a large irregular block, resting on at least three stones, and with other outlying blocks. It lies on a grassy patch, on the slope of a heathy hill, covered with bog. The site commands an extensive and beautiful view over Lough Derg, with its islets and wooded shores and promontories. The hills of Ogonnelloe, the woods of Raheen and Caher, and the point of Aughinish, close in the view; and through the gaps we see a further reach of the lake towards Killaloe, and the great rounded mountain of Thountinna (where Fintan slept securely under the waters of the Deluge, as told in our older legends) and the heights of Slieve Bernagh over the valley of Killokennedy. Behind us, the Bow river and the streams of Sheeaun, Glencullin, and Barnaminnaun, fall down the long valleys from the heathery uplands towards Lough Atorick, the highest point in Cappaghbane being 1126 feet above the sea.

The structure is called "Dermot and Grania's bed" on the 1840 map. I found no one in that lonely valley to tell me any legend or name connected with it on either day when I visited and planned the monument.

It is a small cist of three great sandstone blocks, tapering eastward, and measuring internally 4 feet 2 inches to 3 feet 3 inches wide, and 6 feet 9 inches long. The blocks are about 2 feet thick, and 2 feet 6 inches high; it has been opened, and the west stones lie outside it. The walls are double, and have externally three blocks to the north. The most western is a pillar, 5 feet by 25 inches by 12 inches to 14 inches of conglomerate, with pink and scarlet pebbles embedded in it. There is one block, 4 feet 2 inches long, and 8 inches thick to the west, and three blocks not parallel to the inner side, and respectively 4 feet 7 inches, 2 feet, and 3 feet 10 inches long, 3 feet high, and, except the middle flag, 1 foot thick. The interspace is filled with turf, and makes sides 31 inches to 36 inches thick. The cover

[1] Locally "Cappabane," pronounced Cappa-bahn.



Dolmens in the Barony of Lower Tulla.

block is 7 feet 3 inches east and west, and about 5 feet 6 inches to 6 feet north and south. It is capped with a mass of turf and heather, and has broken across and hangs into the cist; but is still otherwise perfect and in position.[1]

I noticed a very similar pillar and several large loose blocks lying about in the fourth field south of the road to the east of Cappaghbane school-house. It may be a wrecked dolmen, though suitable blocks abound up these valleys. I have seen no others that are not manifestly untouched by man.

Barony of Tulla Lower.

This barony corresponds to the old states of Tuath Ua gConghaile (Ogonnelloe), Ui Thoirdhealbhaith (south of Killaloe), Tuath Ui bFloinn (Kilseily and Clonlea), and Glenomra. It consists mainly of the great slate and sandstone hills of Slieve Bernagh, rising to heights of 1746 feet, 1729 feet, 1458 feet, 1353 feet, &c., above the sea.

The dolmens lie, with one exception, in the circuit of the hills; and several of them—such as Knockshanvo, Ballykelly, Formoyle, Cloonyconry, Killokennedy Drummin, and Lackareagh—occupy prominent positions.

There seems to be little prehistoric legend connected with the hills, save the late one of the death of the poisoned Ard Righ Crimthann at Glennagross, about A.D. 377; but the connection of Aibhell, the Great Banshee of the Dalcassians, with Craglea, is of very antique complexion. At least two examples of Fearbreagas occur: one near Knockaphunta, and one near Killokennedy, neither being very far from dolmens.

We may divide the dolmens, as usual, into simple cists of five slabs—Elmhill, Knockshanvo, Violet Hill; simple cists of several slabs—Drummin, Cloonyconrymore (two), Cloghoolia, Lackareagh (?); complex cists of more than one compartment—Ardnataggle, Longgraves, Formoylemore, Ballykelly, Killokennedy; doubtful and sites—Bealkelly-Purdon, Ardskeagh, Cloonyconrymore (upper dolmen).

Killuran.

(37). Elmhill, Killuran Parish (O.S. Sheet 36, No. 9).—The remains of this cist stand on a grassy ridge not far from Doon Lake, and command a striking view of the highest part of Slieve Bernagh.

[1] Plan, p. 109, fig. 13, *supra*; Plate VII., fig. 1.

It is not marked on the 1840 map, and was first noted by Mrs. O'Callaghan, of Maryfort, to whose interest and constant help I am much indebted for the completion of this paper. The monument was a cist of four blocks and a cover. The northern side measures 7 feet by three feet, by 1 foot 4 inches, lying E.S.E. and W.N.W. The eastern block has fallen, and is 3 feet by 3 feet by 1 foot 3 inches; the other 6 feet by 3 feet to 4 feet 2 inches by 1 foot 4 inches. The cover is tilted up, and measures 5 feet 3 inches by 4 feet 3 inches by 1 foot. In the adjoining field to the east is the disused graveyard of "Lackbrack." Whether this is an old name for the dolmen (of which it would be most descriptive) I cannot now learn. Mr. Borlase has described it from my notes.[1]

OGONNELLOE.

(38). BEALKELLY-PURDON OR BEHERNAGH, Ogonnelloe Parish (O. S. Sheet 37, No. 1).—This dolmen had been overthrown before 1839. Some blocks still remain to mark the site high up the hills over Lough Derg.

KILSEILY.

(39). DRUMMIN, Kilseily Parish (O. S. Sheet 44, No. 2).—This dolmen is shown on the map of 1840 as four radiating blocks on the western slope of the high rounded hill called Laghtnagat,[2] perhaps from the monument. O'Curry calls it a "broken giant's-grave." It is really a cist, of which the top slab has been removed. The west end is a block of conglomerate, 4 feet 10 inches long by 3 feet by 11 inches. The northern side consists apparently of 2 slabs (one of slate, one of conglomerate), and is 10 feet long. The south had three blocks (the western of slate, the eastern of conglomerate), and is 9 feet 3 inches long. The cist measures internally about 4 feet 4 inches wide, and 8 feet long. The axis lies E.N.E and W.S.W. It is nearly buried in small stones, and stands in a cultivated field, with a wide view to the north of the hills beyond the river Graney, and lies over 600 feet above the sea.[3]

There are some blocks in line E.N.E. and W.S.W. among furze in O'Shea's acres, south of the last; but I am not certain whether they

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[1] "Dolmens of Ireland," vol. i., p. 96. See also plan, p. 121, fig. 5, *supra*.

[2] It is 968 feet high. Broadford is only 100 feet above the sea, and lies at it oot to the south-west.

[3] Plan, p. 121, fig. 11, *supra*.

were portion of a dolmen, though they do not seem to belong to a line of fence.

(40). Violet Hill, Kilseily Parish (O. S. Sheet 44, No. 2).—It is not marked on the 1840 map, and lies above the beautifully situated house, looking out across southern and central Clare, with the wooded shores and lakes of Doon and Cullane, and the bluff hills of Knocksise behind Kilseily Church. The cist is nearly buried in furze and a cairn of small stones, and consists of a sandstone slab, 5 feet 9 inches by 5 feet 7 inches, resting on two smaller blocks, about 3 feet apart and 3 feet long. Whether the cist continues farther eastward I am unable to find; but a slate slab, 3 feet 3 inches long, and 4 inches thick, is set in the ground, 3 feet from the west end. Another sandstone block, only 31 inches long and 9 inches thick, lies east and west 2 feet east of the cover; and another block, 4 feet by 2 feet 8 inches, lies 3 feet 6 inches farther east, in line with a side slab south of the cist, which is leaning outward, near the centre of the south side, and is 3 feet 7 inches by 2 feet. Two other large blocks lie down the slope. I was told of another dilapidated cairn, called a "giant's grave," by Mr. James Going, in 1893, but could not find it on my later visit, the hill-top being much covered with furze.[1]

(41). Ardskeagh or Broadford, Kilseily Parish—(O.S. Sheet 44, No. 6).—This place is the Ard Sgiath of the 1390 rental of the Macnamaras. In 1839, three large blocks of stone, lying east and west, occupied a little rounded knoll near the old road from Broadford to Kilbane, at a place called Knockaunnafinnoge, not far from a hollow, called Poulamuckagh, in which stands a large boulder. The dolmen was probably removed when the field was cultivated; and we have seen corn cut and bound on its site. It is on the lower slope of the hill, not on high ground as stated by Mr. Borlase.

(42). Ballykelly, Kilseily Parish (O.S. Sheet 44, No. 5).—This occupies a noble station on a shoulder of the high hill of Knocksise south of the entrance of the valley at Broadford, and about 550 feet above the sea. It commands a view out to Slieve Aughty and Callan, with the Shannon, the Fergus estuary, and a crowd of lakes. Beneath it lies the picturesque lake of Doon, with its wooded shores and crannoges; beyond it lie bogs pink with heath in the season. The massive tower of Tierovannan, the white houses of O'Callaghan's Mills, and beyond them the wooded demesnes of Kilkishen, Kilgorey, Derrymore, and Fortanne, with Maryfort on its woody hill. Mr.

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[1] Plan, p. 121, fig. 4, *supra*.

Borlase figures and describes the dolmen.[1] He lays stress on its having been called "Old Grania" by a woman; but such names as "Granny's beds" are not uncommon. O'Curry mentions it, with Drummin, as a "broken giant's-grave." It is a long dolmen, consisting of a row of seven blocks,[2] extending for nearly 25 feet towards the E.N.E. They are of irregular height; but get lower eastward. The most western is 6 feet 6 inches high, and has a slab set parallel to it in the interior. Three of the covers still rest against the northern side; and scarcely any of the southern blocks are undisturbed.[3] The first and highest slab in the west end and the other blocks (save the second and fourth, which are of grey conglomerate) are of green slate.

(43). Knockshanvo, Kilseily Parish (O. S. Sheet 44, No. 13).—This picturesque and perfect cist lies far up the hill-side, above the Dromsillagh river in a rushy field, sheeted with scabious and bilberry, while long ferns grow in its chamber. The ridge of Knockaphunta, purple with heather, rises boldly not far away to the north-west; and to the east, beyond a picturesque "screen" of fir-trees, we get a fine view of Slieve Kimalta—the Keeper Hill—and its attendant ridges, and the broken edge of Tipperary and Limerick to the serrated peaks of the Galtees; southward, we overlook the plateau and the valley of the Drumsillagh stream, down to Trough.

The monument is shown on the 1840 map as a large block supported at its western end. Tradition says it was used for the mass during the stress of the penal laws; and a hollow near Knockaphunta is also said to have been a place of secret worship.

The cist is of massive sand-stone slabs; they measure respectively: the northern, nearly 10 feet long by 16 inches to 18 inches thick, and 3 feet 8 inches high inside, the peat rising over a foot outside it; the southern, 7 feet 2 inches long and 13 inches thick, being the same height; it leans slightly outwards; the east, 3 feet 4 inches long; it is slightly displaced; and a slab 32 inches wide has been removed from the south-east angle; the west, 4 feet by 9 inches, and has fallen out. The cist tapers from 3 feet 4 inches to 3 feet; the cover does not slope, and is a finely-shaped sandstone slab, from 4 feet 6 inches at the west to 3 feet 3 inches at the east; 7 feet 6 inches long, and 17 inches to 18 inches thick; it has curious corrugations and a small round hole, perhaps an "elf mill," such as occurs in the cover of more than one

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[1] "Dolmens of Ireland," vol. i., p. 97. View and plan.

[2] The "granite" mentioned by Mr. Borlase is, I think, a grey conglomerate occurring elsewhere on the hills.

[3] See plan, p. 121, fig. 1, *supra*; also Plate viii., fig. 1.

of the Swedish dolmens, and even in some Irish ones. The axis of the cist lies towards the E.N.E.[1]

Killokennedy.

(44). Killokennedy,[2] Killokennedy Parish (O.S. Sheet 44, No. 3).—The townland and parish derive their names from the church of the O'Kennedys, a once powerful clan of the Hymbloid, expelled by the O'Briens and Macnamaras after the battle of Dysert O'Dea, in 1318. The church was probably founded by Cronan (perhaps of Tomgraney), to whom its well was dedicated. Passing the steep bohereen past its ivied and broken walls, we find the "giant's grave," high up the steep hillside to the north. The dolmen stands on a little drift mound, projecting from the slope, and is nearly 900 feet above the sea, and 650 above the road from Broadford to Kilbane. The hills rising behind it up to Cragnamurragh, which is 1729 feet high, and Glennagalliagh mountain, 1746 feet high, the highest point in county Clare. A slip has taken place above, and partly buried the monument, which is a "long grave." The outlook is very fine, far over Glenomera to the Galtees, and Knockfierna; flanked by the rounded hills of Glennagalliagh and Cloonyconry; southward, the view includes the pleasing (if not strikingly picturesque) valley to Hurdleston.

The complete monument is 17 feet long, or 27 feet if we include a compartment at its western end, of which the two northern slabs (6 feet 8 inches and 3 feet 6 inches long) remain. These are greatly distorted by the slipping of the earth. The west end is a strong block, measuring (so far as we are able to reach among the other stones in which it is embedded) 5 feet 10 inches long, 20 inches thick, and at least 4 feet high. The main structure had three side slabs to the south, about 5 feet 5 inches, 5 feet 10 inches, and 4 feet 6 inches long; the eastern is prostrate; on it lie two other slabs, evidently the eastern end slab and the cover. There are four cover blocks, each from 6 feet to 6 feet 6 inches long, and partly buried on the north. A narrow block, 5 feet 8 inches long, slopes out from the south-west angle, and a great block of slate rock (evidently natural) projects diagonally to the south-east, and a little stream runs down the face. It is hard to give further measurements of a structure whose slabs lie piled two and three deep; but from the ends it seems to have tapered eastward from 7 feet 2 inches to 3 feet 3 inches.

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[1] Plan, p. 121, fig. 10, *supra*; Plate VIII., fig. 2.

[2] Killogennedid in the Papal Taxation, 1302.

Four other dolmens lay along the southern side of the valley in this parish.

(45). FORMOYLEMORE, Killokennedy Parish (O.S. Sheet 44, No. 9). —This is the Formaol of the 1390 rental of the Macnamaras. A fine long dolmen stands (as the name implies) on a conspicuous bare ridge, to the east of the road from Limerick to Broadford, before it dips boldly into the valley near the perfect earth fort of Lisnagry. It has been planned by Mr. Borlase[1] in his usual careful manner. It was embedded in a modern house, of which (like the dolmens of Slievenaglasha and Commons in this country) it formed a part. The buildings are nearly demolished; but the dolmen is almost perfect. It consists of four blocks of sandstone and slate to the north, and five longer blocks to the south; outside and parallel to these are others—one to the north and two to the south, showing that, like the grave at Ballyogan, it had side rows. Two large cover slabs rest upon it, and others lie about. Its axis lie E.S.E. and W.N.W. It measures 17 feet long, and tapers eastward from 3 feet to 2 feet 4 inches.

(46). CLOONYCONRYMORE, Killokennedy Parish (O.S. Sheet 44, No. 7).—This townland, the Cluan Ui Chonaire of the 1390 rental, possessed a group of three dolmens. The two existing ones are on a rounded shoulder; the larger on a choice situation, crowning a hummock of cultivated land. It is in sight of the dolmens of Lackareagh, Killokennedy, Ardskeagh, and, I think, Formoyle, and looks out of the mouth of the valley over Broadford. The larger dolmen is of coarse and shapeless sandstone blocks, and has been planned and figured by Mr. Borlase.[2] It has the west end, two blocks to the north and one to the south. The cover measures 7 feet 6 inches by 4 feet 3 inches. Seven of the side blocks remain.[3]

The second cist lies lower than the first, which is in sight of it. It is not marked on the maps or noted by Mr. Borlase. It has a small chamber, 8 feet 3 inches by 3 feet 8 inches to 3 feet 4 inches internally, and tapering eastward. There are two slabs to the north, one 6 feet by 2 feet by 2 feet thick to the south, and one at the west end; the top has been removed.[4] The third lay high up the second ridge of the hill. I saw no trace of it; and the new maps mark its site under a fence, by

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[1] "Dolmens of Ireland," vol. i., pp. 98, 99. Plan. See also p. 121, fig. 2, *supra*.

[2] *Ibid.*, pp. 99, 100. View and plan.

[3] Plan, p. 121, fig. 3, *supra*; Plate VII., fig. 2.

[4] Plan, p. 121, fig. 6, *supra*.

which it was destroyed or covered. It is shown on the 1840 maps as a large slab supported by smaller ones, and was evidently a cist.

O'Brien's Bridge.

O'Brien's Bridge is a straggling late parish, and cuts into the Glenomera and Broadford valleys at their junction to the north-east. Near this point stood a dolmen, and another one lay at the further and lowest ridges of the hills to the south-east, three miles away.

(47). Lackareagh, O'Brien's Bridge Parish (O. S. Sheet 44, No. 8).—This cist is shown on the map of 1840 as a large regular slab, evidently the north side, against which a long and more irregular slab, of about the same size, is leaning, with its nearer end on the ground. It is there called "Dermot and Grania's Bed." When Mr. Borlase visited the site, there were only the remains of a cairn; and it is only shown as a "site" on the map made in 1893 (published in 1898). It stood near the summit of the hill above Glennagalliagh[1] Valley, nearly 1180 feet above the sea. The stream and gorge of Aillenagommaun runs down the flank of the hill to the north.

(48). Ardnataggle,[2] O'Brien's Bridge Parish (O.S. Sheet 53, No. 4).—This dolmen lies on the northern slope of a low ridge, not very far from Bridgetown and O'Brien's Bridge, near the so-called "Cromwell's-road." It commands a fine view of the great bluffs of purple and brown which we have been exploring. It is embedded in deep heather and bracken; and its interior is a veritable garden of delicate ferns and sorrel. Mr. Borlase,[3] in publishing a version of my notes, considered that there had been a row of enclosing slabs round the tomb. I do not think this was the case, as none of the supposed "peristyle" is standing, and no loose blocks (even) lie to the north. It is shown on the 1840 map as a large block, supported on two others. It is really a complex cist, with two if not three compartments; the most perfect resembling the little sketch on the map, and is about 8 feet 6 inches. At the west end are two large slabs, 6 feet 6 inches long, the more eastern forming the end of the cist. The first compartment of this is formed of irregular gritstone blocks; the cover is 7 feet 3 inches long, 5 feet to 6 feet 6 inches wide, and 11 feet to 20 inches thick. Beyond this the cist continues in a very

[1] Locally "Glounagollóch."

[2] Ardataggle of the Ordnance Survey maps.

[3] "Dolmens of Ireland," vol. i., p. 131. See plan, p. 121, fig. 9, *supra*.

defaced condition for 11 feet, and, perhaps, had three compartments. The axis lies E.N.E. and W.S.W. It is now locally known as the "lobba," but is called "Dermot and Grania's Bed" on the 1840 map.

(49). CLOGHOOLIA, Clonlea Parish (O.S. Sheet 52, No. 4).—Far from all other dolmens, in a valley in the plateau of Slieve Bernagh, stands the wreck of a small cist. It lies near Oatfield, and to the north of the road running from Sixmilebridge, through the woods of Mount Ievers, and past Trough to the pretty village of Clonlara and the falls of the Shannon at Doonass. It is in a meadow, whence, to the east, we see the great dome of the Keeper Hill, and to the south, over a low boggy hollow and ridge, the blue lake of Colmeen, where, in 1313, Lochlain Macnamara, chief of that powerful clan, was beheaded by his foes during De Clare's wars. "Spray-showering, wind-swept Loch Colmin of the easy landing-places and green shores, . . . Loch of Colmin that has a cruel story."[1] The cist is called "Dermot and Grania's Bed" on the 1840 map, and was possibly perfect at that date, for it is shown as an irregular oblong enclosure. It is nearly buried in the field; the west end, two southern blocks, and, perhaps, part of the north slab, remain. The first is 4 feet 6 inches by 6 inches, and only rises 2 feet above the field; the other two are 2 feet 4 inches by 6 inches, and 6 feet 10 inches by 10 inches to 7 inches; the east end level with the ground. It sloped and tapered eastward, and, if the block north of the east end be *in situ*, was 9 feet 4 inches by from 2 feet 6 inches to 12 inches wide. A tiny holly-bush springs between the side blocks. Two other slabs lie to the south, one 6 feet east and west, and 4 feet 4 inches north and south; and probably the cover lies 3 feet from the east end; the other is 3 feet 9 inches long, and 12 inches thick, and may have been a north block: all are of fine brown sandstone.[2]

This concludes these notes on the dolmens of Eastern Clare. We have described all those marked on the Ordnance Survey maps or known to us. The cairns, which are usually dilapidated, and sometimes of doubtful age, are, however, omitted.

The vast majority of the dolmens are considered by the peasantry to be "Dermot and Grania's Beds"; but the legend, save from modern books, is, I believe, extinct. In some cases they are recognised as

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[1] "Wars of Turlough, 1313; see also Journal Royal Society of Antiquaries of Ireland, vol xxi. (1891), p. 387.

[2] Plan, p. 121, fig. 7, *supra*.

graves, occasionally as "giant's graves,"[1] but no legends of their occupants seem to exist. In other cases they are supposed to be Christian altars (as Altoir Ultach and Knockshanvo) or wells (as Tobergrania). I only met one legend, and that not from a local person, but from a servant, that the "Druids" used to offer black cocks upon the Maryfort cist. I have also heard on local authority that (over fifty years ago) a black cock "without a white feather" was actually offered on the giant's grave at Carnelly in the same county. This was intended to bring about the fulfilment of the sacrificer's dearest wish; but was also believed to have brought misfortune in its train. Whether the dolmen was an accidental rather than an essential adjunct of these unholy rites is not clear; probably the "Druidical" pseudo-archæology of the earlier nineteenth century filtered into the minds of some of the peasantry, superseding their own rational tradition that the dolmens were sepulchral by that of the belief that they were sacrificial altars of the pagans.

In later days (about 1879) great excitement and anger was caused in a place about a mile from the Maryfort dolmen, by four quarters of a beast having been found "offered" at the four corners of a certain field. The comparatively recent date of the latter event prevents my saying more on this very obscure but curious subject, though I am acquainted with the names and circumstances; but these two cases show that it is not impossible that (*minus* the "Druids") the Maryfort story may have, at least, some probability. The most general impression seems to be that they were graves. All seem to have been opened before living memory, except, perhaps, Ballinphunta. Only one find, that of a gold fibula, is recorded (Knocknalappa). Owing to the lapse of time since they were explored, all memory of finds of bones (as at various dolmens in the Burren) or pottery is lost.

To summarise for the four baronies surveyed in these Papers, there are simple cists of four blocks and a cover—Ballyhickey, Ballymaconna, Ballymacloon, Caherloghan (4 ? 5), Kilvoydan, Monanoe, Toonagh (2 ? 3), Ballysheen, Dromullan (?), Tobergrania, Kiltanon, Maryfort, Miltown (at least 6), Moymore, Fomerla (1 ? 2) Elmhill, Violet Hill, Knockshanvo, Lackareaghmore. (In all 26 or 29.)

Simple cists of more than four side-blocks and a cover—Knappoge (with enclosure), Knocknalappa, Altoir Ultach, Ballycroum, Drumandoora (2), Cappaghbane, Corracloonbeg, Kiltanon, Newgrove (with

[1] Dermot and Grania are Christian "saints from Feakle," Grania being a man in the legend at Ballycroum. See Proc. R.I.A., vol. iv., ser. iii., p. 91.

enclosure), Rosslara, Tyredagh Lower, Drummin, Ardskeagh (?), Cloghoolia. (In all 13.)

Cists of several chambers—Rylane, Ballinphunta, Caheraphuca, Kilcornan, Tyredagh Upper, Ardnataggle. (In all 6.)

Long Graves—Ballyhogan (2), Miltown, Ballykelly, Formoylemore, Killokennedy. (In all 6.)

Enclosures of blocks and circles—Clooney (2) Dooneen. (In all 3.)

Massive top block and double-walled cist—Derrymore.

Pillars—Cranagher (5), Magh Adhair, Newgrove, Tyredagh, Tomgraney. (In all 9.)

Making the total of some 66 dolmens, 9 pillars, 3 enclosures.[1]

ILLUSTRATIONS OF DOLMENS.

Plate V.
1. Caheraphuca—Crusheen, from south.
2. Knocknafearbreaga—pillars, from south.

Plate VI.
1. Knocknalappa—Sixmilebridge, Rossroe Castle and Lake in distance.
2. Derrymore-Tulla.

Plate VII.
1. Cappaghbane—Scariff, from north-east; Lough Derg and hills of Thountinna, Ogonnelloe and Glennagalliagh in the distance.
2. Cloonyconrymore—Broadford, from south; Knocksise, Doon Lake, and Broadford in distance.

Plate VIII.
1. Ballykelly—Broadford, from south-west; Doon and Kilgorey Lakes in distance.
2. Knockshanvo—Broadford, from west; Keeper Hill in distance.

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[1] The following photographs of dolmens in the baronies of Tulla are in the collection of the Royal Society of Antiquaries of Ireland:—Tyredagh, Miltown, Newgrove, Maryfort, Rosslara, Altoir-Ultach, Tobergrania, Corracloon, Elmhill, Cloonyconry (2), Formoyle, Killokennedy, Knockshanvo, Cloghoolia, Violet Hill, Drummin, Ballykelly, and Cappaghbane.

My thanks are due to my sister Mrs. O'Callaghan, Col. O'Callaghan Westropp, Rev. J. B. Greer, Mr. A. G. Creagh, and the late Mr. Pierce O'Brien, for assistance in finding and examining the dolmens of Eastern Clare.

INDEX

TO THE ABOVE TWO PAPERS, TAKING THE NUMBERS OF THE LOCALITIES.

[*The figures refer to the sections.*]

IX.

SOME ILLUSTRATIONS OF THE COMMERCIAL HISTORY OF DUBLIN IN THE EIGHTEENTH CENTURY.

(Plates IX.-XII.)

By C. LITTON FALKINER, M.A.

[Read June 9, and June 23, 1902.]

The volumes placed at the disposal of the Council by Colonel Welch came into his possession as executor of the late Charles Haliday, by whose zeal as a collector of Irish books and manuscripts the Academy has so largely profited. They consist of two volumes of minutes, each bearing closely on the origin and early history of two important Dublin institutions, viz. the Port and Docks Board and the Chamber of Commerce. Of the two volumes, the first in date, if not in point of interest, is an old folio bound in calf, and labelled "Ballast Office, 1708 to 1712." It contains the minutes of the proceedings of the Committee of Directors for the Ballast Office during the first four years of the existence of that body. These minutes add considerably to our knowledge of the development of the Port of Dublin. A portion of them has been published in an abbreviated form in Mr. William Gibbon's notes to those "Observations Explanatory of Sir Bernard de Gomme's map, made A.D. 1673," which are printed as an appendix to Mr. Haliday's "Scandinavian Kingdom of Dublin," and which form perhaps the fullest account yet attempted of the history of the Port of Dublin. Through the courtesy of Mr. Proud, the secretary, the writer has been permitted to examine the records of the Port and Docks Board, the successors of the Ballast Committee, and has ascertained that the earliest volume of minutes in the possession of that body is the Committee Book of the Ballast Committee, commencing March 3rd, 1721. The volume acquired by the Academy is thus several years earlier than the oldest official record, and as elucidating the condition of the harbour of Dublin at the very commencement of the eighteenth century, it is of considerable value to all who are interested in the history of the development of our city.

The second and perhaps the more important of these volumes is a folio manuscript book, bound in green boards, and labelled "Merchants'

Rough Book." It contains the minutes of a body called the Committee of Merchants, apparently a sort of Council of the Guild of Merchants, which appears to have taken charge of the commercial interests of Dublin during a considerable portion of the eighteenth century. The entries in this volume cover a period of fifteen years, viz. from 10th February, 1768, to 10th February, 1783; and the importance of this record in relation to the history of our capital may be measured by the fact that it opens with a statement of the circumstances in which the fine building, long known as the Royal Exchange, and now familiar to us as the City Hall, originated, and closes with a "Plan for instituting a Chamber of Commerce in this city," which was the direct origin of the flourishing mercantile association so well known to us now under that name. Incidentally the volume covers a number of topics of interest touching on the development of Dublin, as, for instance, the building of the present Custom House—a project vehemently opposed by the merchants of the day, on the ground that it tended to shift the commercial centre of gravity in Dublin from Essex-bridge and Dame-street, the neighbourhood of the old Custom House, to the inconvenient and then scarcely accessible slobland of the North Lotts.

As in the case of the Ballast Committee's minutes, so in this, the writer has been enabled to consult the minutes of the modern body to whose chronicles the book relates, and has ascertained that though the minutes of the Chamber of Commerce are extant for ten years immediately succeeding its institution in 1783, no document survives to indicate in what manner the Chamber came into existence. The Rough Minute Book is therefore valuable as containing an authentic statement of the circumstances in which one of the most important of our Dublin corporate bodies came to be formed. Advantage has been taken of this acquisition of volumes bearing so directly on two important Dublin institutions which date from the eighteenth century, not only to give a brief description of the nature of their contents, but to offer some account of the origin of those well-known corporations, the Port and Docks Board, formerly known as the Ballast Board, and the Dublin Chamber of Commerce. The history of both institutions throws considerable light on the commercial development of Dublin; and a valuable sidelight is thrown on the same topic by the story of the Ouzel Galley Society, which is also included in the present paper in connexion with one of the Society's Gold Medals, lately added to the Academy's collection.

I.—Origin of the Ballast Office and Port and Docks Board.

Projects for the improvement of the harbour of Dublin and the better regulation of the shipping of the port appear to have been frequent in the last quarter of the seventeenth century. The fear lest the audacity of the Dutch and the defenceless condition of the environs should expose the capital to attack had led, in 1673, to Sir Bernard de Gomme's well-known "Survey of the city of Dublin and part of the harbour below Ringsend;" and although this survey was undertaken from purely military considerations, it naturally drew the attention of mercantile people to the deficiencies of the port from a commercial standpoint. The control of the port was vested at this period in the Corporation of Dublin, to whom it had belonged from the time of King John, when a royal charter had endowed the citizens[1] with so much of the river and estuary of the Liffey as ran within the city franchises.[2] The Corporation does not appear to have paid close attention to that part of its responsibilities which concerned the harbour; but in the year following De Gomme's visit their attention was called to the matter by the visit of Andrew Yarranton, an expert on harbour improvement.[3] Yarranton, "acquainting the Lord Mayor with his thoughts as to the making a very good harbour at Ringsend," was "importuned to bestow some time in a survey and discovery thereof," and devoted three weeks to this task. But though the survey was made, no steps were taken by the Corporation, and the first step towards providing a proper machinery for the control of the port was left to private enterprise. In 1676 one Thomas Howard petitioned the Irish Privy Council for a patent for the provision of a Ballast Office in all the ports of Ireland. Howard's proposal stirred the city fathers to activity. Protesting against the petition, so far as it related to Dublin, as an encroachment on their civic rights, they appointed a committee to consider the erection of a Ballast Office, "the profits whereof is intended for the King's Hospital," and prayed the Lord Lieutenant that no patent should pass to Howard. The protest of the Corporation was effective, and Howard, though he had

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[1] Gilbert's Historical and Municipal Documents of Ireland, 1172-1320.

[2] The Mayor of Dublin anciently exercised, as Admiral of the Port of Dublin, a jurisdiction which appears to have extended from Skerries to Arklow, and the city was entitled to the customs of all merchandise within those limits (Haliday's Scandinavian Kingdom of Dublin, pages 139 and 246).

[3] Haliday's Scandinavian Kingdom of Dublin, p. 242.

obtained a patent in England for the erection of a Ballast Office in Ireland, was unsuccessful in his application. Accordingly his next move was to petition the city, in association with his brother, for a lease of the port of Dublin at £50 a-year, in return for which he undertook to surrender his English patent. A lease for thirty-one years was granted; but as the Howards took no step to perfect it, it was three years later declared void, and petition was made by the Corporation for a patent to the city for a Ballast Office. The activity displayed on this as on the previous occasion was due to the exertions of a private individual who had taken up Howard's project.

In the year 1697 one Captain Davison had made a proposal to the city to erect on or near the bar of Dublin a lighthouse[1] forty feet above water, which should be enclosed with a small fort of thirty guns capable of defending the harbour, and at the same time he proposed a Ballast Office, "by which ships should be supplied with ballast from such places only as should tend to the bettering the harbour." In 1700, having obtained the approval of the Dublin merchants and captains of ships trading there, and being encouraged by the Irish Government, Davison proceeded to London, and petitioned William III. for authority to proceed with the work, and for a grant of the lighthouse and Ballast Office. His petition was referred to the Irish Lords Justices, who reported that the design was useful and "absolutely necessary for the preserving the trade of the place"; but stated that the "city desired that the grant thereof might be made to them." The Lords Justices accordingly recommended that "lest it should be thought a business of clamour to grant such a thing away from a whole city, the grant should be made to Davison as the instrument of the Corporation."

The matter was then referred to the Committee of the Privy Council for the affairs of Ireland, "to investigate the claim of the several parties pretending to a right in the carrying on of this work," several other persons having meantime sought a patent. The Committee found the claims of Davison infinitely superior to those of all private rivals; but the city of Dublin alleging several ancient charters by which they had title to the ground from whence the said ballast was proposed to be taken, "and having in the sitting of the last Parliament obtained a bill to be sent over for the establishment of a Ballast Office," they recommended the claims of the citizens to Her

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[1] Memorial about the Light House at Dublin. Brit. Museum, Add. MS. 21136 folio 82. Printed in Dublin Corporation Records, vi. p. 609.

Majesty's favour in preference to those of any private persons. They at the same time expressed an opinion that, if the authority were given to the city of Dublin, Captain Davison should be employed on the work.

No action appears to have been taken upon this report, and in 1702 Davison renewed his application,[1] which was again opposed by the Dublin civic authorities as highly prejudicial to the city, and the project seems to have remained in abeyance for some years. In 1707, however, a petition under the city seal was ordered to be addressed to His Royal Highness Prince George of Denmark, Queen Anne's Consort, then Lord High Admiral of Great Britain and Ireland, for erecting a Ballast Office. This petition set forth that "the port and river of Dublin are almost choked up, and are very unsafe by the irregular taking in and throwing out of ballast," and besought favourable consideration for a fresh bill which had been sent over for erecting a Ballast Office, the petitioners being advised that without legislation no duty for the support of such office when erected could be imposed on shipping. The petition further averred that "nothing can contribute more to the safety of the lives of seafaring men who resort hither than the mending of one of the most dangerous ports in Her Majesty's dominions"; and in order to obviate the possibility of a grant to any private individual rather than to the city, it expressed the willingness of the assembly that all profits arising from the Ballast Office "should be applied towards the maintenance of the poor boys in the Blue Coat Hospital in this city, whereby they are instructed in navigation to qualify them for Her Majesty's sea service."[2] In a letter from the Lord Mayor to Prince George, in furtherance of the city claim, it was also stated that the port was so unsafe that there was scarce depth of water left for a small vessel to ride, where some years before a man of war could safely anchor.[3]

These applications were not favourably entertained by the Admiralty, Prince George of Denmark being of opinion that the erecting of a Ballast Office by Act of Parliament was a direct infringement of the rights of his office of Lord High Admiral. He therefore expressed his intention of opposing the bill.[4] But His Royal Highness "having a particular regard to the cleansing of the port of Dublin,"

[1] Dublin Corporation Records, vol. vi. p. 272. [2] *Ib.* p. 374–5. [3] *Ib.* p. 616.

[4] Letter of Josiah Burchett, Secretary to the Admiralty. Dublin Corporation Records, vol. vi. p. 618.

was content "if the Lord Mayor would make proper application to him and to him only," to grant a lease of a Ballast Office to the city of Dublin for a term of years, provided that the surplus of the port dues should be applied to the benefit of the Blue Coat School in the manner already mentioned. The objections then raised by the Admiralty were combated in a very vigorous letter addressed to Lord Sunderland, the Secretary of State, in which it was pointed out that the sand and soil whence the ballast was to be taken was the inheritance of the city of Dublin, which by several charters had the jurisdiction of the Admiralty granted to it, notwithstanding which the city would be willing to waive all such rights and take a lease from the Lord High Admiral, were it not that powers under an Act of Parliament were absolutely necessary, as a means of obviating the difficulty raised by Prince George, to enforce payment of harbour dues.[1] And in token of the readiness of the city to admit the claims of the Admiralty, an offer was made on the part of the Corporation to add to the bill a clause saving the Admiralty jurisdiction, by providing in the following quaint terms for the city's "yielding and paying therefor and thereout to His Royal Highness Prince George of Denmark, Lord High Admiral of Great Britain, and to his successors, Lord High Admirals of the same, one hundred yards of best Holland duck, that shall be made or manufactured within the realm of Ireland, at the Admiralty Office of London on every first day of January for ever hereafter." The solution thus proposed was accepted by the Admiralty, and the heads of the bill having been approved in England, there was passed through the Irish Parliament in 1707 the statute of the 6th Anne, chapter 20, entitled, "An Act for Cleansing the Port, Harbour, and River of Dublin, and for erecting a Ballast Office in the said City."

The minute-book acquired by the Academy contains the record of the steps first taken to put this Act in motion, and must form the materials for the first chapter in any history of the Ballast Office, or of its successor, the Port and Docks Board (see Appendix I.).

II.—Origin of the Dublin Chamber of Commerce.

No record exists of the circumstances under which our Dublin Chamber of Commerce was founded, and inquiries recently instituted regarding its origin show that, save in so far as they are contained in

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[1] Dublin Corporation Records, vol. vi. p. 621.

the Rough Minute-Book of the Committee of Merchants recently acquired by the Academy, those circumstances cannot now be traced. For although the Chamber of Commerce still possesses among its records the first minute-book of the Chamber, that volume throws no light upon the mode in which the Chamber of Commerce was first constituted. It begins with an entry dated March 18, 1783, which records the calling of a meeting for March 22 ensuing to elect a President, two Vice-Presidents, and a Treasurer, and to determine on the duties of a Secretary. And the next entry duly announces the election of those officers and the appointment of one William Shannon as Secretary at an annual salary of £30. But of the circumstances leading up to these proceedings no trace remains. The minute-book of the Committee of Merchants not only unexpectedly supplies the lost details, but incidentally gives us a very interesting chapter in the history of the mercantile development of Dublin.

In the account given by Sir John Gilbert in his History of Dublin of the origin of the Royal Exchange (now the City Hall), mention is made of an association of merchants formed to resist the exactions of one Thomas Allen, who, having been appointed in the year 1763 to the office of Taster of Wines, endeavoured to enforce for his own advantage a fee of two shillings per tun on all wines and other liquors imported into Ireland. The struggle against this arbitrary tax did not, according to the authority quoted by Gilbert, last long; "and turning their thoughts to the best mode of applying the redundant subscriptions raised to conduct the opposition," the members unanimously adopted the idea of building a commodious building for the meeting of merchants and traders. A situation having been fixed upon, the purchase-money, £13,000, was obtained from Parliament by the zeal and activity of Dr. Lucas, then one of the city representatives. The building so erected was the Royal Exchange, of which the foundation stone was laid in 1769, which was opened ten years later.[1] It is to the proceedings of the Committee of Merchants, by whom the building of the Exchange was promoted and conducted, that this Rough Minute-Book relates; and the record shows that the committee not only performed for many years many of the functions now discharged by the Chamber of Commerce, but was the actual parent of that institution.

The minute-book opens with the record of a resolution "that the ground for building an Exchange be conveyed to the Corporation of the Guild of Merchants, and the planning of the building and carry-

[1] Gilbert's History of Dublin, ii. 56.

ing into the execution of the Exchange conducted by a committee of certain citizens therein named, together with fifteen wholesale merchants, freemen of the Guild of Merchants to be chosen by the wholesale freemen of the Guild of Merchants from among themselves." The earlier entries in the book are concerned with the steps taken to raise funds for the erection of the Exchange, the money voted by Parliament being absorbed by the cost of the site. These funds were for the most part obtained by means of lotteries. On Feb. 23, 1768, it was resolved "that a scheme be grafted on the State Lottery now depending in England in order to raise a further sum towards the expense of erecting an Exchange on the reserved ground on Cork Hill, and that an advertisement for that purpose be published in due time in all the Dublin papers, except the Gazette." The minute-book is crowded with entries, between the dates 1768 and 1778, relating to the progress of the building, including a resolution of 24th Feb., 1769, for the payment of the bills "for the expenses of entertaining the Lord Lieutenant on the occasion of his laying the foundation stone," notwithstanding the Committee are of opinion they are exceedingly extravagant. The bills amounted to £298 13*s.* 1½*d.*

But the Committee of Merchants was concerned with topics more serious than these. They busied themselves from the first in such matters as the procuring an amendment in the Irish Bankruptcy Laws, in movements for the direct importation of spirits from the British plantations without first landing them in Great Britain, and other questions directly affecting the commercial interests of Ireland. That they also took a lively interest in the mercantile development of their own city is evident from the space devoted in their records to such topics as the building of the new Custom House, and a proposal for erecting Law Courts in College-green. Both of these projects were opposed by the merchants on the ground that they tended to shift the commerce of Dublin from its old centre in the neighbourhood of Essex-quay; the latter scheme was especially obnoxious as tending "to the erection of a bridge east of Essex Bridge"; and the former was formally condemned as "extremely injurious to the interests of thousands of individuals, and highly prejudicial to the commerce of this city in general."[1] It is interesting to note that the erection of the

[1] On 30th Dec., 1773, it was resolved:—"That the removal of the Custom House below Temple Lane slip will tend to draw the inhabitants of the city further down the river, and so furnish a pretext for building a bridge to the east of Essex Bridge, which would be still more injurious to private property, to trade, and to navigation than even the removal of the Custom House."—(*Extract from Minute-book.*)

former Custom House had two generations earlier led to similar complaints. But the objections of the merchants were, of course, unavailing. The Commissioners of Revenue pointed out that the increase of building had been of late so rapid that the town which was formerly terminated to the east of Essex Bridge was now divided by that structure into equal parts, east and west, that the eastern portion had no communication across the river save by ferries, and that as the city must naturally continue to develop in an easterly direction, they would be highly blamable in preventing such a communication in the future. The merchants, however, did not surrender without a struggle; they interviewed the Viceroy, petitioned Parliament, and invoked the aid of the merchants of London; and they voted gold snuff-boxes to two London merchants who had interested themselves in promoting opposition among the traders of the English capital. The result of their efforts was to retard the erection of the new Custom House for about ten years. But in 1781 the Commissioners of Revenue were at length empowered to build the Custom House on the site so much objected to, and although at a public meeting summoned by the merchants under the presidency of the Lord Mayor, a further petition was ordered to be presented to the Viceroy by the members for the city, Mr. Clements and Sir Samuel Broadstreet, the protest was unavailing. The Custom House was built where it still stands, Carlisle (now O'Connell) Bridge became an immediate necessity, and the development of the city to the east and south-east at once proceeded apace.

It was probably a sense of the deficient authority of the Merchants' Committee, as revealed by the failure of their opposition to the Custom House scheme, which led to the institution of the more formal organization of a Chamber of Commerce. The change may also have been hastened by an investigation into the conduct of the lotteries held by the Committee, which appears to have provoked some scandal, though no proofs of fraud were established. It is certain, at all events, that little more than a year later the Committee was convened to meet at the Royal Exchange on February 10, 1783, for the special purpose of taking into consideration the "Plan for instituting a Chamber of Commerce in this city," a copy of which is printed as an Appendix to this Paper (see Appendix II.). Resolutions affirming the plan were at once adopted, and the Committee of Merchants, after a useful and interesting existence of exactly fifteen years, merged in the Chamber of Commerce of Dublin.

Although it is not the province of this Paper to further pursue the history of the Chamber of Commerce, it appears desirable, inasmuch as that history has never been written, to note the steps which were taken to provide the new association with a formal constitution pursuant to the resolution just chronicled. One month after the final meeting of the Committee of Merchants a ballot was held for the election of a Council of forty-one members.[1] One hundred and fifty-three persons appear to have voted, and Mr. Travers Hartley, long the most active member of the old Committee, who had been for many years a representative of Dublin in the College-green Parliament as a follower of Grattan, was returned at the head of the list. At a further meeting held on March 22, for the election of officers, Mr. Hartley was elected President of the Chamber—a position which he appears to have held continuously down to 1788. In that year rules were drawn up for the annual election of officers of the Chamber, but no election under these rules is recorded in the minute-book, which is a blank from March 29, 1788, to 1805, except for a single entry in 1791. Whether or not the Chamber met during this long interval does not certainly appear; but from the fact that the first minute-book in the possession of the Chamber of Commerce is indexed as "Old Chamber," and that what is referred to as the "second" Chamber began to sit in 1805, it may be assumed that the Chamber as originally started failed to meet for several years, and was, in fact, during a period of seventeen years a less efficient guardian of mercantile interests than the old Committee of Merchants which it had replaced. The minute-book ends with the year 1807. No records exist of any meetings from that year until 1820, when the Chamber appears to have been reconstituted; and it is doubtful for how many years its proceedings were suspended. From the latter date the manuscript records have been preserved in perfect sequence, and are in the custody of the present Secretary of the Chamber, Mr. Perry. The printed reports of the Chamber date from 1821.

III.—The Ouzel Galley Society.

At the end of the seventeenth century, in the closing years of the reign of William III., a vessel known as the "Ouzel," in the ownership of a Dublin merchant, and engaged, it is believed, in the Smyrna trade, sailed from Ringsend for the Levant. Prior to her departure she had been insured against risks, with Dublin underwriters, in the usual way. In the ordinary course her absence would have been a lengthened

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[1] Minutes of Chamber of Commerce.

one; but when, after a lapse of some years, nothing had been heard of her, she was assumed to have been lost at sea with all hands. The owners duly claimed their insurance-money, which was paid by the underwriters; the ship was deemed to have made her last voyage, and the commercial transactions in respect of her to have been finally closed. But it fell out that not very long afterwards, to the astonishment of all concerned, the "Ouzel Galley" cast anchor in the port of Dublin. The captain had a strange tale to tell. Proceeding in her eastern course down the Mediterranean, the "Ouzel" had fallen a victim to the Algerine corsairs, who in those days, and, indeed, for long after, were still the scourge of the mercantile marine, and being a large and well-found ship, she had been appropriated by her captors to their own uses. But by some fortunate chance the crew of the "Ouzel" were enabled to turn the tables on their conquerors, to repossess themselves of their ship and its cargo, and to return in safety to the port from whence they had sailed.

So far all was for the best. But the return of the "Ouzel," unfortunately, proved the occasion of a knotty legal difficulty involving troublesome litigation, which in one form or another lasted for several years. The "Ouzel" brought home in her hold, not alone the peaceful merchandize which it was her mission to carry, but the piratical spoils of her sometime Algerine masters. This loot was of a value far exceeding that of the legitimate cargo, and immensely in excess of the amount for which the ship had been insured, and for which the owners had been compensated. A question at once arose as to the ownership of the plunder. Was the booty the property of the original owners under whose auspices it had been gained? Or did it pass to the underwriters in virtue of their completion of the contract of indemnity? The point was a nice one, which apparently had not then been settled, and the gentlemen of the Law Courts exerted their ingenuity in the endeavour to determine the destination of so rich a prize. No records of this litigation are now traceable; but it is reputed to have engaged the Courts for years without any result being reached; and the case was ultimately referred to the arbitration of a committee of merchants, through whom a compromise was effected, and the litigation terminated.

To celebrate this triumph of the elastic principle of arbitration over the unaccommodating and dilatory procedure of the Courts, the merchants of Dublin resolved to found a society which should have for its object the settlement of all commercial disputes without having recourse to the winding mazes of the law; and they gave to their

Association the name of the vessel which had been the means of bringing it into being. Accordingly, about the year 1705, the Ouzel Galley Society was founded.

The books of the Proceedings of the Society for the first half-century of its existence have long been irrecoverably lost, and only the more recent minute-books are now extant. But its rules and regulations, with a list of members, were printed in 1859, as collected from the books of Proceedings which were then available. These rules and regulations include the Report of a Committee of the Society appointed in 1799 "to inquire into and prepare a declaration of the rules, orders, and customs of the Galley." We are thus enabled to understand the precise objects of the Society and the mode in which it was organized. From this it appears that it was the duty of all members of the Galley to sit as arbitrators in the settlement of such disputes as might be referred to them, "provided all the arbitrators chosen are members of the Galley." Parties were prohibited from making any personal applications to members respecting any matter in dispute, and all proceedings were regulated under the guidance of an officer known as the Registrar, to whom a sum of money, arranged according to a fixed scale, was payable by the parties seeking arbitration, "to insure the payment of the Galley Fees," which were appropriated, after payment of the costs of the award, to a charitable fund. Within the limits of the Society parties were entitled to the choice of their arbitrators, but with the arbitrators when chosen lay the appointment of an umpire.

Such were the purposes for which the Society was formally constituted; but it had, or grew to have, other functions at once benevolent and convivial, which appear in time to have engrossed a large share of the attention of its members. From the year 1770 the subscription appears to have been a guinea; but on November 11, 1801, "it appearing by the bursar's accounts that the subscription of one guinea per annum is insufficient to pay the annual dinners," it was raised to a guinea and a-half. Two years later, no doubt for the same reason, it was raised to £2 5*s*. 6*d*.; and the frequent occurrence of the word "dinner" in its rules may, perhaps, be held to account for the mourning accents with which surviving members still speak of this ancient Society. Most of the business of the Society was transacted at or after dinner, except at the November meeting, which was held immediately before dinner. Certain it is, at all events, that while continuing to perform its more serious functions, the Ouzel Galley Society became highly popular among the merchants of Dublin as a convivial association. Its roll being limited to forty members, admission to it was highly prized. The list of its members for a period of a hundred and forty years, contains, it is no exaggeration to say, representatives of all that is most honourable in mercantile Dublin, and attests the high character the Society continuously enjoyed. The names of La Touche, Guinness, Hone, Pim, Jameson, Hatley, Colvill, and others equally familiar constantly recur.

The esteem in which the Society was borne, and the hold it had on the affections of its members, was strengthened by the quaint and characteristic customs which its constitution ordained and its rules enforced. It was organized, in deference to its marine origin, on a nautical basis. The affairs of the Ouzel Galley were administered by a Council, of which the officers were :—"The captain, two lieutenants, master, bursar, boatswain, gunner, carpenter, master's mate, coxswain, boatswain's mate, and carpenter's mate"; and a peremptory regulation enacted that at the meetings of the Galley, of which three were held annually, "the captain, or in his absence the senior officer on board, has supreme command, and any disobedience to him is mutiny." The introduction of officers and new members was conducted "according to the ancient and immemorial usage of the Galley," part of the ceremony being, it is understood, the draining, at a single draught, of a bumper of claret from the glass cup, a beautiful example of Irish glass-work, a photograph of which is reproduced with this Paper. Guests could only be introduced on the invitation of the "captain, officers, and crew of the Ouzel Galley." At each meeting members were bound, on pain of a fine, to wear a gold medal[1] pendant from an orange ribbon. Finally, the members were "piped to dinner" with a boatswain's whistle; and the minutes for 1754 record that a silver whistle, probably that of which a representation appears below, was ordered to be provided by the carpenter for the boatswain's use.[2]

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[1] The records of the Society for Feb., 13, 1772, contain the following :—

"Ordered, that the medal be made of gold. That on one side of the medal the 'Ouzel Galley' be represented, and the motto 'Steady.' That on the reverse be represented the figure of 'Equity,' with the motto 'cuique suum.'"

These medals appear to have been struck at different periods. That acquired by the Academy is believed to be from the design of Parks, a Dublin architect.

[2] The captain's oath, in 1754, was as follows :—"I, *A*, *B*, do swear that I will be faithful to our Sovereign Lord King George the Second; and this galley, entrusted to my command, I will, to the best of my power, defend against all pirates either by sea and land; the rules and orders established on board I will see observed to the utmost of my power, and justice admisistered to the crew, and all who put any freight on board. I will continue to be a good fellow, and, as long as I can, hearty and merry."

That at these convivial meetings the charitable objects associated with them were by no means ignored appears from the regulation that the bursar should keep two accounts; one for the Subscription Fund, and the other for the Charitable Fund; and that after such dinner it was customary to vote away in charity the earnings of the Galley. And it is certain that the Society enjoyed throughout its existence a high reputation for practical benevolence.

The meetings of the Ouzel Galley Society were held throughout the nineteenth century at the Commercial Buildings, and many still recall these gatherings which each November were held in the open square behind the Chamber of Commerce. In the latter part of the eighteenth century, and for many years subsequently, the dinners appear to have been held at Atwell's Tavern in Dame-street.[1]

From the foregoing account, it is easy to understand that a society of this kind must, in time, have outgrown the circumstances in which it originated. Though as a benevolent association it continued to serve a useful purpose, its functions as an institution for promoting arbitration gradually fell into desuetude, as legal procedure adapted itself more closely to the needs of the mercantile community. From a printed account of awards made in each year from 1799 to 1869, it appears that 364 awards, many of them dealing with matters of great magnitude, were made within that period. But of these nearly two-thirds were made in the first quarter of the nineteenth century. In 1888, accordingly, the Ouzel Galley was voluntarily wound-up and dissolved by an order of the Court of Chancery, which provided for the distribution of its funds, to the amount of £3300, among charitable institutions connected with the city in which the Society had so long flourished.

Many citizens of Dublin must be familiar with the large painting of a full-rigged ship which hangs over the door of the news-room in the Chamber of Commerce, with the legend, "The Ouzel Galley,"

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[1] The meeting-places of the Society, as recorded in their Transactions, throw interesting light on the taverns or eating-houses of Dublin and its environs, in the second half of the eighteenth century. In 1748 the Galley met in the Phœnix Tavern, Werburgh-street; in 1751, at the Ship Tavern, Chapelizod; in 1775, at the Rose and Bottle, Dame-street; in 1770, at the Eagle Inn, Eustace-street; in 1776, at Power's, Booterstown; in 1796, at Harrington's, Grafton-street; and, in 1800, at Atwell's Commercial Tavern, Dame-street. In the early part of the nineteenth century the favourite resorts were Leech's Royal Hotel, Kildare-street; Morrison's, in Nassau-street; the Bilton, in Sackville-street; and Jude's Hotel, Commercial Buildings.

beneath it. It seems right that in this notice of the Society the pedigree of this painting should be preserved so far as it can be collected from the records of the Society.

The painting appears to have been presented to the Society as far back as 1752 by Alderman John Macarrell, the then captain of the Galley. Whether or not it was a merely fancy picture, or an authentic representation of the actual ship from which the Society took its name, cannot be stated, for nothing further is known of the date of the picture or of the artist. In the minutes of the meeting of the Galley held at Chapelizod in August, 1753, a receipt is inserted, in which one John Morris acknowledges the receipt of "a large painted piece representing the Ouzel Galley, which is put up in the great room in my house," and admits the picture to be the property of the Galley. Morris was probably the owner of the inn or tavern in which the Society was then in the habit of meeting.

Nineteen years later, 16th July, 1772, the minutes record the appointment of a committee "to inquire after and recover the picture of the Galley presented to the Society by Alderman Macarrell," but the result of the inquiry is not given in any subsequent minute. It may be presumed, however, that the picture was recovered, and is identical with that which still hangs in the Chamber of Commerce, and is thus referred to in the entry for 3rd June, 1870:—"That the offer of the Chamber of Commerce to place the old painting of the Galley in a more conspicuous place be accepted."

[No account of the Ouzel Galley Society has ever appeared in print, save a brief notice in Whitelaw & Walsh's "History of Dublin," vol. ii., p. 914. The account given above of the origin of the Society, and its history prior to 1753, is not sustained by any documentary authority, but is derived from oral tradition preserved among its members. The writer has to express his cordial obligations to Mr. R. F. S. Colvill, of Coolock—whose father, the late James Chaigneau Colvill, was the senior officer of the Society at the date of its dissolution—for much information and assistance. To Mr. Colvill, also, as the custodian of the glass cup and silver whistle, and the possessor of one of the medals shown in the illustrations, the Academy is indebted for permission to photograph these interesting relics.—C. L. F.]

APPENDIX.

I.

Being the First Entry in the Minute-Book of the Ballast Office Committee.

"The Committee appointed to consider the proper methods for settling the Ballast Office, &c., are come to the following resolutions, which they humbly offer to your Lordships and the Assembly as follows:—

Imprimis.—That it is necessary there should be a standing committee of 3 or 5, who shall be called Governors and Directors, and have the management of the business, and report their proceedings to the Lord Mayor and Assembly quarterly at their meetings, and oftener if needful—the Committee to be altered every Assembly if thought fit.

2ndly.—That there be a proper officer appointed called the Master and Treasurer of the Ballast Office, who shall duly attend the said office in person, and observe such directions as he shall receive from the Committee of Directors; and that he have a good Clerk for receiving and paying, etc., for whom he will be answerable, but if recommended by the Assembly then security to be given by him to the Directors.

3rdly.—That there be a good and sober Clerk, called Accountant and Registrar, to officiate; also a Secretary to the Directors, and to attend the General Assembly with the Registry, and other books of the proceedings of the office when required.

4thly.—That there may be an officer knowing in Shipping, by the name of Chief Gauger and Supervisor, to gauge the Ships, and inspect into the working of the Lighters and Gabbards, and make return to the office of what ballast is put on board, etc.

5thly.—That there may be a sober and careful person appointed to be messenger and office keeper, who may be frequently employed to assist in other matters in the daytime.

6thly.—That there ought to be an office immediately appointed in a proper place, as near to the Custom House as can conveniently, and where boats and Ringsend cars may come without disturbance to the street.

That at Temple-bar there is a proper place if none more convenient be found; it has large rooms and warehouses, at £15 ann.

7thly.—That there ought to be a convenient boat with 2 boatmen, to attend the Gauger and Supervisor, and other services.

8thly.—That there being no Gabbards in this port of the kinds of the Lighters used at London, for the raising the ballast with expedition and ease—it is necessary that 2 Lighters be immediately built, one of twenty the other of thirty tun, without decks or bends. When these Lighters are set to work by the men belonging to the office, they will show what quantity of ballast can be raised in a certain time, and what the cost will be to put each tun on board; and this will be the guide either to build more of these Lighters, or come to agreements with masters of Gabbards. The Governors and Directors, after they have met 2 or 3 weeks, will be able (it is believed) to inform your Lordship and the Assembly what are the more proper steps to be taken in relation to the raising the ballast. This Committee are humbly of opinion that no salaries can well be settled till 3 months after the 1st of May next.

11th Dec., 1707.

"Robert Cheatham.	John Pearson
Wm. Quaile.	Matthew Pearson.
Tho. Kirkwood.	Humphry Jervis.
Tho. Thorne.	John Rogerson.
John Nevill.	Wm. Fownes.
Ed. Surdevill.	John Eccles.
Thos. Wilkinson.	John Godley.
	Nath. Whitwell."

II.

Resolutions of Dublin Merchants, and of the Committee of Merchants, relative to the Establishment of a Chamber of Commerce.

Royal Exchange, Dublin,
7th February, 1783.

Present—Travers Hartley, Esq., in the Chair. Messrs. William Colville, James Horan, John Binns, Denis Thomas O'Brien, David Dick, Alexander Armstrong, George Lang, Henry Lyons, John Cowan, Samuel Dick, Robert Magee, Arthur Bryan, Paul Patrick, James Anderson, George Lunell, Edward Forbes, Edward Patrick, William Bruce Dunn, Daniel Marston, Joshua Pim, Frederick Geale, George Sutton, Leland Crosthwaite, Thomas Mitchell, Robert Black.

A paper having been introduced, containing "Propositions for the Establishment of a Chamber of Commerce in the City"—

Resolved—That the said Paper be referred to the Committee of Merchants, and their opinion requested thereon.

The meeting adjourned to Tuesday evening next at seven o'clock, when the answer of the Committee of Merchants will be received.

Royal Exchange,
February 10, 1783.

Present—

Mr. Colvill.
Mr. Hartley. Mr. O'Brien.
Alderman Sutton. Mr. Cosgrave.
Mr. Carothers.

At a meeting of the Committee of Merchants regularly convened by summons for the special purpose of taking into consideration a plan of instituting a Chamber of Commerce in this city, Mr. John Patrick and Mr. Joshua Pim presented to the Committee the plan hereunto annexed, which being received, read, and considered, the following resolutions were entered into:—

"That we highly approve of the said plan as forming a broad and firm foundation on which may be expected to arise a superstructure of eminent usefulness in the commercial department.

That from this measure the trading interest is likely to derive great additional importance and respect, and the public in general the advantages consequent thereto.

That on the great change expected shortly to take place in the commercial system of Great Britain and Ireland, and probably in that of some other countries, it is highly necessary and peculiarly seasonable by a scheme of this nature to collect the experience and abilities of every intelligent trader in the various lines of commerce and manufactures that their united knowledge may be happily directed to the general good.

That this Committee do therefore most heartily recommend to their fellow-citizens the carrying said plan into effect as speedily as possible, and they will think themselves happy in resigning their appointment as the Committee of Merchants when on the liberal and extensive plan now proposed a Council of the Chamber of Commerce shall be elected.

PLAN FOR INSTITUTING A CHAMBER OF COMMERCE IN THIS CITY.

"The present important situation of this country, its lately renewed constitution, its fond hopes of rising commerce, and consequently increasing opulence, the variety of commercial regulations necessarily incident to this change of circumstances, and particularly requisite from the late revolution in the political system; every consideration appearing to demand a general union among traders and a constant unwearied attention to their common interests; from a view whereof, to promote these laudable objects in this particular district, and to hold forth an example for imitation and co-operation to the rest of the kingdom, it is proposed to institute forthwith a Chamber of Commerce for the city of Dublin.

That any merchant or trader resident within the said city or its dependencies shall be eligible as a member of this Chamber on his paying one guinea to Mr. John Patrick or Mr. Joshua Pim, who have kindly undertaken to act as Treasurers until a person shall be elected to that office; such subscribers to continue members as long as they shall respectively comply with the rules which shall be adopted by the said Chamber for its good government; and for the continuation of a fund to answer the purposes of its institution.

That when the subscribers shall amount to one hundred the said temporary treasurers shall call a meeting by public advertisement, at which said first meeting of the Chamber, or at an adjournment of said meeting, the members present shall choose by ballot a certain number of persons who shall be called the *Council of the Chamber of Commerce*, to continue in office until the 1st of May, 1784; and that an annual ballot for such Council shall be held on every first day of May, not being Sunday, and when Sunday, on the 2nd day of May.

That it shall be the business of said Council to attend to the interests of commerce, and for that purpose to hold frequent meetings, to confer when necessary with persons in high stations or others, to have a watchful attention to the proceedings of Parliament respecting trade in both kingdoms; to inspect into the methods of transacting business in Dublin, and to continue and recommend improvements therein when such shall be thought expedient.

That the said Council for the time being shall choose by ballot from among themselves a President, two Vice-Presidents, and a Treasurer, and shall appoint a Secretary with a fixed salary suitable to his services.

That it be understood that the members of the Chamber of Commerce shall be peculiarly entitled to the protection of the institution on every proper occasion."

X.

THE ITINERARY OF PATRICK IN CONNAUGHT, ACCORDING TO TÍRECHÁN.

By J. B. BURY, M.A., LL.D., Litt.D.,
Regius Professor of Modern History in the University of Cambridge.

[Read January 26, 1903.]

If we attempt to trace on a map the itinerary which Tírechán marks out for St. Patrick through the kingdom of Connaught, we are met by several difficulties, but by none perhaps more awkward at first sight than that which arises at the very outset in regard to the point where Patrick crossed the Shannon. In the present paper I propose to show that this difficulty is only apparent, being due to an erroneous identification which has been accepted without question, and to determine as nearly as possible the alleged route of Patrick from Granard to Rath Crochan. Further, I shall have occasion to point out a fundamental confusion which pervades Tírechán's memoir.

To avoid misconception, it may be well to state explicitly that I am concerned here merely with the interpretation of that document; not directly with what Patrick did, but with what Tírechán says he did.

§ 1. At the end of Book i., our text of Tírechán thus marks the progress of Patrick from the *cacumen Graneret* to the Shannon:—

> venit in campum Rein (311_5 Rolls ed.);[1]
> venitque P. ad alueum Sinone ad locum in quo mortuus fuit auriga illius Boidmalus et sepultus ibi in quo dicitur Cail Boidmail usque in hunc diem (311_9).

That is: Patrick proceeded through Mag Rein, and reached a place on the Shannon, which, in the writer's time, was Cail Boidmail. Mag Rein included the southern part of County Leitrim; and the name is

[1] While I supply the reference to the Rolls edition, I give the text of the passages which I quote from the proof-sheets of Dr. Gwynn's edition of the Codex Armachanus which is shortly to appear.

still preserved in Lake Rinn and the river Rinn. We have no means of identifying the exact site of Cail Boidmail; but its whereabouts seems to be indicated clearly enough. It was *ad alueum Sinone.* The question arises: why did Tírechán, whose language is always plain and unadorned, use this phrase, which recurs 312_2, and 313_3, instead of saying simply *ad Sinonam*? There can, I think, be only one answer. Requiring a Latin word to express the swellings or lakes of the Shannon, Tírechán adopted *alueus* as the best equivalent he could find.[1] Otherwise *alueus* in these passages is perfectly unmeaning. Now the Shannon-swelling which Patrick would reach, advancing westward from Granard through the plain of Rinn, is that which is known as lakes Bofin and Boderg. The inference is that Cail Boidmail was somewhere on the eastern bank of these lakes.

§ 2. *Digression on Mag Slecht.*—An interesting question presents itself here, bearing on the criticism of Tírechán's text. In later biographies, which depend largely on Muirchu and Tírechán, we find a notice that Patrick visited Mag Slecht, where Crom Cruach was worshipped, and cast down the idol. Now, this incident is not recorded in the documents contained in the Codex Armachanus; and therefore it might seem reasonable to infer that it was a story of later origin than the events, whether legendary or historical, recorded by Tírechán and Muirchu. On general grounds I do not feel that such an inference would be quite safe; but there are certain particular considerations in this case which must make us hesitate. The later biographies, to which I referred, are those which it is usual to designate, following Colgan's nomenclature, as the Vita Tertia, Vita Quarta, and Vita Tripartita. Now, in the Vita Tertia, the story of Mag Slecht (c. 46) is inserted immediately after the incidents connected with Coirpre and Conall, sons of Niall (c. 43 and 44), and immediately before the tale of the darkness which the magicians drew down upon Mag'Ai, when Patrick entered Connaught. In the Vita Quarta, the visit to Mag Slecht (c. 53) occurs in exactly the same position (between Coirpre and Conall (c. 51, 52), and the darkness on Mag 'Ai (c. 54)). As these two Lives are quite independent of each other, this is highly significant, for it shows that both depended here on a common source in which these incidents were related *in this order*. Now the story of the two sons of Niall, and the legend of the magic darkness, are derived from Tírechán; so that the conclusion which naturally presents itself is

[1] The association of *alueus*, 'river-bed,' with *aluus*, 'paunch,' explains the use of the former word by Tírechán.

that the common source of V_4 and V_3 here was an intermediate document in which the compiler inserted at this point the story of Mag Slecht.

Turning to the Vita Tripartita, in which large portions of Tírechán's memoir have been reproduced, we find that the visit to Mag Slecht immediately precedes the crossing of the Shannon (pp. 90–92, ed. Rolls), and follows the visit to Granard. This confirms our conclusion. The coincidence in these three documents points to an older document, in which the episode of Mag Slecht immediately preceded the crossing of the Shannon.

Now, it is easy to see why a compiler who was following the memoir of Tírechán might have been tempted to introduce from another source the Mag Slecht incident just at this point. The following words in Tírechán's text obviously might supply the motive:

mittens autem Patricius methbrain[1] ad fossam Slecht barbarum Patricii propinquum qui dicebat mirabilia in deo uera (311_{17}).

The mention of Rath Slecht here might have readily induced a compiler, who was at a loss where to insert the story of Crom Cruach, to choose this place as appropriate. If so, the author of the Tripartite Life, Part ii. (or his source), has gone further; and in the process of inserting the story, has altered a point in Tírechán's narrative. Having recounted the overthrow of the idol, the Tripartite proceeds to reproduce as follows the passage which I have just quoted from Tírechán:—

Forothaigsium [dano] eclais isininutsin .i. Domnach Maige Slécht, ocus foráccaib and Mabran Barbarus Patricii, cognatusque ei et propheta.

Apart from the notice of the foundation of Domnach Maige Slecht, which is not mentioned by Tírechán, there is an important discrepancy between the two passages. In Tírechán's memoir, Patrick, from some place in Mag Rein, *sends* his relative *to* Rath Slecht; in the Tripartite he *leaves* his relative *in* Rath Slecht. This difference could of course be accounted for, as due to an alteration entailed by the insertion of the Mag Slecht story.

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[1] How is this to be reconciled with *mabran* in the Tripartite? Must we not suppose that *m* is in both cases an error for *ni*, the name being *Niabrain?* Cf. L. B. fo. 15 a, b. For *nieth*, cp. Ann. Ult. A.D. 693, and Rhys, Welsh People, p. 51. A similar mistake occurs in the Biburg MS. of the Vita Tertia (Colgan, p. 26, c. lxuii): Mothfer for Niothfer. Colgan's note to the passage shows that this is not a misprint.

But I confess that I do not feel quite satisfied with this explanation of the notable coincidence between Vita 3, Vita 4, and the Tripartite. It is the only possible explanation if we assume that the text of Tírechán is right, as it stands in the Liber Armachanus. But there are grounds for questioning this assumption. In the first place, there is some corruption, whether large or small, in the passage quoted above (*mittens autem . . . in Deo uera*); for there is no finite verb for the subject *Patricius*. The scribe of the Armagh Ms. noted the difficulty of the passage by his symbol z in the margin. In the second place, it seems strange that Tírechán should not have mentioned explicitly that the purpose of the mission of Patrick's follower was to take charge of a church which had been founded at Rath Slecht. This is evidently implied; but we expect it to be stated. Combining these two considerations, we cannot avoid the conclusion that there is a lacuna here. For the sense, it is necessary only to asume a short lacuna; the sentence might have been completed by a few words referring to Domnach Maige Slecht. But the suspicion forces itself upon us that the lacuna may have been of larger compass, and that the original text of Tírechán *may* have contained a notice of the visit to the Field of Adorations.

§ 3. Having brought Patrick to the bank of an *alueus Sinone* in Book i., Tírechán thus resumes his journey in Book ii.:—

Uenit ergo Patricius sanctus per alueum fluminis Sinnae per uadum duorum auium in campum 'Ai (312_{21});

et uenierunt per alueum fluminis Sinnae quae dicitur Bandea ad tumulum Gradi (313_{2});

uenierunt ad campum Glais et in illo posuit celolam magnam quae sic uocatur cellula magna (ib. $_{10}$);

deinde uenit ad Assicum et Bitteum et ad magos qui fuerunt de genere Corcuchonluain Hono et Ith fratres. Alter suscepit Patricium et sanctos eius cum gaudio et immolauit sibi domum suam. Et exiit ad Imbliuch Hornon . . . Et posuit ibi Assicum &c. (ib. $_{13}$).

Patricius uero uenit de fonte Alofind ad Dumecham nepotum Ailello et fundauit in illo loco aeclessiam quae sic uocatur Senella Cella Dumiche usque hunc diem (314_{10}).

Patrick is thus said to have proceeded to Mag 'Ai by crossing the Shannon at *Vadum Duarum Auium*, the Latin equivalent of the Irish Snámh-dá-én. The plain known as Mag 'Ai comprises a large part of County Roscommon, stretching from the town of Roscommon northward beyond Elphin. It is in the north part of this plain that we find Patrick when he has crossed the river; first of all, he does certain things in Mag Glais, a district whose name still survives (as we shall see) close to Boderg; and then he goes on to Elphin, evidently crossing the Baune (Badgna) hills, which divide Mag Glais from Mag 'Ai. Accordingly, if we had no other knowledge, we should, without much diffidence, conclude that the Vadum Duarum Auium was in the neighbourhood of Boderg and Bofin.

But when we consult modern authorities on Irish topography, we find the Snámh-dá-én placed, without any hesitation, far from the scene of the events described by Tírechán. It is shown by O'Donovan that it was an old name for a part of the Shannon close to Clonmacnois. It is mentioned as a landmark in a description of the boundaries of the Hy Many, in a context which shows that it was south of Athlone [1]; and the situation near Clonmacnois is implied in the story of the *Aided Diarmada*, published in Mr. O'Grady's Silva Gadelica,[2] and in a passage in the *Agallamh na Senórach*.[3]

It may be said without the least reserve that this situation is quite irreconcilable with the narrative of Tírechán. It would mean that this writer supposed Patrick to have travelled southward from Mag Rein (in Leitrim) to a point south of L. Ree in order to cross the river, and returned northward again along the western bank just for the purpose of reaching Mag Glais. It is as if one who wanted to reach Battersea from Hampstead were to go round by way of Henley. Mag Rein lay on one side of the Shannon; Mag Glais opposite to it on the other. If Tírechán had intended to bring Patrick round by this circuit of seventy miles, it is inconceivable that he should not have said something to explain it or indicated more precisely the route; nor is there any imaginable cause why such a route should have been chosen, if it were not for the purpose of preaching and founding churches in the districts through which it lay. Not a hint is given of any such activity in the territory through which Patrick would have passed, and the Vadum Duarum Auium is introduced as if it were the direct and natural passage from Mag Rein to the northern part of Mag 'Ai.

In the case of another chronicler, we might suspect that, through ignorance of topography, he had mixed up his information and failed to perceive the incongruity of his story. But, as I have pointed out at

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[1] O'Donovan, Hy Many, p. 5; compare the map.

[2] Text, pp. 72-3; translation, p. 76: "two birds that Nar son of Conall Cernach's son Finncha killed there on Eistine the Amazon's shoulder, whence it is named Snámh-dá-én.'

[3] *Ib.* Text, p. 134; transl. p. 147.

length elsewhere,[1] Tírechán was personally acquainted with the geography of Connaught and Meath; and we must feel the utmost hesitation in imputing to him the apparent absurdity.

These considerations seem to me so weighty as to be fatal to the notion that Tírechán supposed Patrick to have crossed the river in the neighbourhood of Clonmacnois. But the argument becomes simply irresistible when we turn to the details which the memoir supplies as to the crossing. The crossing was at a river-swelling (*alueus fluminis*); and this condition is not fulfilled by O'Donovan's Snámh-dá-én. In order to meet the difficulty, it might be proposed to take the words *per alueum fluminis per uadum duarum auium* in an unnatural way, so as to mean that Patrick, having travelled along the left shore of L. Ree (*alu. flum.*), proceeded down the river to the Snámh-dá-én, and there crossed. But if we could entertain such a forced explanation, it would be only to encounter a new difficulty on the other bank. Having crossed over by the *uadum*, Patrick and his companions came to another *river-swelling*:—

> Et uenierunt per alueum fluminis Sinnae quae dicitur Bandea ad tumulum Gradi (313_3).

Thus Patrick, having already crossed the Shannon by the *uadum*, has again to cross the *alueus* 'Bandea,' in order to reach Duma Graid.[2] Unfortunately Duma Graid no longer bears that name; and we cannot make use of it to determine the situations of other places. But it was clearly in Connaught, on the western side of the Shannon, on the same side as Mag Glais; for Patrick proceeds from it into Mag Glais without again crossing the river.

If any doubts be still felt as to the justice of my negative criticism on the view that Patrick (according to Tírechán) crossed by O'Donovan's Snámh-dá-én, they must yield to the positive fact that there is another place on the Shannon which satisfies fully the conditions of the problem. The essential condition is that having crossed by a river-swelling, Patrick should then come to another river-swelling

[1] English Historical Review, April, 1902.

[2] The only way out of this conclusion would be to assume that here *per alueum* does not mean 'across' but 'along the banks of'—*per* in these passages being used in different senses with *alueum* and with *uadum*. In that case the *alueus Bandea* might be sought anywhere (except in L. Ree, which, on this theory, would be a different *alueus*), since, *ex hypothesi*, circuitous routes not traced by the writer are admissible. But such possible attempts at exegesis will not satisfy a reasonable critic.

which he should also cross without returning to the left bank. This seems imperative; but it will also be admitted as a desirable, if not indispensable, condition that the required river-passage should lie in the direct, or more or less direct, route from Mag Rein to Mag Glais.

Now, these conditions are exactly fulfilled by the river-swellings which are known as Bofin and Kilglass. We saw above, following Tírechán's route, that the natural place to locate Cail Boidmail was on the eastern bank of Bofin or Boderg. We may say, more generally, that any one passing from Mag Rein to Mag Glais, in the north part of the barony of North Ballintober, would be sure to cross the river somewhere between Roosky and Drumsna.

But if the second condition is satisfied, the first condition is also strikingly fulfilled. If he crossed L. Bofin, Patrick would have found himself on the river-girt promontory (which forms part of the modern parish of Kilglass), with L. Bofin on one side, and L. Kilglass on the other. In order to reach Mag Glais, whither he was proceeding, he would have to cross L. Kilglass, unless he took a long détour round the south extremity of this river-lake. It is manifest that this topography conforms precisely to the requirements of the narration of Tírechán. Having crossed a first *alueus*, L. Bofin, the saint then goes on to cross a second, L. Kilglass, by which means he is able to proceed into Mag Glais. It follows that Bandea was the old name of the branch swelling which is now known as the lake of Kilglass.[1]

Having crossed Bandea, Patrick went to Duma Graid. Topographers expect to find this appellation in the form Doogary, a place-name

[1] The Tripartite Life, Part ii., which depends here on Tírechán, gives an additional piece of topographical information, derived from an unknown source. The passage is translated by Dr. Stokes as follows (p. 93): "There Patrick found the *fertas* (bar ?, bank ?), namely, the earth was raised up under Patrick in the ford; and the learned still find that ridge. And he went into the harbour at once, and there died Buad-moel, Patrick's charioteer, and was buried in that place. Cell Buadmóil is its name, and it belongs to Patrick." [Cell Búadmáil should be corrected, after the text of Tírechán, to Cail Búadmáil.] While this abbreviates Tírechán's account, it adds the token that at the passage there was a ridge of raised earth in the river-bed. This notice is far more likely to have a basis of fact than to be a pure invention. There is no reason to suppose that the name Cail Búadmáil had disappeared between Tírechán's date and the composition of the Vita Tripartita; and we need not have many scruples in accepting the statement that near Cail Búadmáil there was a bank in the river which, according to the people of the neighbourhood, rose out of the bed as the saint was crossing. It would be interesting to know whether there are traces of this bank in L. Bofin. There is at all events an island.

which occurs in different parts of Ireland.[1] But in the neighbourhood where we seek Tírechán's Duma Graid, near Mag Glais, there is none to be found.[2] Thence Patrick and his companions went to Mag Glais. The name of the plain of Glas has survived unchanged since Tírechán's day, though with a far narrower signification. Moyglass is now a small townland adjoining L. Tap in the parish of Kilmore.[3] The ancient Moyglass included the modern parish of Kilmore, of which it is now only a small portion. This follows from the fact that the Patrician church which gave its name to the parish of Kilmore was in Moyglass, combined with the geographical consideration which suggests the probability that there was a name to designate the whole district between the Baune hills and the Shannon. It is possible that the territory thus named extended considerably beyond the parish of Kilmore, south-westward, into the barony of Roscommon. This may be inferred from the existence (a mile or so west from the south extremity of L. Kilglass) of another townland, Moyglass, which looks as if it too preserved the denomination of the original Mag Glais; and likewise from the name of the 'Church of Glas,' from which L. Bandea came to be called L. Kilglass.

In this district, Patrick founded a large *cellula* called *Cellula Magna*, that is, in Irish, Cell Mór. This foundation has been preserved, and the original *cell* was, we may assume, not very far from the modern church, about two miles north of the bridge which spans the mouth of L. Kilglass.

The circumstance that *Cellula Magna in campo Glais* is situated close to that part of the Shannon which, in other respects, conforms to the conditions which are implied in Tírechán's narrative, strongly corroborates my conclusion that this writer makes Patrick cross the Shannon at L. Bofin. We must now return to the original difficulty. While, as has been shown, the details of Tírechán's story make it clear that the crossing was at L. Bofin, Tírechán designates the place of

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[1] There is a L. Doogary in Leitrim; another in Armagh; there are Doogarys in Cavan, Fermanagh, Tyrone, Monaghan, Down, Kerry. The nearest places to Mag Glais are Doogarymore in the barony of Ballintober South, near L. Ree (Ordnance Map of Roscommon, Sheet 40), and Doogary in barony of Boyle (*ib.*, sheet 4); but neither is possible.

[2] Yet it seems possible that the name survives in a corrupted form in the islet which is known as Dockery's island at the mouth of L. Kilglass. If so, we might infer that Duma Graid was opposite this island in the townland of Rushport.

[3] Rightly identified by Mr. Hennessy in a note to his translation of the Vita Tripartita in M. F. Cusack's Trias Thaumaturga (p. 427, n. 8).

crossing as Vadum Duorum [*sic*] Auium, or Snámh-dá-én, which was a wholly different place.

In the case of a more commonplace name, one might, with some reason, leap to the conclusion that there were two places so called on the Shannon—one at L. Bofin, and one near the later monastery of Clonmacnois. But the 'Swimming-place of the Two Birds' hardly lends itself to such a facile explanation, which we should have no difficulty in accepting if the name were, for example, the 'Swimming-place of the Ox'; and it seems to me that we can hardly escape the conclusion that Tírechán did not intend to associate Patrick's crossing-place with the name Snámh-dá-én, and that an error has crept into his text. The thought naturally occurs that the Vadum might have been known by the name of the two cows, the red cow and the white cow, Boderg and Bofin, which gave its names to the river-swelling. If Tírechán wrote *Vadum duarum vaccarum* (to translate Snámh-dá-bó), and if *vaccarum* fell out accidentally (through homœoteleuton), it is easy to conceive that *duarum* might have been corrected to *duarum auium* by a scribe to whom the name of the Snámh-dá-en was familiar, but who had no accurate knowledge of the geography of the Shannon.[1]

§ 4. From Moyglass, the saint proceeds, in the pages of Tírechán, to the territory of the 'Corcu-chonlúain';[2] and one of the chiefs of this tribe (one of two brothers, named Ith and Hono, described as *magi*) welcomed Patrick, 'et immolauit sibi domum suam et exiit ad Imbliuch Hornon.' It seems probable that *Hornon* is an error for *Honon* (genitive of *Hono*); and this is the view suggested by the Tripartite Life (p. 94), where 'Imlech Onand' is the dwelling of Ono, 'de quo Ui Onach.' If this correction is legitimate, one

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[1] As there was a Druim-dá-én near the Snámh-dá-én on the river-reach below Athlone, so it is possible that, if there was a Snámh-dá-bó, there may have been a ridge of corresponding name. The modern Drum-sna is north of the river-swelling; but it may at least be suggested that the ridge from which the place derives its name was called from the ancient Vadum—the ridge of the Snámh (dá bó). At all events Drum-sna must be short for a fuller name in which the particular *snámh* was designated.

[2] The name (suggesting *stercus caninum*) is puzzling; but the *Corcu Ochland* (so Vit. Trip. 94) are meant. Their territory is described in Vita Trip. (*ib.*) as 'on this side of the land of the Hy Ailella, and to the north of Sliav Baune.' See O'Donovan, 'Annals of Four Masters,' A.D. 1256, p. 458, *note*; and 'Topographical Poems of John O'Dubhagain, &c., notes, p. xl, on the Corca Sheachlann or Corca Achlann, one of the three tuathas which formed a deanery in the diocese of Elphin.

ambiguity will be removed from the narrative, which, at this point, is not quite clear. It is not made evident which of the two brothers received Patrick; but if *Imbliuch Honon* is the true reading, it will follow that it was *Hono* (as the Tripartite Life assumes).

Another ambiguity lies in *exiit*. The sentence reads as if *Hono* were the subject; but if this means, as it would naturally mean, that Hono went thither alone without Patrick, a difficulty arises as to the reference of *ibi* which occurs just after. The text is :—

et immolauit sibi domum suam et exiit ad imbliuch hornon et dixit illi Patricius Semen tuum erit benedictum et de tuo semine erunt sacerdotes domini et principes digni in mea elimoysina et tua hereditate et posuit ibi assicum et betheum filium fratris assici et cipiam matrem bethei episcopi.

The awkwardness is increased when, reading on, we find that the place from which Patrick started when he had thus set up Assicus and Betheus was a place which he was not said to have reached—*fons Alofind* (314_{10}).

Now, it seems certain that *ibi* means Alofind, for there can be little doubt that Assicus was stationed there.[1] The inference might seem to be that one sentence at least has fallen out, in which the coming of Patrick to Alofind was mentioned. But if we turn to the Tripartite Life, we find a solution which may enable us to dispense with the assumption of a lacuna. There we find Alofind identified with Imbliuch Honon (94_{30}). This interpretation implies that Patrick, received by Hono somewhere in the territory of Corcu-chonlúain, went with him to Imbliuch Honon—that is, Elphin—and founded a church there.

It must be allowed that the text of Tírechán, just as it stands, admits of this interpretation. A different punctuation from that adopted in the Rolls text will make it clear :—

Alter suscepit Patricium et sanctos eius cum gaudio et immolauit sibi domum suam. Et exiit ad Imbliuch Hornon et dixit illi Patricius : "Semen tuum erit—hereditate." Et posuit ibi Assicum, &c.

The subject of *exiit* is Patricius, who proceeds to the Imbliuch of Hono; and it is to be observed that, with this interpretation, the probability that *Honon*, to which the following *illi* would refer, is a true correction for *Hornon*, approaches certainty.

[1] Compare Tírechán, 313_{28}.

Yet it remains strange that the close proximity of Alofind to Imbliuch Honon is not more clearly brought out, and also that the foundation of the Ecclesia there is not formally mentioned.

§ 5. In any case, Alofind gives a fixed point in the territory of the Corcu-chonlúain; and for the purpose of marking the itinerary, it is enough to determine that, from Kilmore, Patrick, having crossed Sliav Baune, proceeded south-westward to Elphin. From there he passed on to Dumecha in the country of the Hy Ailello, and founded the church called Senella Cella. The 'land of Ailill' has survived in the name of a portion of western Sligo; but the barony called Tir-erill corresponds only to a part of the original territory, and the present passage has topographical importance in proving the southern extension of the territory of that tribe.[1] For it is clearly right to seek the Senella Cella to which Patrick passed from Alofind, in the district of Shankill, which is close to Elphin. Thus the territories of the Hy Ailello and the Corcu-chonlúain would have adjoined close to Alofind.

But the church which Patrick founded here at Dumecha cannot have borne the name of 'Old Church' when it was newly founded by him. Tírechán speaks as if it were so called from its very foundation; but it must have been in contrast to some newer establishment that the *cell* of Dumecha was distinguished as old. We are here in presence of the same kind of problem that is puzzling Roman archæologists in regard to the name of that early church of which the plan has recently been discovered in the Forum. But S. Maria Antica is more baffling than the Cella Senella of Dumecha. The clue seems to lie in the close vicinity to Alofind. If we suppose that the church was situated on ecclesiastical ground near the cemetery at the Shankill crossroads, a mile from Elphin, then the natural conjecture would be that the foundation of Dumecha was earlier than that at Alofind, and that, when the newer church was planted, the earlier came to be distinguished from it as the 'Old Cell.'

The obvious objection to this conjecture is that it contradicts the narrative of Tírechán, who represents the foundation at Dumecha as subsequent to that at Imbliuch Honon, or Alofind. This objection, however, is not fatal. In fact, we come here into close quarters with a problem of great importance regarding Tírechán's itinerary. He tells us himself that Patrick *peruenit per Sinonam*, that is, visited

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[1] O'Donovan, Leabhar na g-Ceart, p. 101.

Connaught three times (329_{12}); and the question suggests itself whether Tírechán, in collecting his information from various sources, has not gathered up and compressed into the one visit to Connaught, which he describes, incidents which really belonged to other visits. At the end of this paper I will adduce a larger argument to prove that Tírechán was guilty of such a confusion; but here I may point out that some of the incidents mentioned by Tírechán imply a previous visit. Thus, we have a statement that, on crossing the Shannon, Patrick ordained Ailbe, *cui indicauit altare mirabile lapideum in monte nepotum Ailello* (313_5). The natural implication is that Patrick had, on a previous occasion, visited Sliab hua nAilello, and seen the altar. Again, it is important to observe that, when Patrick comes to Corca Ochland, he is described as coming not only to the chiefs Hono and Ith, but to Assicus and Betheus, his disciples (313_{13}). Thus Assicus and Betheus were already stationed in the district; and the inference may be that Patrick had visited it before, and planted a small Christian community somewhere. If so, the conjecture that the Senella Cella had been founded on the occasion of the previous visit seems plausible.

§ 6. At Senella Cella, Patrick was visited by Mathona, the sister of Benignus; and here we encounter a difficult passage, which requires elucidation :—

> Et uenit apud se filia felix in perigrinationem nomine Mathona soror Benigni successoris Patricii quae tenuit pallium apud Patricium et Rodanum. Monacha fuit illis. Et exiit per montem filiorum Ailello et plantauit aeclessiam liberam hiTamnuch. Et honorata fuerat adeo et hominibus, et ipsa fecit amicitiam ad reliquias sancti Rodani, et successores illius epulabantur ad inuicem.

It is obvious that the words *et exiit . . . hiTamnuch* interrupt the context most awkwardly, and that the sentence should run: *Monacha fuit illis, et honorata fuerat adeo et hominibus. Et ipsa*, &c. Moreover, the idea forces itself upon us that the subject of *exiit* and *plantauit* in the inserted clause must be Patricius, not Mathona. And, turning to the Tripartite Life, we find that, in the text in the Rolls ed. (p. 98), though it agrees with the Armagh text, the clause in question is referred to Patrick.[1]

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[1] So, too, in Colgan's Latin translation (Tr. Th., p. 135); where, however, the sentence *et ipsa fecit*, &c., becomes *et ipse fecit*, &c., and is postponed to the following notice of the ordination of bishop Cairell, to whom *ipse* is made to refer.—In regard to the clause *fothaigis ineclais* sair *hiTamnach* (p. 98_{12}, ed. Rolls),

This criticism is borne out, and the problem defined, when we discover that almost the same clause recurs in f. 15 r° a (328_1):

et exiit trans montem filiorum Ailello et fundauit aeclessiam ibi, id Tamnach et Echenach et Cell Angle et Cell Senchuae.

Now, the fact that this crossing of Sliab macc nAilello and founding of the church in Tamnach (in Tirerrill) is mentioned in almost the same words in two different contexts, at two different stages of the itinerary which Tírechán has marked out for Patrick, is highly significant. It seems clear, in the first place, that the foundation of Tamnach was not the work of an excursion of the saint from Shankill on this occasion, but belongs to the context of other work in the region of Tirerrill. And in the second place, it seems probable that the foundation of the churches in Tirerrill (as described in the passage just quoted) belonged to a previous visit to Connaught. For it is natural to suppose that it was from Tamnach that Mathona came *in peregrinationem* to see Patrick, at Shankill; and if so, the Tamnach community was already established.

Moreover, the mention of the *mons filiorum Ailello* corroborates these inferences. This chain of hills can hardly be any other than the Bralieve mountains which divide Tirerrill from Leitrim. Therefore if Patrick crossed these hills to reach the districts of Tamnach and Senchua (Tawnagh and Shancoe), he must have come from the Leitrim side. This confirms the conclusion that the work in those districts belonged to a different visit.

A corollary of considerable importance may be drawn. We cannot easily explain this particular confusion unless Tírechán had a written source before him, in which the crossing of the Mons filiorum Ailello was distinctly recorded in connexion with the foundations in Tirerrill. If his material had been merely oral, he would have been less likely to fall into the topographical inconsistency which helps to reveal his methods to us. But, having a written authentic statement before him: *exiit trans montem filiorum Ailello*, he simply wrote it out without criticism.

In both the passages where he repeats this statement (314_{18} and 328_1), there are signs of patchwork. We have seen how the Mathona passage is dislocated; but there is also an awkwardness, though of a

the editor translates "founded the church *east* in Tamnach," and observes, in a note, that Colgan gives *insignem ecclesiam*, "as if for *sair*, his texts had *sóir*, 'noble.'" But surely Tírechán's *liberam* shows that the word is *saer*, 'free.'

slighter kind, in the Tirerrill passage. The singular *aeclessiam*, introducing four churches, is curious; and Dr. Stokes, feeling this, was led to suggest *aeclessias quatuor*. But *aeclessiam* seems to me not to be a textual error, but to let out a secret of compilation. As I have said, Tírechán was here using a written source; he used it both for the Mathona passage and for the Tirerrill passage. Why did he think of using it for the Mathona passage? The obvious conjecture is that it mentioned Mathona in connexion with Tamnach. This conjecture at once supplies the explanation of the singular *aeclessiam*. In the source, the words *fundauit aeclessiam liberam ibi, id est Tamnach* (or *hiTamnuch*), were followed by a notice of Mathona's association with that community, after which the foundations of the other churches (Echenach, &c.) were enumerated. But Tírechán had worked the notice of Mathona into his account of Shankill and Rodanus; and, consequently, he dropped it out when he came to speak of the communities of Tirerrill. But in doing so, he left the *aeclessiam* (which in his source applied only to Tamnach), although he added, in dependence on the same verb, the names of three other foundations.

§ 7. From Elphin and Shankill, Patrick went on to Rath Crochan, seven or eight miles to the south-west (314_{30}); and there I must leave him.

The two things which I have endeavoured to do in the foregoing pages are (1) to identify the place at which, according to Tírechán's memoir, Patrick crossed the Shannon; and (2) to show that—assuming the author's statements as to Patrick's doings in Connaught to be more or less authentic—we are forced to infer that, in putting together his material, he has worked into the frame of one visit events which must have belonged to different visits; because he has unwittingly left certain implications which betray this unconscious contamination.

But the suggestion that the events of more than one expedition to Connaught have been confused and conbined in the narrative of Tírechán admits of a clearer and more trenchant demonstration, which touches the whole plan of his memoir. The motive of the circular tour which the writer describes is represented to have been the meeting of Patrick with the sons of Amolngaid. It was arranged by Endae, one of these brethren, and Patrick that they should travel together to Endae's country in north-western Connaught, to establish the Christian faith in those regions. But the route followed by Patrick is quite inconsistent with this motive. In the first place, he spends a long time in missionary or ecclesiastical work in Meath before he enters Connaught. And when he crosses the Shannon, he makes a long tour in Roscommon and Mayo before he comes to Tirawley. The goal of his journey is entirely lost from view; Tirawley is almost the last part of Connaught he visits. It is manifestly absurd to suppose that Endae and his followers undertook to accompany the apostle on this long round of missionary activity. Nor is there, in the itinerary itself, the slightest indication that they did so. Endae and his arrangement to travel with Patrick are completely forgotten in Tírechán's story, until suddenly—after the lapse of months, or years—he reappears with his son Conall, as Patrick's companion, when the saint at length crosses the Moy and enters Tirawley.

At this point, indeed, the suture in Tírechán's compilation is visible. The route can be traced from stage to stage through Roscommon and Mayo to Mount Egli in Murrisk. After his fast on the mountain, Patrick proceeds to the region of Corcu-themne, which seems to have been near the Partry mountains and L. Mask. Then we find him in *regionibus maicc Hercae in Dichuil et Aurchuil* (324_{16}), and in the White Plain *in regionibus nepotum maini.* This was probably in southern Roscommon. Then there is an extraordinary leap:—

> Per Muadam uero uenit et ecce audierunt magi filiorum Amolngid quod sanctus uir uenisset, etc. (325_{25}).

The break here in the itinerary is manifest, and exhibits very clearly the method of Tírechán. The narrative between 310_{12} and 325_{25}—between the starting for Tirawley and the coming to Tirawley—is wholly or mainly concerned with the incidents of another journey, or other journeys, than that which was taken expressly for the purpose of converting the tribe of Amolngaid.

In one passage Tírechán himself betrays a consciousness of the incongruity. He states—inconsistently with the context and the situation—the object of the expedition of Patrick and Endae to have been Mount Egli (310_3), whereas the tenor of his own account implies that it was Tirawley. This is the only attempt he makes to conciliate the actual itinerary with the avowed motive of the journey.

This investigation confirms the suspicion which I hazarded in a former paper on Tírechán, that, while the notices of the particular incidents which he records depend on sources written or oral, and may in many cases be credible, yet the actual route which he traces and the chronological order which he assumes may be due to his own combinations. I must add that further study and more minute analysis of Tírechán's text have led me to conclude that he had more written material at his disposal than I was before inclined to suppose.[1]

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[1] See Tírechán's Memoir of St. Patrick in Eng. Hist. Review, April, 1902, pp. 235, *sqq.*

XI.

THE COUNTIES OF IRELAND: AN HISTORICAL SKETCH OF THEIR ORIGIN, CONSTITUTION, AND GRADUAL DELIMITATION.

By C. LITTON FALKINER, M.A.

Read November 29, 1902.

Not the least of the many merits of that most luminous of nineteenth-century historians, the late John Richard Green, is his insistence on the importance of the relation in which geography stands to history. By geography Mr. Green meant not so much physical as political geography. The dominating influence upon the development of any given race or people of the main physical characteristics of the land in which their lot is cast has long been understood by historians; and the effects produced on the history of the world—in modern times, by the insular position of Great Britain, or, in the world of the ancients, by the peninsular position of Greece—are among the commonplaces of historical criticism. What is not so much a commonplace is the extent of the influence exerted upon the domestic history of any community by the accidents of its early local history, and the degree in which archaic conditions of tribal division may survive in the modern organisation. For these divisions often continue for long centuries after their origin has passed into the partial oblivion of unexplained tradition, to mould the shape and form of a more advanced civilization.

The application of this principle to the case of Ireland is direct and obvious. For the local history of Ireland is, as has been acutely observed, in a special degree, the backbone and foundation of its general history. Owing to what may be described as the inorganic character of the social structure in the Ireland of the Middle Ages, to the absence of a strong central government or settled constitution, capable of giving to the country and the people the impress of its own uniformity, it is almost exclusively to clan or sept history, and to the history of the particular areas with which the septs were associated, that we must chiefly look if we would seek to realise the body politic of the Ireland of a not very remote past. If this statement should appear at all exaggerated, let it suffice to note two simple but striking illustrations. As late as the reign of Henry VIII., in a memorandum on the State of Ireland, which is among the most instructive documents in the Tudor State Papers, the names of the "Irish regions," and not the territorial divisions to which we are accustomed, are the units employed by the writer to describe by far the greater portion of the country.[1] And in the Elizabethan Map of Ireland, drawn by Dean Nowel, in the third quarter of the sixteenth century, division by territories, or "chieferies," and not that by counties, is the method adopted;[2] for down to the reign of Philip and Mary, as Sir John Davies observes in the lucid paragraphs devoted to the history of the shiring of Ireland in his well-known work:—"The provinces of Connaught and Ulster, and a good part of Leinster, were not reduced to shire ground. And though Munster were anciently divided into counties, the people were so degenerate as no justice durst execute his commission among them."[3] It is the main object of this Paper to indicate the process by which these large districts were gradually brought within the ambit of English administration, and by which the counties of Ireland, as we now know them, came to be formed.

"The civil distribution of Ireland," to quote Bishop Reeves's most valuable Paper on 'The Townland Distribution of Ireland,' "in the descending scale, is into Provinces, Counties, Baronies, Parishes, and Townlands."[4] But this highly convenient division of the surface of Ireland, as the Bishop goes on to say, is characterised neither by unity of design nor by chronological order in its development. "The

[1] "Who list make surmise to the King for the reformation of his land of Ireland, it is necessary to show him the estate of all the noble folk of the same, as well of the King's subjects and English rebels, as of the Irish enemies. And first of all to make His Grace understand that there may be more than 60 countries, called regions in Ireland, inhabited with the King's Irish enemies; some region as big as a shire, some more, some less, unto a little; some as big as half a shire and some a little less; where reigneth more than 60 chief captains . . . that liveth only by the sword and obeyeth to no other temporal persons, but only to himself that is strong . . also there is no folk daily subject to the King's laws but half the county of Uriel, half the county of Meath, half the county of Dublin, and half the county of Kildare." "The State of Ireland and Plan for its Reformation." "State Papers Henry VIII.," vol. ii., Part iii., p. 1.

[2] Copy of an ancient map in the British Museum by Laurence Nowel, Dean of Lichfield, ob. 1576. Printed by Ordnance Survey.

[3] "Discovery of the True causes why Ireland was never entirely subdued," &c.

[4] "Proceedings of the Royal Irish Academy," vol. vii., p. 473.

provinces, subject to one suppression and some interchange of adjacent territories, represent a very ancient native partition which in the twelfth century was adopted for ecclesiastical purposes. The counties and baronies, though principally based on groupings of native lordships, are of Anglo-Norman origin, and range, in the date of their creation, from the reign of King John to that of James I. The parochial division is entirely borrowed from the Church, under which it was matured probably about the middle of the twelfth century; while the townlands, the *infima* species, may reasonably be considered, at least in part, the earliest allotment in the scale."

With the two last of these grades of classification we have nothing to do here. But a word must be said regarding the third. The baronial division does not indeed present any very difficult problem. For though it be not easy to account for the adoption of the term "barony" as signifying the division of a county,[1] seeing that it has no such meaning in the territorial classification of Great Britain, there is no doubt that in general the baronies were successively formed on the submission of the Irish chiefs, the lands of each chieftain constituting a barony, and that they thus represent more nearly than any other unit the ancient tribal territories. The origin of the parochial system is much less easily traced; and the relation between the diocesan areas and the provincial or county divisions is a subject which might well engage the attention of some of our ecclesiastical antiquaries.

The limits of the five kingdoms of what has been called the Irish Pentarchy, into which Ireland was anciently divided, correspond closely to those of the provincial divisions, as the latter were maintained down to the seventeenth century. They represent, as Dr. Reeves has pointed out, "a very ancient native partition," the adoption of which in the twelfth century, for ecclesiastical purposes, served to embalm a division of our island which, being based on no great natural boundaries, must otherwise have perished. The five provinces are shown separately as late as 1610 in Speed's map. For it was not until late in the reign of James I. that Meath ceased to be

[1] "The cause of the difference in name between the Irish baronies and English hundreds has been thus accounted for: When the kingdom of Meath was granted to the elder De Lacy, shortly after the arrival of the English, he portioned it out among his inferior barons, to hold under him by feudal service, and hence their estates naturally took the name of baronies, which gradually extended itself to similar subdivisions of other counties." See Hardiman's "Notes to the Statute of Kilkenny," in "Tracts relating to Ireland," ii., p. 108.

generally reckoned a separate province; in popular usage it long retained its provincial identity; and Boate, writing under the Commonwealth, mentions the province as but lately merged in Leinster. The Ulster of unsubdued Ireland was conterminous with the modern province of that name, save that it included Louth—a fact commemorated in the still existing incorporation of that county in the See of Armagh and the northern ecclesiastical province—and that it did not include Cavan. Ancient Munster differed from the modern only by including within its bounds the territory of Ely (the O'Carroll country), which, now represented by two baronies of the King's County, forms a part of Leinster. Connaught included, in addition to its present territories, the County of Cavan, and a part of Longford; while during the sixteenth century the earldom of Thomond or County of Clare oscillated, as we shall see, at the pleasure of successive deputies, between Munster and Connaught, giving to the western province, in the periods of its association with it, a predominance it has long ceased to enjoy. Meath, which is substantially identical with the modern counties of Meath and Westmeath—it is practically conterminous with the diocese of Meath—also embraced a considerable portion of Longford; while Leinster comprised the modern Leinster counties, less Louth, Meath, Westmeath, Longford, and the part of the King's County specified above.

The first attempt at a division of Ireland into counties was, of course, subsequent to the Anglo-Norman conquest, and is commonly dated from the reign of King John. It is generally ascribed to the tenth year of that monarch's reign; but it does not appear that this ascription, though doubtless substantially correct, rests upon any extant documentary authority of ancient date. It has been adopted, however, by every writer, and Sir John Davies's account is as succinct and accurate as any other: "True it is that King John made twelve shires in Leinster and Munster—namely, Dublin, Kildare, Meath, Uriel or Louth, Catherlogh, Kilkenny, Wexford, Waterford, Cork, Limerick, Kerry, and Tipperary. Yet these counties did stretch no further than the lands of the English colonies did extend." Harris, in his additions to Ware's account of the division of Ireland,[1] asserts and, indeed, elaborately argues, that the twelve counties attributed to King John were really of earlier origin, and were, in fact, part of an earlier division effected by Henry II. Without a division into shires and the appointment of sheriffs, Henry's grant to Ireland of the laws

[1] "Antiquities of Ireland," chap. v.

of England would, in his opinion, have been no better than a mockery: "For without sheriffs, law would be a dead letter;" and without a shire there could be no sheriff. That there were sheriffs in Henry's reign Harris considers proved by the language of a patent to one Nicholas de Benchi, directed to all archbishops, bishops, *sheriffs*, &c.; and that shires were known in Ireland prior to the tenth year of King John is shown by a patent of the seventh of that reign, in which the County of Waterford is distinguished from the City of that name. In further support of his thesis, Harris also argues that the division of Connaught into the two counties of Connaught and Roscommon is of earlier date than King John's counties; that Leix and Offaly were reckoned in Kildare, and other portions of the Queen's County in Carlow, prior to the reign of Philip and Mary; and that there were unquestionably sheriffs of Down and Newtownards, of Carrickfergus and Antrim, and of Coleraine, long prior to the division of Ulster into counties under Elizabeth. But though he would be a bold antiquarian who would venture to controvert a proposition maintained by the erudition of Ware, the authority of Ware's laborious editor is hardly so formidable. It may at least be said that if the shiring of Ireland was really accomplished by Henry II., all substantial traces of it have perished; and the historian must be content to start with King John.

As has just been noted, there is no conclusive evidence now extant of the formation by King John of the twelve counties traditionally ascribed to him. And it is certain that though these divisions were probably known as separate geographical areas, they cannot in several instances, if in any, have formed counties in the modern administrative sense till a date considerably later than King John's reign.[1] For it must be remembered that the earliest grants of territory by Henry II. were in the nature of counties palatine rather than of ordinary counties, though the term "palatine" nowhere occurs in any early instrument; and of the twelve counties imputed to King John, five formed part of the single liberty or palatine county of Leinster. In order to follow the process of the development of our Irish counties, it is essential to have regard to this fact and to the consequences flowing from it. It is therefore necessary to consider the origin of the institution of counties, and the difference, in the extent and nature of their respective jurisdictions, between simple and palatine counties.

[1] See Hardiman's "Notes to the Statute of Kilkenny" in "Tracts relating to Ireland," ii., p. 102.

The name and office of Count were derived from the Court of Charlemagne, and the institution of counties in England is of earlier date than the Norman Conquest.[1] The creation of a count involved from the first a delegation of royal authority for legal and administrative purposes, and the ordinary county had two courts—the King's Court for criminal cases, and the Earl's Court for civil causes. But the judicial officers and sheriffs were in all cases appointed by the Crown. Between a county palatine and an ordinary county the distinction was broad and well defined. According to Blackstone, "counties palatine"—of which there were in England the three great examples of Chester, Durham, and Lancaster, besides the smaller ones of Hexham and Pembroke—"are so called *a palatio*, because the owners of them had formerly in those counties *jura regalia* as fully as the King in his palace."[2] The Earl of a county was Lord of all the land in his shire that was not Church land; and his jurisdiction was equivalent in all essential points to the jurisdiction of the King in an ordinary county.[3] The *jura regalia* included a royal jurisdiction and a royal seignory. By virtue of the first the Earl Palatine had the same high courts and officers of justice as the King; by virtue of the second he had the same royal services and escheats, and could even create barons, as was certainly done in Chester. Included in the power to appoint officers of justice was the appointment of the sheriff; and with the functions of the sheriff in the palatinate no King's sheriff might interfere. And therefore, says Sir John Davies, "such county is merely [absolutely] disjoined and separated from the Crown, so that no King's writ runs there, except a writ of error, which being the last resort and appeal is excepted out of all their charters."[4]

The origin of these immense delegations of royal power was of course the inability of the Sovereign in early times to establish an efficient administrative system throughout his realm; and the same considerations which compelled resort to the palatine system in England by the early Norman Kings, rendered necessary the application of an analogous method of administration in Ireland by Henry II. In the case of England, where the central authority was strong, the palatinates were limited to the march or border districts, as Chester

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[1] Selden's "Titles of Honour," p. 694.

[2] Stephen's Blackstone, i., p. 131.

[3] Stubbs's "Constitutional History," i., p. 363.

[4] Sir J. Davies's "Reports des cases et matters en Ley," "Le Case del Countie Palatine de Weixford," p. 62.

on the Welsh and Durham on the Scottish or Northumbrian borders. In the case of Ireland, the Crown having practically no authority, the policy of Henry II. was to hand over the country to Strongbow and his followers, with powers practically co-extensive with the powers of the Crown, but subject to and excepting any grants of Church lands. Only the sea-coast towns and the territories immediately adjacent were reserved to the Sovereign. And, in fact, it was in these latter districts, and in these only, that for a long period the authority of the English Kings had any direct force in Ireland.

Accordingly, as Sir John Davies, with his usual insight, observes, all Ireland was "cantonised" by Henry II. among the persons of the English nation, who, "though they had not gained the possession of one-third part of the whole kingdom, yet in title they were owners and lords of all, so as nothing was left to be granted to the natives." Of these grants at least three—those of Leinster to Strongbow, of Meath to De Lacy, and of Ulster to De Courcy—were grants of royal jurisdiction equivalent to palatinates; and most probably all were intended to be such. It is clear at all events that the liberty of Leinster was confirmed in right of Strongbow's daughter to William Marshal, Earl of Pembroke, by King John, and that, on the division of Leinster among the five co-heiresses of the latter, the five divisions of Carlow, Kilkenny, Wexford, Kildare, and Leix were regarded as separately enjoying, within their respective territories, the same palatine privileges which had pertained to the undivided liberty of Leinster. That Leinster was long regarded as preserving its palatine privileges may be seen by the Statute 25 Ed. I., in which "the whole community of Leinster" is referred to as "lately but one liberty."

Of the remaining palatinates or liberties, Meath was divided between the sisters of Walter de Lacy, of whom Matilda married Walter de Greenville, and Margaret, John de Verdon. The half known as the liberty of Trim passed to the Crown through the marriage of a descendant of Matilda de Lacy with Mortimer, Earl of March; while the second half, descending to the Talbots, Earls of Shrewsbury, was resumed by Henry VIII. under the Statute of Absentees.[1] Ulster, originally granted to De Courcy, was re-granted by John to the De Lacys, and descending through a daughter to the De Burghs, and thence to the Mortimers, ultimately became vested in the Crown in the person of Edward IV., as the descendant of Lionel Duke of Clarence. Connaught, granted to the De Burghs, also technically passed with

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[1] Stat. 28 Henry VIII., cap. iii.

Ulster to the Crown; though the rebellion of the younger branch of the Burkes, on the failure of heirs male of the elder, deprived the legal title of the Crown of all effective force. The union of all these territories in the Crown of England is incidentally recognised in an Act of Parliament of Henry VII.'s reign (10 Henry VII., c. 15), which, reciting that "the Earldoms of March, Ulster, the Lordships of Trim and Connaught, bin annexed to our sovereign lord the King's most noble Crown," makes provision for the better keeping of the records of those ancient dignities, the title to which had been jeopardised by the loss of the muniments. This Act expressly refers to "Richard, late Duke of York," as lord of Trim.[1]

The precise character of the jurisdiction conferred by King John on the early Palatine counties of Ireland does not appear from any extant documents. But if, as it seems reasonable to suppose, the later jurisdictions conferred by Edward III. were similar in their general scope, its nature may be gathered from the records of the Palatinate of Tipperary. The process of *Quo Warranto* by which James I. resumed possession of Tipperary enumerates the courts and offices which existed at the beginning of the sixteenth century, and which, doubtless,

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[1] Selden, in his "Titles of Honour" (third edition, p. 694), has a reference to the use of the name and office of Palatine Earl in Ireland, which seems to state the facts with great accuracy:—"The title of local Earl Palatine, as well as of other Earls, occurs in the Records of that Kingdom. But I do not believe that any man was ever created into the title of Count Palatine there, or the County expressly made a County Palatine by Patent; but as in other countries, so here, the enjoying of the title of earl (and sometimes of lord), together with a territory annexed to that title, wherein all royal jurisdiction might be exercised, was the original whence in speech and writing the title of Earl Palatine or Count Palatine grew." This was written in 1614; and it is noteworthy that Selden's view as to the title of Palatine is confirmed by the Patent of Charles II. to the Duke of Ormond in 1660 for the County Tipperary. Tipperary was an undoubted Palatinate; yet neither the Patent nor the Act of 2 George I., cap. 8, by which it was revoked, contains the term "Palatine"; but they speak only of the *regalities and liberties* of Tipperary.

The extent and character of the privileges of a county palatine or liberty of England appear by the Charter of Edward III. to John of Gaunt for the Palatinate of Lancaster—a dignity which, owing to the prudent sagacity of Henry IV., has been preserved in its ancient independence and prerogatives almost down to the present day. Anxious that the hereditary honours of his dukedom should be secured to him, even should fortune deprive him of a usurped crown, Henry, on attaining to the throne, had an Act passed providing that the duchy of Lancaster should remain in himself and his heirs in like manner as though he had never acceded to the royal dignity.

represented in all essentials the Palatine constitution of earlier times.[1] The jurisdiction, authorities, and liberties set out in the *Quo Warranto* of James I. were restored on the reconstitution of the Palatinate in 1662 in favour of James, first Duke of Ormond, with the exception (which appears to have been a reservation common to all Palatine grants) of the four pleas of arson, rape, forestalling, and treasure trove, as originally reserved in the grant of Edward III.

In tracing the position of the Irish counties through the obscure

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[1] The following are among the more important of the privileges vested in the Earls of Ormond within their Palatinate:—

1. To have and to hold within the county of Tipperary one *Curia Cancellariae*, commonly called a Chancery Court, and to make, appoint, and constitute one *Cancellarius*, or officer of the same Court, commonly called a Chancellor, which Chancellor, under colour of such his office, makes and causes to be made all kinds of original writs and other processes in all actions, as well real as personal and mixed, within the aforesaid county arising, occurring, or happening.

2. To have and to hold within the aforesaid county one other Court of Pleas of the Crown of the said Lord the now King, and to make, appoint, and constitute one other officer or Seneschallus, commonly called a Seneschal, and one other officer or Justiciarius, commonly called a Justice, to hold Pleas of the Crown of the said Lord the King.

3. And also to have and to hold within the aforesaid county one other Court of Common Pleas held before the aforesaid Seneschal and Justice.

4. And also yearly to nominate, appoint, make, and constitute in the same county one other officer, viz., one *Vicecomes*, commonly called a Sheriff, for the custody of the same county, which sheriff makes execution of all writs, &c., issuing and directed to the same sheriff from the four courts of the said lord the King held at the King's Courts in the County of the City of Dublin, also from the Justices assigned to take the assizes in the County of Tipperary aforesaid, as well as from the aforesaid Chancellor, Justice, and Seneschal in the same county. And he holds in the same county divers Courts of *Turn*, *Leet*, and *Curiae Comitatus*, called County Courts.

5. And moreover to have and appropriate to themselves the power of granting charters of Pardon, and *ad pardonandum—Anglicè*, to pardon—whatsoever persons are suspected, accused, convicted, outlawed, condemned, or attainted of any felonies and treasons by them within the aforesaid county in any wise done, committed, or perpetrated. . . . . And further to do and execute within the aforesaid county all other things whatsoever which appertain to any Earl of any County Palatine to be done or executed.

6. And also to make, appoint, and constitute in the aforesaid county divers other officers, viz., one or more Coroners, and one Escheator and one Feodary, and one Clerk of the Markets, and one Sub-vicecomes, commonly called a Sub-sheriff.—Fifth Report of the Deputy Keeper of the Public Records of Ireland, pp. 34–36.

complexity of Irish administration under the Plantagenet Kings, the only guide whom we may follow with any degree of confidence is the Sheriff. The whole machinery of local or county administration in Plantagenet times practically centred in the Sheriff, who united the threefold functions of a civil officer in relation to the courts of law; of returning officer in relation to the election of parliamentary representatives; and of revenue collector in relation to the royal exchequer. Owing to the destruction in the reigns of the two first Edwards of most of the early records of the Kingdom of Ireland, the materials available in regard to Plantagenet Sheriffs are unhappily meagre; and the Act of Henry VII. just referred to indicates the paucity of the records of several of the greater earldoms. But a study of the Plea Rolls, Pipe Rolls, and Patent Rolls, as well as of the Plantagenet statutes, so far as these survive, is not wholly fruitless; and the last-mentioned source is fairly rich in references to the functions and office of the sheriff. An examination of these sources establishes, at least negatively, the fact that from the time of King John to that of the Tudors no new county was formed, or if formed that it did not survive; and that no Sheriff was created for any new district, with the single exception of the subdivision of the great territory of Connaught into the separate districts of Connaught and Roscommon.[1] It is impossible to say how much or how little of Connaught was intended to be included in Roscommon, or precisely when the division was made. But the separation is certainly as old as the thirteenth century, and Roscommon is among the counties and liberties[2] whose respective Sheriffs and Seneschals were directed by the Statute 25 Ed. I. (1296) to return to the "general parliament" held in Dublin in that year "two of the most honest and discreet knights of each county or liberty." This vagueness of the territorial divisions and of the shrievalties associated with them was not confined to the western province, but was characteristic of all the so-called counties of King John. And this was especially so in the case of the Leinster counties, whose south-western borders were probably in a state of continuous flux. Thus in 1297 a list of Coroners of Kildare shows that county to have included Offaly, Leix, and Arklow, and therefore to have

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[1] See Hardiman's "Statute of Kilkenny," p. 106.

[2] The following is the enumeration in the Statute :—"Likewise the Sheriffs of Dublin, Louth, Kildare, Waterford, Tipperary, Cork, Limerick, Kerry, Connaught, and Roscommon; and also the Seneschals of the liberties of Meath, Weysford, Katherlagh, Kilkenny, and Ulster." See Betham's "Feudal Dignities," p. 262.

extended far over its present borders into the modern counties of King's County, Queen's County, and Wicklow.

The broad distinction which was drawn between counties ordinary and counties palatine was reflected in the designation of the most important office in their respective jurisdictions. In the county proper that officer is invariably styled sheriff; but in the county palatine he is as uniformly referred to as "the seneschal of the liberty." The distinction is clearly marked in a mandate of Edward III. to the Treasury of Ireland, which directs that "because the liberty of Carlow has been taken into the King's hands,"[1] the writs of the King for execution should be directed to the sheriff of Carlow, in place of the late seneschal of that liberty."[2] It appears, however, that a general jurisdiction lay in the sheriff of Dublin for districts not clearly belonging to a specific county or liberty, or wherever the seneschal of the latter should be found in default, as in the case of Kildare prior to the Statute of 25 Edward I. In 18 Edward II. precepts were issued to the sheriffs of Dublin and Meath to execute writs "in spite of the liberties of Kildare and Louth"; but this interference with the general principle of palatine independence was doubtless exceptional and probably due to the disorganisation resulting from the Bruce invasion. For so extensive were the privileges of the liberties that, though the King might and did appoint sheriffs within their limits, the authority of the royal officers extended only to the Church lands, whence they were known as sheriffs of the County of the Cross. Of such counties there must originally have been as many in Ireland as there were counties palatine[3]; but with the gradual absorption of the palatinates in the Crown, either by inheritance, as in the case of Ulster, or by forfeiture, as in that of Wexford, they had all ceased to exist before the reign of Henry VIII., except the County of the Cross of Tipperary, which, being within the great Ormond palatinate, created by Edward III., survived till Stuart times.

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[1] This had been done by virtue of Edward III.'s arbitrary but temporary revocation of all franchises, liberties, and grants formerly made in the Kingdom of Ireland—a measure doubtless intended primarily as an answer to the renunciation by the Bourkes of Connaught of their allegiance to the Crown, and to the general disorganisation which followed the wars of the Bruces.

[2] Close Roll, 17 & 18 Edward III.

[3] In the list of Proffers and Fines of Sheriffs & Seneschals in the time of Edward III., Sheriffs of the Cross are mentioned for the Crosses of Kilkenny, Tipperary, Carlow, Wexford, Kerry, Kildare, Meath, and Ulster.

Whatever the precise origin of the counties so generally ascribed to King John, there appears to be no doubt that the writs either of the king or of his palatines ran in all of them for a full century from John's time, and that these counties represent the extent of the effective predominance of English power down to the invasion of Edward Bruce in 1315. Prior to that event some efforts seem to have been made to extend the counties to Ulster, and to define more accurately the limits of the Leinster counties. An Act of 25 Edward I. (1296), for the settlement of Ireland, enacted that "henceforward there shall be a certain sheriff in Ulster, and that the sheriff of Dublin shall not intermeddle henceforth in Ulster." Meath was declared to be a county by itself; and Kildare, which had been regarded as a liberty of Dublin, was discharged from the jurisdiction of the Dublin sheriff, and given an independent position. But from the wars of the Bruce the English colony received a blow from which it did not recover until the Plantagenets had been replaced by the Tudors. The authority of the State, so far as it was effective in the interior of the island, was exerted through the three great earldoms of Ormond, Desmond, and Kildare, all of which date from the fourteenth century. The area under the direct control of the Crown was narrowed continually, until after a lapse of precisely two centuries more the boundaries of the English Pale had shrunk to its lowest limits, and, in the quaint language of Stanyhurst, were "cramperned and crouched into an odd corner of the country named Fingal, with a parcel of the King's land of Meath and the counties of Kildare and Louth." Thus from the reign of Edward II. to that of Henry VIII. the extension of the Irish counties was politically impossible.[1]

That the shrinking of the English Pale had been accompanied by

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[1] The Pale at this period is thus described in the State Paper of Henry VIII. already referred to:—

"Also the English Pale doth stretch and extend from the town of Dundalk to the town of Derver, to the town of Ardee, alway on the left side leaving the march on the right side, and so to the town of Sydan, to the town of Kenlys,* to the town of Dangle,† to Kilcock, to the town of Clane, to the town of Naas, to the bridge of Cucullyn,‡ to the town of Ballymore,§ and so backward to the town of Ramore,‖ and to the town of Rathcoole, to the town of Tallaght, to the town of Dalkey, leaving alway the march on the right hand from the said Dundalk following the said course to the said town of Dalkey."¶

* Kells. † Dangan. ‡ Kilcullen. § Ballymore-Eustace. ‖ Rathmore.
¶ "State Papers," Henry VIII., vol. ii., part iii., p. 22.

a parallel diminution of the interest in and knowledge of the country possessed by the English Sovereigns may be sufficiently inferred from the language used in 1537 in a "Memorial for the Winning of Leinster," addressed by the Irish to the English Council, which begins by reciting that "Because the country called Leinster and the situation thereof is unknown to the King and his Council, it is to be understood that Leinster is the fifth part of Ireland."[1] But from this period, nevertheless, may properly be dated the revival of English authority. In 1541 the resolution of the Sovereign himself to convert his long nominal lordship of Ireland into an effective supremacy, was shown by the Act constituting Henry VIII. King of Ireland; and this was the prelude to the adoption of that policy of converting the chiefs of the Irish septs into the immediate feudatories of the Crown which led directly to the conversion of the lands without the Pale into districts cognisable by English law, and ultimately to their formation into modern counties. Little, indeed, was done under Henry VIII. towards defining the County boundaries, the only actual change in the map being the severance of Westmeath from Meath by a Statute of 34 Henry VIII. But though the proverb quoted by Sir John Davies continued to hold good during the reign of Henry VIII., that "whoso lives by west of the Barrow, lives west of the law," the area of the anglicised districts steadily increased. The greater part of Leinster was in this and the succeeding reign gradually won back to what was called "civility"; till towards the close of Elizabeth's reign the Pale was understood to extend through all Leinster, Meath, and Louth.[2]

The first step in this process of restoration, and the first real addition to the list of Irish counties made since King John's time, was the formation of the King's and Queen's Counties in the time of Philip and Mary.[3] The districts of Leix and Offaly, the territories of the powerful septs of the O'Moores and O'Connors, were, in that reign, reduced to subjection, during the Viceroyalty of the Earl of Sussex, who, in the words of Sir John Davies, "took a resolution to reduce all the rest of the Irish counties unreduced into several shires." Sussex was the first of the Tudor Deputies to acquire a really systematic personal acquaintance with the country he was sent to govern; and the accounts of his journeys through the provinces,[3] of which he made

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[1] "State Papers Henry VIII.," vol. ii., Part iii.

[2] See "A Perambulation of Leinster, Meath, and Louth, of which consist the English Pale" in 1596. "Carew Cal.," iii., p. 188.

[3] See "Calendar of Carew Papers, I.," pp. 257, 265, 274, 330, 352

at least three, together with his reports to Mary and Elizabeth of the results of his observations, are among the most valuable of the State Papers of that age. Sussex proposed to divide Ireland into six parts, viz., Ulster, Connaught, Upper Munster, Nether Munster, Leinster, and Meath; and he enumerates in his Report the countries which these divisions respectively comprised. But though he appears to have been the first to conceive any large plan for an efficient administrative settlement of Ireland, he was recalled before he had had time to grapple effectively with that problem of the shiring of Ireland, which he saw lay at the root of all real administrative reform. But at least he made a beginning. It is worthy of remark, too, that Sussex is the only Deputy who, in addition to creating fresh counties, gave to his creations names not borrowed from the territories by which they were constituted.[1]

In 1556 there was passed the Statute 3 & 4 Philip & Mary, Cap. II., "whereby the King's and Queen's Majesties, and the heirs and successors of the Queen," were declared entitled to the countries of Leix, Slewmargy, Irry, Glenmaliry, and Offaly, and provision was made for making these countries shire ground. After reciting that these countries had been subdued in the previous reigns, but had rebelled and been again reduced by the Queen's Deputy, Thomas Ratcliff Fitzwalter, Earl of Sussex, the Statute proceeds thus:—"And for that neither of the said countries is known to be within the limits of any shires or counties of this realm, be it enacted that the King and Queen, and the heirs and successors of the Queen, shall have, hold, and possess for ever, as in the right of the Crown of England and Ireland, the said countries of Leix, Slewmargy, Irry, Glenmaliry, and Offaly." A further section provided that "to the end that the same countries may be from henceforth the better conserved and kept in civil government, the new fort in Leix be from henceforth for ever called and named Maryborough, and the countries of Leix, Slewmargy, Irry, and part of Glenmaliry, be one shire and county named the Queen's County"; and, similarly, that the new fort in Offaly should be named Philipstown, and the country of Offaly and part of Glenmaliry be called the King's County.

That the Government of the Earl of Sussex contemplated a further extension of the policy embodied in this Act appears from the

[1] The case of Londonderry is an exception to this statement more apparent than real. In its first form, the County of Londonderry was known as Coleraine, taking its name from the well-known town of that name.

Statute immediately succeeding it,[1] "to convert and turn divers and sundry waste grounds into shire ground." This Act provided for the appointment of Commissioners "to view, survey, and make inquiry of all the towns, villages, and waste grounds of the realm now being no shire grounds," with power to the Commissioners to erect such districts into counties. Nothing was done in this short reign, nor for some years afterwards, to give effect to this enactment. But widely as the general policy of Elizabeth differed from that of her predecessor, her attitude towards Ireland was in principle the same as Mary's. The Statute (11 Elizabeth, Cap. 9), "for turning of countries that be not yet shire grounds into shire grounds," substantially re-enacted the earlier legislation.[2] And the task of giving effect to these provisions was confided by Elizabeth in great measure to the same statesmen who had devised them under Mary.

Though the actual delimitation of the counties was not finally settled until, in the reign of James I., it was accomplished by Sir Arthur Chichester with the assistance of Sir John Davies, the business of shiring Ireland, in the sense of formally naming and constituting the county divisions of Connaught, Ulster, and part of Leinster under their modern designations, was practically the work of the two last Tudor Sovereigns. Their policy was carried out by three statesmen of eminence—the Earl of Sussex, Sir Henry Sydney, and Sir John Perrot. And as in the case of the final measures taken in the reign of James I. to perfect the county system we have been provided by the chief agent of the work, Sir John Davies, with a vivid description of the proceedings, so in the case of the earlier and tentative steps taken under Elizabeth, we have the advantage of an authentic narrative by one of the principal actors. The part played by the Earl of Sussex has just been noticed. Sussex was followed by the gifted and valiant Sir Henry Sydney. Not only has that ablest of Elizabethan Deputies left detailed accounts of his progress through the provinces, but he has given in a memoir of his services in Ireland, drawn up in 1583, a striking statement of the Irish policy of Elizabeth

[1] 3 & 4 Philip and Mary, Cap. III.

[2] The preamble to both Statutes is worth quoting as showing the principle on which this policy of shiring was based:—"Whereas divers and sundry robberies, murders, felonies, and other heinous offences be daily committed and done within the sundry countries, territories, cantreds, towns, and villages of this realm being no shire ground, to the great loss both of the Queen property and of divers and sundry her Highness true subjects of this realm, and to the boldening and encouraging of many offenders. Be it enacted," &c.

in the first half of her reign, and a full summary of the proceedings taken by him to reduce the backwoods of Ireland to shire ground. The circumstances in which this memoir was written add to its intrinsic value the piquancy of an interesting historical association. For the occasion of the narrative was the then approaching marriage of the writer's son, Sir Philip Sidney, the chivalrous author of the "Arcadia," to the daughter of Sir Francis Walsingham, a lady whose fate it was to be successively the wife of Philip Sidney, of Robert Devereux, the unfortunate Earl of Essex, and of the third Earl of Clanricarde. The memoir was written primarily as an apology for Sydney's inability to make a sufficient settlement on his son. Sir Henry explained how his expenses as the representative of the Queen in Ireland, and the neglect of the Sovereign to relieve his impoverished fortune, had reduced him to a position of "biting necessity," which prevented him make such provision as he desired for his much-loved son. "Three times," wrote Sydney to Walsingham, "her Majesty hath sent me her Deputy into Ireland, and in every of the three times I sustained a great and violent rebellion, every one of which I subdued, and with honourable peace left the country in quiet. I returned from each of those deputations three thousand pounds worse than I went."[1]

Sydney's contribution to the formation of the Irish counties consisted in the main in the shiring of Connaught. In 1566, in the first of his three Viceroyalties, he took the first step in this undertaking by providing efficient and permanent means of communication between Dublin and the western province. "I gave order," he writes, "for the making of the bridge of Athlone, which I finished, a piece found serviceable; I am sure durable it is, and I think memorable." A few years later a bridge over the Suck at Ballinasloe, "being in the common passage to Galway," was constructed by Sir Nicholas Malby at Sydney's direction. This was the necessary preliminary to any effective assertion of English law in the remoter parts of the country. It was followed by the division of Connaught into four of the five counties of which it now consists, viz:—Sligo, Mayo, Galway, and Roscommon, with the addition of Clare. In his "orders to be observed by Sir Nicholas Malby for the better government of the province of Connaught," issued in 1579, Sydney's reasons for this arrangement are thus given:—"Also, we think it convenient that Connaught be restored to the ancient bounds, and that the Government thereof be

[1] The accounts of Sydney's provincial journeys have been printed in the Ulster Archæological Society's Journal, vol. iii., *et seq.*

under you, especially all the lands of Connaught and Thomond, being within the waters of Shannon, Lough Ree, and Lough Erne." In the same document suggestions are made for the appointment of "safe places for the keeping of the Assizes and Cessions." Sligo, Bures (Burris hoole), Roscommon, and Ballinasloe, are respectively designated as suitable county towns.[1]

Leitrim for the present was excluded. O'Rorke's country was not reduced to a county until Perrot's time in 1583. But the country of the O'Ferralls, called the Annaly, and the territory of the O'Reillys, or East Breny, both of which, as already noted, were then reckoned in Connaught, were formed into the modern counties of Longford and Cavan.[2] East Breny was described at the time by Sir N. Bagnal as "a territory where never writ was current," and which it was almost sacrilege for any Governor of Ireland to look into. The precise allotment of these counties among the provinces seems to have been left open, for Sydney, as will appear in a moment, was solicitous lest Connaught, which he had already extended in another direction, should become disproportionately large.

The district of Thomond had always been reckoned a part of the southern province. Indeed, the name signified North Munster, and its people were a Munster people. But Munster was a troublesome responsibility in Sydney's time; and the Deputy, who was then forming the system of Presidencies by which for the next seventy years the provinces of Munster and Connaught were to be administered, desired to reduce its importance.[3] He therefore ignored this ancient division, and taking the Shannon as a natural boundary (the province, if we exclude Leitrim, being thus, as the author of the "Description of Ireland" has it, "in manner an island"), he added this large territory to Connaught. "Thomond, a limb of Munster, I annexed to the President of Connaught by the name of the County of Clare," is Sydney's concise summary of this important transaction.[4] In his instructions to Malby, already quoted, the north part of the city of Limerick was suggested as the "shire town," "because a jury may be had there for the orderly trial of all country causes." But the President was

[1] See O'Flaherty's "West Connaught," ed. Hardiman, p. 305.

[2] Sussex appears to have designed to add Cavan to Leinster rather than Ulster, "O'Reilly," he writes, "bordering upon Meath, and lying by situation of his country unfit for any of the other Governments, is to be under the order of the principal governor." Carew Calendar, i., 338.

[3] "Reasons for retaining Thomond in Connaught." Carew Calendar, iv., p. 471.

[4] Collins's Sydney Papers, i., 75.

directed to choose some apt place in Thomond; and Quin, Killaloe, and Ennis were suggested as suitable.

We may pause at this point to consider the subsequent administrative history of Thomond. It continued to be included, under its new designation of Clare, in the government of Connaught almost to the end of Elizabeth's reign. It was then erected into an entirely distinct division, and governed as a distinct entity under a separate Commission, by Donagh, Henry, and Barnaby, successive Earls of Thomond.[1] In 1639, however, under Strafford's Government, it was arranged that on the death of the last-mentioned earls the territory should be reannexed to Munster; and though the ensuing disturbances delayed the fulfilment of this intention, the County of Clare was finally reunited to Munster at the Restoration.

But to revert to Sir Henry Sydney. If he was successful in his operations in the distant provinces of Connaught, he was less fortunate, not only in the north, where, indeed, the conditions were hardly ripe for such work, but in a district much nearer to the seat of his Government. It is certain that the County of Dublin was originally much larger than its present area indicates; and it appears probable that it anciently extended from Skerries, in the north, to Arklow, in the south. It had been conterminous, in fact, as has been pointed out, with the ancient Scandinavian kingdom of Dublin—a territory still marked for us by the ecclesiastical division of the United Dioceses of Dublin and Glendalough.[2] But the Danish rulers of Dublin troubled themselves little about the interior of the country,[3] and it is doubtful whether at any time prior to Henry VIII. the wild septs of the Byrnes and Tooles, whose incursions in the neighbourhood of the city Stanyhurst describes so graphically, had given even a nominal recognition to the Norman or English power. In the thirty-fourth year of that monarch's reign they are said to have petitioned the Lord Deputy and Council to make their county shire ground, and to call it the County of Wicklow, but nothing came of the proposal.[4] Be that as it may, the sway of these Wicklow chieftains was exercised without dispute down to Sydney's day right up to the near neighbourhood of Dublin, and the inhabitants were ever, as Davies observes, "thorns in the side of the Pale." Indeed, it may be said that the whole

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[1] Liber Munerum Hiberniæ, Part II., p. 185.

[2] Haliday's "Scandinavian Kingdom of Dublin," pp. 139 and 246.

[3] Stokes's "Ireland and the Celtic Church," p. 277.

[4] Book of Howth, p. 454.

country south-west of Dublin, including large portions of Kildare, Carlow, and Wexford, as well as the modern Wicklow, long remained a rude "hinterland" into which law and order seldom penetrated. The State Papers are full of such entries as this of 1537—"Devices for the ordering of the Kavanaghes, the Byrnes, Tooles, and O'Mayles for such lands as they shall have within the County of Carlow and the marches of the same county, and also of the marches of the County Dublin,"—which plainly show the unsettled state of these districts. In 1578, however, a Commission issued under the Act of 11th Elizabeth and "the Birns' and Tooles' country, with the Glens that lie by South and by East of the County of Dublin, was bounded out into a shire, to be named and called the County of Wicklow."[1] But though this Commission was carried out, and the boundaries of the counties defined by Sir William Drury, who succeeded Sydney as a Lord Justice, the troubles of Elizabeth's latter years in Munster and Ulster left little leisure to her Deputies to attend to the Wicklow septs. The Byrnes and Tooles resumed their independence; and in 1590, as Sir George Carew wrote, "those that dwell within sight of the smoke of Dublin" were not subject to the laws.[2] When Sir Arthur Chichester came to complete the work Sydney had begun a generation earlier, of "adding or reducing to a county certain, every bordering territory whereof doubt was made in what county the same should lie,"[3] he found that the mountains and glens of Dublin were almost as far as ever from "civility," and contained such a multitude of untutored natives that it seemed strange that "so many souls should be nourished in these wild and barren mountains." The shiring of Wicklow was only finally accomplished in 1606, and it thus fell out that the county nearest to the metropolis was of all the last to be brought effectively within the scope of English government.

In connexion with this attempt towards the formation of the County Wicklow, Sydney had also a project for dividing Wexford into two shires, of which the northern part should be called Ferns. This county, severed by the Wicklow mountains from the metropolis, had, though less disturbed than its neighbours, been practically outside the Pale.[4] The southern part of it, indeed, according to a "Description of

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[1] Fiant of Elizabeth, No. 3,603, Irish Record Office.

[2] Carew Cal., iii., p. 44.

[3] Sir J. Davies's "Discovery."

[4] See Hore and Graves's "Social State of the South-Eastern Counties in the Sixteenth Century," p. 27.

the Provinces of Ireland," written about the year 1580, was "civil," "that part contained within a river called Pill" (a name given to the estuary of the Bannow) being inhabited by "the ancientest gentleman descended of the first conquerors." But this district was connected with the capital by sea only, and the rest of the county was inaccessible. Sydney and Sir William Drury finding "that there were no sufficient and sure gentlemen to be sheriffs, nor freeholders to make a jury, for her Majesty," the project was let drop. Their successor, Sir John Perrot, had the same object in view, and in a report to Elizabeth, "how the natives of Ireland might with least charge be reclaimed from barbarism to a godly Government,"[1] he gives a picturesque account of the condition of the south-eastern counties and the need which existed for providing a proper system of administration. "The Birnes, Tooles, and Kavanaghs must be reduced." They are "ready firebrands of rebellion to the O'Moores and O'Conors, and till they be brought under or extirped, Dublin, Kildare, Meath, Westmeath, and the King's and Queen's County cannot be clear either of them or of O'Moores or O'Conors, or of the incursions and spoils of the McGeoghegans, O'Molloys, and other Irish borderers." But though he stated the difficulty thus vigorously, Perrot, like Sydney, left Ireland without doing anything effective to remedy it. Sir Henry Sydney's last tenure of the office of Lord Deputy closed in 1578, and for the next few years the Desmond rebellion perforce put a stop to the work he had set himself to accomplish. It was not until the southern rising had been crushed that Sir John Perrot, who, in 1584, succeeded to the Irish Government, was able to resume the work. Though this statesman is best remembered in our history in connexion with the composition of Connaught, which was effected during his administration, it is in relation to Ulster that his proceedings have most interest in the present connexion. To Perrot belongs the honour of having divided the northern province into divisions substantially corresponding to its modern counties, though twenty years were to elapse before these divisions were generally recognised, or before they became effective portions of the administrative machinery of the country.

The story of the Anglo-Norman colonies of Ulster and the settlement of Lecale, the Ards, and Carrickfergus, has never been fully analysed, and to tell it is outside the purpose of this Paper. Here it must suffice to observe that the only counties in the modern sense of

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[1] Sloane MS., 2,200, Brit. Mus.

the term which can be recognised as existing in Ulster before the time of Elizabeth were Louth, which, as already noted, was anciently accounted part of that province, and the counties of Antrim and Down. The precise date at which the two last were constituted is unknown; but it appears by the "Black Book of Christ Church" that they, or at least certain districts bearing these names, had existed prior to the reign of Edward II. From that time down to the settlement in Antrim of the McDonnells of the Isles, under Henry VIII., little is known of them; but the two counties had been recognised as settled districts by Perrot's time, and as such were distinguished by that Deputy from the "unreformed" parts of Ulster. In 1575 Sir Henry Sydney had made a journey to Ulster with a view to dividing the province into shires, but had failed to effect anything—an effort which was referred to by Sir John Davies in his address as Speaker of the Irish Parliament in 1613; when, congratulating the Commons on the completeness of its representation, he observed, "How glad would Sir Henry Sydney have been to see this day, he that so much desired to reform Ulster, but never could perfectly perform it."

Perrot's contribution to the shiring of Ulster was little more than a settlement on paper of the boundaries of the new counties he desired to create. It is best described in the language of Sir John Davies:—"After him [Sydney] Sir John Perrot . . . reduced the unreformed parts of Ulster into seven shires, namely, Armagh, Monaghan, Tyrone, Coleraine, Donegal, Fermanagh, and Cavan, though in his time the law was never executed in these new counties by any Sheriff or Justices of Assize; but the people left to be ruled still by their own barbarous lords and laws." Perrot's work was of course interrupted, and for the time rendered nugatory, by the rising of Hugh O'Neill; but it was so far effective that his division became the basis of the subsequent allocation of the northern territories, which a few years later followed the Flight of the Earls and the Plantation of Ulster.

Had affairs in England permitted the Government to bestow steady and continuous attention on the affairs of Ireland, it is probable that the work initiated by Sussex and Sydney, and so largely extended by Sir John Perrot, would have been completed before the close of Elizabeth's reign. But Perrot was recalled in 1588, and the business of shiring Ireland was arrested for nearly twenty years. With O'Neill taking full advantage of the difficulties in which England was involved by the struggle with Spain, and asserting his power effectively throughout Ulster, the sub-division of the northern province remained purely nominal, and even in the more settled districts much confusion reigned. The result is seen in the discrepancies which appear between the various accounts which remain to us of the division of Ireland at this time. These exhibit considerable confusion, not only as to the counties of which each province was made up, but even as to the provinces themselves. Thus Haynes, in his "Description of Ireland," in 1598, states that Ireland is divided into five parts. He includes Meath among the provinces, mentioning it as containing four counties, viz., East Meath, Westmeath, Longford, and Cavan, though he adds that the last is by some "esteemed part of Ulster." On the other hand, in a survey printed in the Carew Calendar,[1] revised to the year 1602, Longford is included in Connaught, while Cavan is not mentioned, and the completeness of the relapse of Ulster from "civility" is shown by the description of that province as containing three counties and four "Seignories."

Thus it was not until after the accession of James I., in the time of Sir Arthur Chichester, that, in the words of Sir John Davies, "the whole realm being divided into shires, every bordering territory whereof doubt was made in what county the same should lie was added or reduced to a county certain." The boundaries of the counties forming the provinces of Connaught and Ulster were ascertained one after another by a series of Inquisitions between the years 1606 and 1610, which confirmed in the main the arrangements tentatively made by Perrot, though in the case of Ulster these were necessarily varied in some important respects, particularly as regards Londonderry, by the changes resulting from the Flight of the Earls and the Plantation of the northern province. The enumeration of counties and provinces in Speed's "Description of the Kingdom of Ireland," in 1610, shows, as already noted, that in that year the precise allocation of counties among the provinces still remained vague and indeterminate in the popular estimation. But Meath had by that time finally disappeared from the list of provinces; and though some years were to elapse ere all the counties could be finally delimited, this process had been practically completed when Sir John Davies left Ireland in 1616, except in the case of Tipperary, where the exceptional conditions created by the existence of the Ormond Palatinate long retarded the final settlement.

Although Munster is of all the great divisions that which, if compared with the original distribution imputed to King John, shows the least alteration in its county system, the southern province has not been without its vicissitudes in this respect. In Perrot's time Munster consisted of as many as eight counties, and the final settlement of

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[1] Carew Calendar, iv., pp. 446-454.

the six counties now embraced in it was, in fact, delayed until after the other provinces had assumed their present form. The shiring of Munster was effected chiefly through the instrumentality of the provincial government known as the Presidency of Munster, which was established by Sydney in 1570. No single act of Elizabethan policy had more important or more satisfactory results than the institution of the Presidencies of Munster and Connaught; and as the gradual demarcation of the counties of both provinces as they now exist was largely effected by their means, it seems desirable to give a brief account of an institution which was devised by Sydney, as Davies puts it, "to inure and acquaint the people of Munster and Connaught again with English Government."

The first idea of these instruments of administration was formed in the time of Edward VI., when a scheme was devised for the appointment of separate Presidents for each of the three provinces of Munster, Connaught, and Ulster. But although Sussex had a clearly defined scheme for giving effect to this policy, it was not until Sir Henry Sydney's first administration that, in 1565, definite shape was given to it, or that the constitution of what for the next century were known as the Presidency Courts of Connaught and Munster was formally drafted. The Presidency not only included a President answerable to the Lord Deputy, but a Council composed of prelates and nobles of the province, and a Chief Justice with two Justices and an Attorney-General, together with a Treasurer, Clerk of the Council, and other administrative officers. In 1568 Sir John Pollard was nominated first President of Munster, and in the year following Sir Edward Fitton became President of Connaught. No President was appointed for Ulster, the charge of which was confided, under a temporary Commission, to a marshal, an officer whose duties were half-civil, half-military. Pollard, however, never entered on his Government, and the first acting President of Munster was Sir John Perrot, who, appointed in 1570, was for six years a strenuous representative of the Crown in that province.

It is a matter of great regret that the records of these Presidencies have long since perished.[1] They seem to have been lost in the

[1] See Prendergast's "Introduction to Cal. S. P. Ireland," James I., 1606–1608, pp. xx.–xxxv. A volume called "The Council Book of Munster" survives in the Harleian Collection at the British Museum (Harl. Col., No. 697); but it only extends from 1601 to 1617. The "Instructions for the Lord President and Council of Munster," in 1615, have been printed in "Desiderata Curiosa Hibernica," vol. ii.

troubled times succeeding the rebellion of 1641, and the Presidential institution itself did not long survive that cataclysm. Though they lingered beyond the Restoration, the Presidencies were not regarded by the Duke of Ormond as necessary or efficient instruments of government; and in 1672, during the Viceroyalty of Lord Essex, they were finally abolished. But though the Presidency system was not destined to remain a permanent feature in the administrative system of Ireland, its operation during the years first following its institution was unquestionably effective. In Perrot's hands, both as President of Munster, and later when as Deputy he became responsible for the whole country, it was largely utilized to effect what was practically a fresh delimitation of the old counties of Munster. In an old "note," probably dating back to the fifteenth century, quoted by Perrot in his Report to Elizabeth, already cited, the Munster counties are thus enumerated: "In Munster there be five English shires—Cork, Limerick, Waterford, Kerry, Tipperary; and three Irish shires—Desmond, Ormond, and Thomond." It will be noted that the five former of these counties with Thomond or Clare nominally make up the modern province of Munster. Ormond represents Tipperary less the County of Cross Tipperary, and as such still possesses a well-defined meaning. Desmond is a district perhaps less clearly defined in the popular mind. It embraced a large portion of East Kerry and West Cork, and at one time was actually erected into a separate county. In 1571 a Commission issued to Sir John Perrot and others, under the Statute 11 Eliz.,[1] for the counties of Waterford, Tipperary, Cork, Limerick, and Kerry, and the countries of Desmond, Bantry, and Carbery, and all countries south of the Shannon in Munster, to make the country of Desmond one county, and to divide the rest into such counties as may be convenient." As a result of this Commission, Desmond became and was long regarded as a distinct county, and its boundaries appear from an Inquisition of 1606. But though Fynes Moryson places Desmond on the list of the Munster counties, stating it to have been lately added, its separate identity is not invariably recognised, though for a time it boasted that essential note of independence, a separate sheriff. This, however, had disappeared before the close of Elizabeth's reign, for Haynes writes in his account of Cork that that county,[2] "being the greatest in the realm, have been tolerated to have

[1] Fiant, Eliz., 1486. Irish Record Office.

[2] "The Description of Ireland in 1598," ed. by Rev. Edmund Hogan, S.J., p. 169.

two sheriffs—the one particular in Desmond, the other in the rest of the county—and this without any ground of law, but by discretion of the L. Deputies; the inconvenience thereof being espied, it had been of late thought good that one sheriff should be for Kerry and Desmond, and so two sheriffs in one county against law taken away.' The amalgamation with Kerry appears to have been completed by 1606,[1] when Mr. Justice Walshe, in describing to Salisbury the Munster Circuit of that year, mentions particularly the successful union of Desmond and Kerry.

The dual representation of Tipperary in the list of Irish counties was long a puzzle to antiquaries, and even an inquirer so diligent and in general so accurate as Sir John Davies was misinformed on the subject, notwithstanding the minute inquiries he appears to have instituted into the origin of what struck him as a curious administrative anomaly. "At Cashel," he writes in his account of the Munster Circuit of 1606,[2] "we held the Sessions for the County "of the Cross. It hath been anciently called 'the Cross' (for it had "been a county above 300 years; and was, indeed, one of the first that "ever was made in this kingdom) because all the lands within the "precincts thereof were either the demesnes of the Archbishop of "Cashel, or holden of that See, or else belonging to Abbeys or houses "of religion, and so the land as it were dedicated to the Cross of Christ. "The scope or latitude of this county, though it were never great, yet "now is drawn into so narrow a compass that it doth not deserve the "name of shire."

Davies' confusion as to the two counties of Tipperary, which continued to be separately represented down to Strafford's Parliament of 1634, was extremely natural in view of the limited information available when he thus accounted for the anomalous existence of the County of Cross Tipperary. But, in fact, the duplication had really originated in the Palatine system. To the accident which preserved Tipperary as the last of the Palatinates was due the survival of Cross Tipperary as the last of the counties of the Cross; and it will be convenient here to trace the history of both jurisdictions. The County Palatine of Tipperary was originally created by letters patent, granted in 1328 by Edward III. to James le Botiller, Earl of Ormond, and confirmed by successive monarchs to that nobleman's successors in the honours of the Butler family. The jurisdiction thus granted

[1] Cal. of "State Papers," Ireland, 1603-6, p. 573.
[2] Cal. of "State Papers," Ireland, 1606-8.

embraced the whole County of Tipperary, with the exception of certain Church lands, which constituted, as was usual with Church land in Palatine counties, a distinct shrievalty under the ordinary jurisdiction of the King's Courts. In addition to these districts of the Cross, there was also excepted from the Palatine grant the district of Dough Arra, or MacBrien's country, adjacent to Killaloe, which, long a debatable land on the borders of the three counties of Clare, Limerick, and Tipperary, was in 1606 joined by Chichester to the County of the Cross of Tipperary.

In 1621, during the wardship of the daughter and heiress of Thomas, tenth Earl of Ormond, the Palatinate of Tipperary was seized into the Crown by James I. The County of the Cross apparently remained unaffected by this exertion of the Royal prerogative, and, as already noted, it was represented in the Parliament of 1634, though the county proper appears to have returned no members to that assembly. The Palatinate remained in abeyance for a period of forty years, till after the Restoration it was reconstituted by Charles II. in 1664, in favour of the first Duke of Ormond. The grant on this occasion included both the old territory of the Cross, which never thereafter returned members to Parliament, and the district of Dough Arra, formerly excepted from the Palatine county. The liberties and royalties of the whole County of Tipperary were enjoyed by the Butlers until the attainder in 1715 of the second Duke put an end to the last Irish example of these great mediæval jurisdictions.[1] The Statute 2nd George I., cap. 8, "an Act for extinguishing the royalties and liberties of the County of Tipperary," by its second section enacted, "that whatsoever hath been denominated or called Tipperary or Cross Tipperary, shall henceforth be and remain one county for ever, under the name of the County of Tipperary."

[No attempt is made here to discuss the origin of the names of the Irish counties. This may form the subject of a separate inquiry.

The writer desires to express his obligations to the courteous officials of the Irish Record Office, and especially to the Assistant Deputy Keeper, Mr. H. F. Berry, M.R.I.A. He has also to thank Mr. Tenison Groves, C.E., for many useful suggestions.—C. L. F.]

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[1] See 5th Report of the Deputy Keeper of Public Records of Ireland, p. 7, and Appendix III, pp. 33-38.

XII.

NOTES ON THE ORIENTATIONS AND CERTAIN ARCHITECTURAL DETAILS OF THE OLD CHURCHES OF DALKEY TOWN AND DALKEY ISLAND.

By JOSEPH P. O'REILLY, C.E.

[Plates XIII.–XVII.]

Read February 23, 1903.

The churches of Dalkey Town and Dalkey Island are of course alluded to, or mentioned, in the different works treating of these localities, but generally with relatively few details; the dates of their foundations, as well as the names of their founders, are apparently unknown. All that can be ascertained as to their early history is to be obtained from the records of Christ Church Cathedral, and from those of St. Patrick's, to the Chapters of which these churches were given over by Hugh de Lacy, who had received them in grant from Henry II. Both churches date, therefore, from a period anterior to the Norman Invasion. As to the saints or saint to whom they were dedicated, or are mentioned as having been dedicated, there have been some doubts. Seward's "Topographia Hibernica" (1795) says of the town: "This village in the reign of Queen Elizabeth, and a great part of the last [seventeenth] century, before the port of Dublin was improved, was the repository of the goods belonging to the merchants of Dublin. Here are the ruins of a few old castles, places of defence against the incursions of the pirates who at that time swarmed on the Irish coast."

As regards the island, the work says: "It is so called [Dalkey] from *Dalki*, on account of the pagan altar there." There is no ancient building on Dalkey Island but the ruins of a church.

In Carlisle's "Topographical Dictionary of Ireland" (1810), it is stated: "*Dalkey Island.*—Here are the ruins of a church."

Lewis's "Topographical Dictionary" (1837) says, as regards the town: "The church is in ruins; it was situated in the village, and appears to have been a very spacious structure."

As regards the island: "There are the ruins of a church dedicated to St. Benedict; and 'kistvaens,' or stone coffins of rude workmanship and great antiquity, have been found near the shore."

D'Alton's "History of the Co. Dublin," 1838, says (p. 882): "While in the town, are the not uninteresting remains of an ancient church, picturesquely situated at the foot of the Rochestown Hills, and presenting a nave fourteen yards long, by five broad, and a choir eight by five, divided by a well-executed arch." Page 885: "On the shore, in a little rocky cove, the tourist will find a ready boat to facilitate his pilgrimage to the island, where, surrounded by cliffs and a frequently tempestuous sea, an ancient mariners' chapel was erected and dedicated to St. Begnet or Benedict." Page 886: "On it [the island] is a doubtful remain, said to be the patron's church; but certainly having nothing of the ecclesiastical aspect, unless perhaps a plain gable belfry; and wholly disconsecrated, even in the traditions of the people, by its present uses." Page 887: "In 1178 Archbishop O'Toole assigned to Christ Church (amongst several) the church of St. Begnet of Dalkey, with all its tithes; and his grant was further assured by letters-patent from Prince John. In 1200 the Archbishop had a grant of a Wednesday market here [in the town], and an annual fair to be held on St. Begnet's day."

"The Parliamentary Gazetteer" (1846), speaking of the island, says: "A small old ruin on the island is usually regarded as having been a church dedicated to St. Benedict; but though possessing a belfry, it exhibits very distinct marks of simple domestic or dwelling-house structure. 'Kistvaens' enclosing human bones are said to have been found upon the island, and are regarded as vestiges of Celtic or Belgic tribes of a very remote era."

Mr. F. Elrington Ball, in his "History of the County Dublin," 1902, says as regards the churches (p. 79): *Dalkey Island.*—"The ruined church—for such undoubtedly is the structure on the northern end of Dalkey Island—is coeval with, and similar in construction to, that of the Kill of the Grange. It has a primitive doorway and window; and its side walls project upon the end ones, as do those of the Kill Church, forming pilasters." "The belfry is a later addition; and a fire-place and enlarged doorway and window in the south wall were made by the workmen employed in the construction of the Martello Tower, who used it as their dwelling" (Wakeman's "Primitive Churches in the County Dublin," Journal R. Soc. Antiqq. of Ireland, vol. xxi., p. 701; see also vol. xxvi., p. 415). "The church [on the island], which is supposed to have been dedicated to St.

Begnet, the patron saint of Dalkey, indicates, by its state of preservation, use in the middle ages; but nothing is recorded of the history of the island from the twelfth century, when it was given by Hugh de Lacy to the See of Dublin, until the seventeenth century, when it was destitute of inhabitants, and used for grazing cattle." Page 81: "The church [of Dalkey Town] was dedicated to St. Begnet the virgin, the patron saint of Dalkey, who is supposed to have flourished about the seventh century, and whose festival falls on the *12th November*. After the English Conquest [second Norman Invasion?], it was assigned to the priory of the Holy Trinity."

The most important paper for the purposes of this present one, is that of Mr. Wakeman, cited by Mr. F. E. Ball. It appeared in vol. xxi., 1890-91, of the Journ. Roy. Soc. Antiqq. of Ireland, p. 697, the title being: "Primitive Churches in the County Dublin," by W. F. Wakeman, Hon. Fellow, Hon. Sec. for the County Dublin.

After some introductory remarks as to the existence of early Christian *cellæ* around Dublin, "some of which have not hitherto attracted antiquarian consideration," he says: "It is a significant fact that while several *cellæ*, teampulls, or cills, in the Dublin district, are as generally ancient in character as any structure of the like class to be seen in remoter provinces of Erinn, no architectural connecting-link between them and churches of late twelfth- or even thirteenth-century date can be discovered." "The primitive churches when not utterly dismantled or razed by Northern ravage were, in all likelihood, left in ruinous neglect; and it would seem there exists architectural evidence that it was not until some considerable time subsequent to the overthrow of Danish influence, or, indeed, until the Anglo-Norman settlement had commenced, that many of our old parish churches were once more used as places of Christian worship." P. 698: "When it was deemed necessary to enlarge the church, by the addition of a chancel (a feature very rare in our earlier teampulls), they broke through the eastern gable, hacking an aperture, the edges of which were then lined, in jambs and arch, with plain or hammered stones. The added choir or chancel was simply built up against the original east gable, and not bounded with it." "Surmounting the western gable, at the time of transition referred to, it was customary to erect a turret with provision for one, two, or sometimes three bells." P. 701: "I now draw attention to an old church which still stands, almost intact, upon the island of Dalkey (see Pl. II., fig. 1). This structure has long been regarded by Dublin people as very mysterious in character. They could scarcely fancy it a church;

and yet in all its features it presents characteristics which unmistakably point to one conclusion, viz., that the structure is neither more nor less than a slightly modified example of our oldest style of *cill* or church."

Its form is oblong—27 feet 7 inches in length by 20 feet 3 inches in breadth, external measurement. The walls average 2 feet 10 inches in thickness. Pilasters or extensions of the side walls are found on the eastern and western ends. Similar features are observed in connexion with a considerable number of our oldest churches, such as Teampull McDuagh, in Arranmore, County Galway; on St. M'Dara's Church in Inis M'Dara, off the coast of Connemara; at Dulane, near Kells, County Meath; and, indeed, in many other places. "Here they are 2 feet 7 inches wide, and project 1 foot 2 inches beyond the gables."

"A fine flat-headed doorway measuring 7 feet 3 inches in height by 2 feet 8 inches in breadth at the top, and 2 feet 9 inches at the base, occupies a position in the centre of the west end. The lintel in this example is peculiarly massive" (see Pl. II., fig. 2). "Above the western gable rises a somewhat clumsily-constructed bell-turret containing a single aperture, the head of which is in a rather late pointed form." "It is quite evident that this campanile is a comparatively late addition." "Its aperture would have been completely covered by the original roof, the pitch of which is indicated by traces of mortar or cement which still remain." "A small flat-headed window (see fig. 3, p. 702), placed high on the south side wall, appears to be the only original light to be found in the building." "The structure, indeed, bears evidences of alteration at various dates; but the principal change, no doubt, occurred in the second or third year of the nineteenth century, when this curious and mysterious *cill* was utilized as a dwelling-place by the Government employés engaged in building the Martello Tower, which was intended to command the Sound of Dalkey, and much of the neighbouring coast. I myself, some thirty years ago [*ante* 1890], when residing in the vicinity, was well acquainted with a truly ancient mariner named Tom Doyle, who had assisted in the work." "He stated that the church was used as a house by himself and fellows; and that to make themselves comfortable, and the building suitable for their occasions, they had broken a doorway and window in the southern wall, and constructed the still existing fireplace. He stated further that when disturbing sods or scraws to be used in roofing material, the diggers found human bones apparently of great antiquity."

"Not far from the church, on the brink of the Sound, is a well which the old people consider very sacred, and highly efficacious for the cure of sore eyes. One relic of extremely early days may be observed carved or picked out upon the natural undisturbed rock which stands immediately facing the western gable. It is what Bishop Graves styles an 'eastern' cross, enclosed by a circle, and is probably as early as the sixth or seventh century (see fig. 4). Within the quadrants are raised pellets. Indeed, the figure is extremely like some found on certain of the oldest remains for which Inismurray and some districts of Kerry are famous. It is the only rock-marking of its interesting class which I have seen out of the West or South of Ireland."

"The Church of Dalkey (Island), its details, and this cross, are here, so far as I am aware, for the first time figured and described."

Practically all that was known up to their time concerning the churches of Dalkey Town and Dalkey Island is given in the two citations from Mr. F. E. Ball's work and Wakeman's paper cited by him. This latter may indeed be taken as a text for the further consideration of these two remarkable ruins.

As regards the name of the saint to whom both these churches are said to have been dedicated, I am indebted to Mr. Ball's courtesy for the communication of the following details to be found in the Report of the Deputy Keeper of the Public Records and Keeper of the State Papers in Ireland (1896). There is given therein an Index to the Calendar of Christ Church deeds, 1174 to 1684, contained in Appendices to the 20th, 23rd, and 24th Reports. It gives the following forms of the name "*Dalkey*," and the indications of the mentions of that name in the extracts given in the reports:—

Dalkey, Dalkaye, Dalkeya, Dalkie, Dalky, Gilbeknith, Killekenet, Kilbekenet, St. Begnetes, St. Begnetts.

Entries—51, 219, 379, 381, 2, 413, 415–6, 431, 779, 927, 1145, 1303, 1306, 1341, 1346, 1374.

Dalkey Church—52–3, 379, 431, 440, 557, 1378.

Dalkey Churchyard—1341.

In these extracts the Church of Dalkey Town is designated as follows:—

51—*Circa* 1240—Chapel of Kilbekenet.

52— ,, ,, —Church of Killekenet.

53—16th March, 1245—Church of Kilbek[enet].

379—17th Septr., 1504—The Church of St. Begnet of Dalkey.

557—Circa 1320—A messuage in the tenement of Gilbeknith, the frontage looking from the sanctuary and lying on the western side of Gilbeknit Church.

(*In dorso*) Quit claim of the land of the Church of Dalkey.

In the 24th Report, 26th May, 1892, there is the entry :—

P. 161, 1302—Lessors in No. 1298, and the Vicars choral of Holy Trinity Church leave to Shane Kennay, alias Shane McDonaghe "inclaune" of Saint Begnete's, Co. Dublin, fisherman, a house and land in St. Begnete's for 41 years. Dated 8th Jany. 1565–6 & 28th Eliz. (*In dorso*) Dalkey, Kilbegnet.

P. 77, 1374—Lessors in No. 1298, lease to John Dongane, second Remembrancer of the Irish Exchequer, a moiety of a messuage, castle, orchard, and land, in St. Begnett's, alias Dalkey, Co. Dublin, for 61 years. Dated 20th March, 1585–6 & 28th Eliz.

There will thus be remarked the great variation in the form of the name applied to the church, as regards the name of the saint, and the further fact that, according to the entry 1374, "St. Begnett's" was at one time an *aliter* name for Dalkey Town.

As regards the St. Begnet to whom the churches are said to be dedicated, and whose festival is mentioned as occurring on the *12th Nov.*, there is no such saint mentioned in Butler's "Lives of the Saints," and none such under the date 12th November. The name "Begnet" appears to be the diminutive form of Beg or Bec; and the question arises what particular saint of that name is thereby referred to. In this respect the following citation from the "Book of Obits and Martyrology of the Cathedral Church of the Holy Trinity," with introduction by Jas. H Todd, D.D. (1844), is of interest. P. xiv. Nov. 12th, "St. Begneta or Begnait is not mentioned in the Martyrology of Ængus. In the calendars of two ancient manuscript breviaries, now in the Library of Trinity College, Dublin, she is styled '*Virgo non-martyr.*' One of these (B. 1, 3) belonged to the Church of Clondalkin; the other (B. 1, 4) to the Parish Church of St. John the Evangelist, Dublin. The ancient church, now in ruins, on the Island of Dalkey, near Dublin, is dedicated to St. Begnet; although, in Lewis's 'Topographical Dictionary,' it is erroneously said to have been dedicated *to St. Benedict*. Mr. D'Alton also, in his 'History of the County Dublin,' improves upon this mistake. He says (p. 885): 'On the shore, in a little rock-cove, the tourist will find a ready boat to facilitate his pilgrimage to the island, where, surrounded by cliffs, and a frequently tempestuous sea, an ancient mariner's chapel was erected and dedicated to St. Begnet or Benedict.'

"Does Mr. D'Alton mean to say that 'Begnet' and 'Benedict' were one and the same? In Alan's Register (folio 9 b) there is an exemplification of an Act of Parliament held in Dublin on the Friday next after the feast of St. Luke the Evangelist, 22nd Edward IV., where it is enacted in favour of the Archbishop of Dublin: 'Ordeyne est, et establie par auctorite du dit Parlement, que le dit Erchevasque poet auer un marchêe al dit ville de Dalkey annuelement, chescun maresdye per ane, de Sepmaine en Sepmaine, et un jour de faire Cestassauere le jour de Seyncte Begnet la Virgine, continnuaunt III. jours annuelment,' &c."

Starting from the statement that the St. Begnet in question was a virgin, and presuming that the termination of the name is a diminutive, it may be asked what was the original form of the name of the saint. The simplest would be Beca or Bega, and such a name is found in Smith and Wace's "Dictionary of Christian Biography" (1877). Thus it gives (p. 300) *Becga* or *Begga*, daughter of Gabhran, virgin; her festival on the 10th February. It is said (Colgan, "Tr. Thaum.," 121) that when St. Patrick was in East Meath, he left at the Church of Techlaisran, in that county, two of his disciples, *Bega*, a virgin, and Lugaidh, a priest (Ap. 17th), probably brother and sister, the children of Gauran, the latter (place) having the name of Feart-Bige or *Bega's Tomb*. The same Dictionary gives (p. 304) the following:—"Bega, Beza, Beya, Begga, Bec, St. A Cumbrian saint of whom nothing is clearly known, and whom the endeavours of the hagiographers have only succeeded in investing with a history that belongs to several other saints. According to Alban Butler, she was an Irish saint (September 6th) and virgin who lived as an anchoret in the seventh century, and founded a nunnery in Copeland. He also mentions a place in Scotland called Kilbees after her. This is the most reasonable account. According to the life of her, seen by Leland (coll. iii., 36), after founding her monastery in Cumberland, she removed into Northumberland and founded another north of the Wear; then to Hert, where she becomes identical with St. Heiu (HEIU), and then to Tedcaster, winding up her career at Hackness, as identical with St. Begu (Mon. Ang. iii. 575)."

"Begu and Heiu are well known from Bede, and were two different persons, neither of them possibly identical with the Cumbrian saint. Yet Suysken, in his commentary on St. Bega (AA. SS. Boll., Sept. 2, 684–700), accepts this version as true. In default of an English reer for the saint, she is next sought in Ireland and Scotland, and the Aberdeen Breviary contains lessons of two saints with either of whom she might be identified—(1) St. Bega, venerated at Dunbar, who lived in an island called Cumbria in the Ocean Sea as an anchoret, visited occasionally by St. Maura, and dying on September 3rd, was buried in her island, whence the Rector of Dunbar, attempting to fetch her remains, was driven back by a storm; (2) St. Begga, an Irish princess, given in marriage by her parents against her will, hears of the Gospel as preached in England, flies to England to Oswald and Aidan, and becomes the first abbess of nuns in England. She has her home in a desert island, and, in her old age, resigns her abbey to St. Hilda, under whose rule she ends her days (October 31st). After 460 years her remains were removed to Whitby (Brev. Aberd. pars Æstiv., fo. 145 and 136). Here are probably some reminiscences of St. Heiu. She was probably a local saint of the eighth century. The monastery bearing her name was founded as a *cell* to St. Mary's at York in the reign of Henry I." This same Dictionary also mentions "St. Begha, Virgin, *circa* A.D. 660, also called St. Bex and St. Begagh. She left her home in Ireland on hearing of the flourishing state of Christianity in Britain, and, in order to avoid a marriage intended for her, fled into Scotland in a ship that was in waiting. She received the veil at the hands of Bishop Aidan in the reign of King Oswald in Britannia, and ruled a community in a cell constructed by him in a certain desert island. When St. Hilda returned from Gaul (Bede, Eccles. Hist., IV., c. 23), St. Begha prayed that she might be freed from the burden of government, and that St. Hilda might be consecrated Abbess in her stead, and this was accordingly done. After many years she died in the odour of sanctity, attested by many miracles at her tomb (Brev. Aberd. pars Æstiv. f. c. xxxvi). Bede mentions a nun called Begu, in the monastery of Hacanos, thirteen miles from Whitby, to whom the death of St. Hilda was revealed in a vision (Eccl. Hist., IV., c. 23). St. Begha is honoured at Kilbagie and Kilbucho in Scotland; but her greatest foundation was within the kingdom of Strathclyde at St. Bees, which takes its designation from her. It was founded in A.D. 656."

P. 305. "There was a cell of this house at Nendrum or Mahee Island in Down County (see "Description of Nendrum," by Rev. William Reeves, D.D., 1845), and his Eccl. Antiq., 163, 190–199 for the grant of the Island of Nedrum, or Nendrum, by Sir John de Courcy in 1178 to the Priory of St. Bega de Copeland" (Bishop Forbes, "Kal. of Scotch Saints," pp. 248–52).

In the "Proceedings of the Royal Irish Academy," vol. viii., p. 258, there is a Paper by Dr. Wm. Bell (read by Dr. Reeves) on

"The so-called Ring Money in reference to many specimens in the possession of the Right Hon. the Earl of Londesborough, and more especially an Irish one with a movable Swivel Ring" (read Monday, December 8th, 1862). In it, it is stated: "St. Bega was the patroness of St. Bees in Cumberland, *where she left a holy bracelet*, which was long an object of profound veneration." A small collection of her miracles, written in the twelfth century, is extant, and has been published. In the prefatory statement of the compiler, we learn, among other things, "that whosoever foreswore himself upon her bracelet swiftly incurred the heaviest punishment of perjury or a speedy death." [May there not be some possible relation between the Greek Cross on the rock in front of the church on Dalkey Island and this swearing on St. Bega's bracelet?]

In Butler's "Lives of the Saints," under *September 6th*, St. Bega, or Bees, V., it is said: "She was a holy virgin, who flourished about the middle of the seventh century, led an anchoritical life, and afterwards founded a nunnery in Copeland near Carlisle. Her shrine was kept there after her death, and became famous for pilgrims. There is in Scotland a place called Kilbees from her name, according to a note of Thomas Innis on the Manuscript Calendar kept in the Scotch College of Paris." (See Alford Annal., t. 2, p. 294. Monasticon Angles. Suysken, t. 2, September, p. 694. Note: "She is honoured on the *22nd November* under the name of St. Bees.")

It may not be out of place to cite from Montalembert's "Monks of the West," vol. v., p. 247, where he speaks of her: "She was, according to the legend, the daughter of an Irish King, the most beautiful woman in the country, and already asked in marriage by the son of the King of Norway. But she had vowed herself, from her tenderest infancy, to the spouse of virgins, and had received from an angel, as a seal of her celestial betrothal, a bracelet marked with the sign of the cross. She escaped alone with nothing but her bracelet which the angel had given her, threw herself into a skiff, and landed on the opposite shore in Northumbria, where she lived long in a cell in the midst of the woods. Fear of the pirates, who infested these coasts, led her after a while further inland. What became of her? Here the confusion, which is so general in the debatable ground between legend and history, becomes nearly inextricable. (P. 250) What is certain, however, is that a virgin of the name of Bega figures among the most well-known and long venerated saints of the north-west of England. In the twelfth century, the famous bracelet which the angel had given her was regarded with tender veneration; the pious confidence of the faithful turned it into a relic, upon which usurpers, prevaricators, and oppressors, against whom there existed no other defence, were made to swear, with the certainty that a perjury committed on so dear and sacred a pledge would not pass unpunished. It was also to Bega and the bracelet that the cultivators of the soil had recourse against new and unjust taxes with which their Lords burdened them."

In the "Imperial Dictionary of Universal Biography" (1865) there is a notice of her by John F. Waller, LL.D., M.R.I.A., Hon. Sec., R. D. S., as follows: "*Bega*, Saint, a native of Ireland, according to Butler; but Dempter asserts that she was born in Scotland, misled probably by the earlier writers on hagiology, who are accustomed to call Ireland 'Scotia.' Be this as it may, she was a virgin of great sanctity, and spent her life in retirement and devotion in Carlisle, where she died in the latter half of the seventh century. A religious house was established in her honour, and the *7th of September* is observed in memory of her.—J. F. W."

From the whole of these citations it may be concluded that, so far as ascertainable, there is a tradition that the two churches were dedicated to a St. Bega, or St. Begnet, "a virgin but not a martyr," whose festival is stated to have been celebrated on the *12th November*. It is equally clear that more than one saint and virgin bearing the name of *Begha*, *Bega*, or *Begge* is mentioned in the ancient records bearing on the subject, and that up to the present it has not been possible to determine the particular St. Bega to whom the churches were said to be dedicated, otherwise than by the date of the festival. Now there is no saint of this name having a festival in the month of November mentioned in any of the works cited. If, however, it were allowable by way of argument to assume that there is a possible confusion between the names "Begnet" and "Benen," we have a possible clue in the account given of St. Benignus or Benen, who died the 9th November, 468, of whom it is said in Dr. Healy's "Insula Sanctorum et Doctorum," p. 95: "Benignus, son of Sescnin, Bishop of Armagh, died *9th November*, 468," p. 95. The death of Benignus is thus noticed in the "Martyrology of Donegal": "*November 8th.* Benignus, *i.e.* Benen, son of Siscnen, disciple of St. Patrick, and his successor that of Primate of Armagh. He was a virgin without ever defiling his virginity."

This would furnish a date for the festival very close to that mentioned, viz., the 12th. But confining the question to the determination of the particular St. Bega or Begnet, to whom the church of Dalkey was dedicated, the choice would lie between *St. Bega* (1), venerated at Dunbar already referred to, whose festival is on the *3rd September*, according to Smith and Wace's "Dictionary of Christian Biography"; or on the *7th September*, according to the notice of the "Imperial Dictionary of Universal Biography."

Or on the *22nd November*, according to Allan Butler (under the name of St. Bees).

Or St. Begga (2) mentioned already, whose festival would be on the *31st October* (old style or new style not stated).

Or St. Becga or Begga, d. of Gabhran, V., whose festival is on the 10th February.

Or St. *Begghe,* Duchess of Brabant, daughter of Pepin le Vieux, Mayor of the palace of Austrasia, who died in 692 or 698. She was the mother of Pepin, called "*Heristal.*" After the death of her husband she consecrated herself to the service of God, and founded in 680 the monastery of Andenne ("Art de verifier les dates"). It is further said of this saint, that to her is attributed the foundation of the "*Beguines,*" an order of uncloistered nuns still existing in a modified form in Ghent, Belgium. No date is mentioned for her festival.

In a question involving so much uncertainty it is allowable to offer a suggestion with a view to helping to clear it up. It is that the name *Bec*, *Beg*, or *Bega* may have had a titular or collective signification, and have been attached to the heads of a certain female Order; or as a name for the whole Order, as in the case of the "*Beguines*" just mentioned; or as in the case of the "*Clairettes,*" the name given to the Bernardines (Littré, "Dictionnaire de la L. Fr."), wherein the termination seems to be a diminutive of the same character as the "net" in "Begnet." This view would be to some extent supported by the fact that in Old and Middle Age French the word "Bec" was used with regard to women, as mentioned by Littré in his dictionary, under that word. Thus he says: §4°, "Minois":

> "Un sien valet avait pour femme
> Un petit bec, assez mignon."
>
> LA FONTAINE, "Paté."

"Tu voudrais me déplaire, À moi, Crispin, à moi, que tu nommais tojours 'Ton Bec,' ton petit bec?" (Hauteroche, "Nobles de Province," iv. 4).

The word "minois" is given by the same "Dictionary" as meaning, "par extension," "une jolie fille." From this point of view "Begnet" might represent either the Order collectively, or the head of the Order or house for the time being; and the date of the festival might vary from place to place, and even apply to different saints.

On the other hand, some consideration may be had of the Orientation of the church of Dalkey Town. In Chambers's "Encyclopædia" (1901), under the word "Orientation," it is stated: "The Orientation of churches is not usually very exactly to the east; and it is supposed that the east end, in some cases, has been set so as to point towards the place where the sun rises on the morning of the patron saint's day. In other cases, the choir and the nave are not built exactly in a straight line, the choir having thus a right inclination to one side, which in the symbolism of the middle age, was supposed to indicate the bowing of our Saviour's head on the cross."

Now the church of Dalkey presents the peculiarity of having the old nave a more modern chancel orientated in slightly different directions (Pl. XIV., fig. 2). The older or western portion is orientated about east 8° 10′ north; while the eastern and modern end has a direction of about east 9° 30′ north. Assuming that this or these orientations were intended to point to the point of the horizon at which the sun rose on the festival day of the patron saint, we have simply to see to what dates in the year these northern declinations of the sun correspond. This should take place at two different periods of the year, the one on the passage of the sun from equinox to summer solstice, and the other on his return southwards. In the first case, there is an indicated north declination of from 8° 4′ 24″ to 9° 31′ 47″ occurring between the *11th and the 15th April.* In the second case there is an indicated north declination of from 9° 36′ 38″ to 8° 10′ 26″ occurring between the *29th August and the 2nd September.* Searching among the different saints whose festivals occur about these dates, we find mentioned *St. Benezet* or little St. Benedict, of Avignon, who died in 1184, and whose festival is kept on the *14th April*—a possible solution if there were any equivalence between Begnet, Benen, and Benedict, which, as shown, is denied by scholars such as Dr. Todd and Dr. Joyce, not to speak of the difficulty of the St. Begnet in question having been a virgin. As regards the St. Bega, or Begga, the daughter of Gabhran, virgin, already mentioned, and whose festival is given as occurring on the 10th February, it should be remembered that she is mentioned as being the sister of Lugaidh, a priest whose festival is on the *17th April.*

As regards the festivals mentioned as occurring between the *29th August and the 2nd September*, the nearest in date would be that of St. Bega (*September 3rd*), of whom it is stated, as already mentioned, that she was an Irish princess of the seventh century, was venerated at Dunbar, who lived in an island in the Ocean Sea, and whose festival is given by Allan Butler on the *6th September*, and by Waller, in the citation from the "Imperial Dictionary of Biography," as occurring on the *7th September.* But, as has been already pointed out, a great confusion rests over the different saints known by this name. At all events, if the Orientation of the church of Dalkey be taken as having a connexion with the patron saint's festival, then it would point to the St. Bega of Dunbar, whose festival is given as occurring on the 3rd, or 6th, or 7th September, and relatively close approximation to the dates indicated by the Orientations (*29th August to 2nd September*). The question of the Orientation of the *Church* on *Dalkey Island* will be discussed further on: it is sufficient here to say that it is quite different from that of the church of Dalkey Town. The data concerning the church on Dalkey Island are, as has been already pointed out, very scant. The only thing apparently on record is its transference by Hugh de Lacy to the Cathedral Chapter of Dublin, as mentioned in Mr. Elrington Ball's account of it, already cited. Nothing is seemingly known as to the date of its foundation, nor, strictly speaking, as to the particular saint to whom it was dedicated, except the tradition that it also was dedicated to St. Begnet, the patroness of Dalkey Town church.

It might seem that any further description of it than that given by Wakeman, already cited, would be superfluous; but the closer examination of the ruin on the one hand, and meagreness of documentary record concerning it on the other, justify a more careful examination of the remains, were it only for the purpose of securing a fairly correct plan and details of the structure. Moreover, the question of the orientation presents an interest in this case also, and being different from that of Dalkey Town church, it is presumable either that the church may not have been originally dedicated to the same saint, or that a different intention guided the founders in that respect.

The position (Pl. XIV., fig. 6) occupied by the building is remarkable, as shown by the east and west cross-section of the island through the old church. It lies in a sort of depression on the central and longer axis of the island, at a point where the ground offers an extent of surface sufficiently level to allow of its being conveniently built on. It also lies near the little rocky cove by which communication is still had with the land; and to the west of it, at a comparatively short distance, stands the rock with the cross and circle described as Greek by Dr. Graves, and mentioned and sketched by Wakeman in his Paper already referred to. Towards the east the ground rises, as indicated by the section, and nearly hides the structure on that side, since but the summit of the roof and the points of the gables could be seen from the sea. This disposition may have been intentional, with a view to more completely hiding the building from the attacks of the sea-rovers, who seem to have continually infested these coasts, and, indeed, those of Ireland in general, more notably during the seventeenth and eighteenth centuries, as would appear from the Public Records. In the Report of the Keeper of Public Records in Ireland (2nd May, 1888), p. 23, mention is made of "the orders and letters concerning principally the guarding of the coasts against pirates, Turkish and other sea-rovers, with instructions to the commanders how to carry out the orders of the State," and dating from 1631 to 1638.

The roof of the church, just overlooking the sea to the east and north-east, would have afforded an advantageous position for a look-out, from which to give warning by means of a bell to those on land. In this respect it may not be out of place to cite the following from Chambers's "Encyclopædia" of 1864 under the word "*Martello* Tower":—

"The name is said to have been taken from certain Italian towers built near the sea during the period when piracy was common in the Mediterranean, for the purpose of keeping watch and giving warning if a pirate ship was seen approaching. This warning was given by striking on a bell with a hammer (ital., "martello"), and hence the towers were called ("*Torri da Martello*"). Such a look-out should, of course, have been constantly kept up, and necessitated, therefore, the continuous residence of an outlooker or outlookers on the island. The position selected for the Oratory may also have been influenced by the vicinity of the well, that of the landing cove, and the relative shelter from the easterly and south-easterly storms afforded by the ground. In any case the position was well selected from all these points of view.

As is indicated by the section, the eastern horizon would have been visible from a point at the height of the belfry; and it is proposed to examine in this Paper the possibility and the probability of the building having been either intended as, or at least used as, an observatory for the determination, by direct observation, of the rising of the sun on the horizon, and thus to fix the precise period of the equinox and summer solstice—the former fundamentally necessary for the correct determination of the Paschal Time.

The plan of the church was carefully made, and, for reasons here unnecessary to explain, the dimensions were taken in metres and centimetres, which can always be converted into English feet and inches when required. It will be observed that the plan (Pl. XIV., fig. 1) does not indicate a very great precision in the laying out of the foundations, and that measurements to a centimetre give the amount of accuracy attainable.

The principal feature which strikes one on the examination of the plan is the projections of the north and south side wall, beyond the gable faces, so as to form what have been called, in the description by Wakeman, "pilasters," but which, more properly, might be called "antæ"—a detail of form so characteristic of the more ancient styles of Greek and Italian temples. These projections are not quite equal at the four corners; the two at the western end of the building are practically equal in amount of projection; but at the east end the projections are unequal and somewhat greater than at the west end.

The door in the western gable is marked in its style as noticed by Wakeman. The jambs are slightly inclined; the breadth of doorway between them is, at the top, under the lintel, 80 centimetres; while at the ground, where a sill may have existed, it is 82 centimetres: thus barely an inch, but determinable.

A character of the building, which does not seem to have been noticed, is the "*batter*" *of the walls*, which may be observed on the angles of the building, but more particularly on the jambs of the door, which showed a thickness of wall of 93·5 centimetres at the floor, and only 85·5 centimetres under the lintel. This batter, or inward inclination of the walls, is fairly recognisable in the photographic vignette placed at the end of the chapter (p. 80) in Mr. Elrington Ball's work already referred to. It would favour the presumption of great antiquity for the building, and would, to some extent, account for the resistance of the walls to the destructive action of time, wind, and weather.

The masonry is very rough, and is composed of stones, which seem to have been either surface-boulders or very weathered material from some other structure. The sizes of the stones vary much, from very large in the lower parts, to middling- and small-sized in the upper parts. Of courses there are, strictly speaking, none, the stones having been seemingly fitted to one another as they came to hand, with, however, a very abundant use of "spawls," and much intelligence shown in their use.

The mortar seems, indeed, to have been employed rather to secure the "spawls" than to bed the stones.

The material is, for the most part, of granite; but here and there may be noticed stones, more or less dressed, of limestone, evidently dressed glacial boulders from the drift, and some slabs of mica-schist from Killiney shore. As "spawls" were employed, pieces of granite, mica-schist, andalucite-schist from Killiney shore, and even pieces of the "epidiorite" now found in Killiney Park, and described by the author of the present Paper in the Proc. Roy. Ir. Acad. (3rd Series, vol. vi., No. 1). As to the source which furnished the greater part of the material, the rounded and weathered nature of which is so evident, it may be recalled here that a *dun*, or fort, existed on the island prior to Christian times. It is mentioned in "The Annals of the Four Masters," p. 6, as having been built, according to that authority, in the age of the world 3501, by Sedgha, a Milesian chief of great renown. This date would, according to the chronology of these authorities, correspond to B.C. 1700. It may be assumed that its remains still existed down into Christian times; and there is therefore a certain probability that the material employed in the construction of the church was, to some extent, procured from the remains of this "*dun*," since so few loose stones or boulders are to be met with at present on the island. It would certainly add to the interest attaching to the present ruin if it were presumable that the materials employed therefor had at one time formed part of the walls of that prehistoric monument.

That the materials for the building of the dun itself were all procured from the neighbouring shore is hardly likely, and such would imply the use of a size and style of coasting vessel, and skill in handling it, that might with difficulty be conceded to the "Milesians" of B.C. 1700; but that some part of the material may have been so transported is conceivable.

The only openings in the walls, besides the western door, are the small window in the south wall described by Wakeman, and considered by him as original. He gives a sketch of it on p. 702 of the volume containing the paper. This woodcut is so far incorrect as it would lead to the impression that the jambs of this window are vertical, or but slightly inclined. But the contrary is the case; the window is at 360 cm. from the present ground-level on the outside; it has a single-stone lintel and sill. The breadth in the clear under the lintel is 27 cm., and on the sill is 30 cm., while the height of the opening is about 55·5 cm. The inclination of the jambs is therefore well marked, and more marked and distinct than in the case of the door. The splay of the sides on the inside gives an interior breadth of opening of 75 cm.

This window was seemingly intended to light a small room placed above the floor, at the west end of the building, and of which traces still remain on the interior surfaces of the walls. It seems to have formed part of the original design. The larger window in the south wall, situated at the south-east end, sketched and briefly described by Wakeman, is by him considered as quite recent; and he gives testimony in support of that view. As the masonry has been exposed to the action of the air and weather for at least a century or so, since the period of the alterations referred to by him, it does not show with marked evidence the certainty of this change, unless by the relative smallness of the material employed on the sides of the opening and the presence of the two sill-stones so strangely placed across the opening (Pl. XVI., fig. 1). That the space underneath these stones has been the result of quite recent work, and is roughly a hole broken in the wall, may be at once granted. But it is probable that there was originally at the south-east end of this south wall an opening or window of the same character as that still existing in the western part of Dalkey Town church (Pl. XVI., figs. 2, 3, 4, and 5).

This is a tall, narrow slit, so placed as to throw light on the altar at the east end of the church; possibly that of Dalkey Island was divided towards the mid height by a cross-stone or sill, as in the case of the Dalkey Town church window referred to, and of the two stones remaining across this south-east end opening; the upper one was probably the middle sill of the original window. This is to some extent suggested by a comparison of the relative distances of the two windows in question from the respective south-east corners of the buildings. In the Dalkey Town church the distance of the eastern vertical edge of the opening from the south-east corner of that building is 186 cm.; while the same measurement in the case of Dalkey Island church gives 182 cm.—practically the same—and so far suggests that an entirely new window was not broken in the wall, but rather that the narrow light or opening, such as that of Dalkey Town church, was enlarged towards the west side to its present breadth. It is proposed to discuss hereinafter the possible usage of this narrow opening for the purpose of the determination of the periods of the solstices, by means of the relative positions of the patches of light formed by the sun's rays, on the floor and walls, for which object the narrowness of the opening would be more advantageous than if it were wide, as at present is the case.

The only other opening in the walls of the building is a small square cavity, situated in the northern wall, quite near the north-west interior angle of the building, and situated at a height of 273 cm. from the ground. Its dimensions are about 40 cm. by 40 cm. It was originally evidently a recess in the nature of a cupboard, and did not then extend through the thickness of the wall; since on the outside, as it presents itself at present, it is represented by a hole, the place from which a stone had been forced out.

On the walls, in the interior, are to be seen the remaining traces and patches of plastering, leading to the presumption that the greater part of these surfaces had been so treated. On the interior face of the west wall, this plastering shows the traces of a floor having once existed at the height of 273 cm. from the present ground, and in the south-west corner at this height, appears a rectangular space measuring 135 cm. by 98 cm., marked on the plastered surface, as if some article of furniture had been in position there (see Pl. XV., fig. 2).

The fire-place in the eastern wall is mentioned by Wakeman as having been made by the workmen who took up their dwelling in the old church during the building of the Martello Tower. The recessed space above it is probably original, and is unsymmetrical in its lines, as regards the vertical axis of the wall face. The workmanship is very rough, as is also that of the arching. There is a crack in this face over this recess, as if there were a void space in the wall, such as a chimney-flue.

There is every reason to suppose that the original roof was of stone slabs, probably of the chiastolite mica-schists that outcrop on Killiney shore, possibly of the ordinary mica-schist to be found in connexion with the granite there. What was the form of the termination of the eastern gable can only be a matter of conjecture at present; but it supported the roof at all events, and may have presented an opening just under the ridge of the roof, or this eastern gable may have carried a belfry or opening such as that still remaining on the western gable. Wakeman considers this latter belfry to be a recent addition; but the appearance of the masonry hardly supports that opinion; while, on the other hand, the thicknesses of the two gable walls at the base, 91 cm. (about one-tenth greater than that of the two side walls), would point towards the presumption that these two gables were intended to carry belfries or elevated parts of that nature.

In the two elevations (exterior and interior, Pl. XIII., fig. 1, and Pl. XV., fig. 1) of the western gable herewith submitted are shown two square holes in the sides of the belfry, one on either side of the belfry opening, which may have been intended to receive the ends of the purloins which supported the roof. These holes are thorough; and I have assumed the existence of, and sketched in dotted lines in the longitudinal section (Pl. XIII., fig. 2), a projecting platform, supported on these beams where they pass through these holes. I have done so in order to bring out the idea already suggested, viz.: that observations may have been made from this platform by an observer standing on it, and looking through the existing belfry opening, and a corresponding one in the eastern gable, on to the horizon, which I assume to be clearly visible from that point through such an opening. This implied use of the belfry is to some extent supported by Wakeman's remark that it must have been enclosed by the roof, which would precisely fit it for such an application. It is not necessary to examine here the size or form that such an opening should have had for that purpose; but there is ground for discussing the more general question of to what extent and in what way were direct observations of the sun and stars made currently, in connexion with these ancient churches, with a view to the determination of the festivals and hours of service, of the equinoxes and solstices, and of the due fixation of the paschal time and other festivals and seasons of the year.

That from the earliest periods of Irish history the division of time into years, months, and days was known and employed, need not here be discussed. Dr. Joyce, in his "Irish Names of Places," vol. i., p. 200, chap. vi., discusses the names arising out of "customs, amusements, and occupations," and says: "The Pagan Irish divided their year, in the first instance, into two equal parts; each of these was subdivided into two parts or quarters. The four quarters were called *Earrach, Samhradh, Foghmhar, and Geimhridh* [Arragh, Sowra, Fowar, and Gevre] (Spring, Summer, Autumn, and Winter), which are the names still in use; and they begin on the first days of February, May, August, and November, respectively." Now such a division of the year must have been based on some sort of actual astronomical observations, and could only have been maintained by continual and regular observations of the heavenly bodies which determine the divisions of the year. Hence, there must have been at all times of

Irish society, astronomers and places and methods of observation sufficient for the requirements of the period. Moreover, observatories or places of observation were requisite as matters essential to the security of aggregated communities, and most essentially along the coasts, on which incursions might be made by enemies or by piratical adventurers. High points offering extended views in all or certain directions would naturally serve as such observatories or look-outs; and in the case of buildings their highest points. Hence, places of defence, fortifications, castles, &c., from the very earliest periods of history have had, as part of their general scheme of arrangement, elevated places or towers from which views, either of the heavens or of the country in the neighbourhood, could be securely and advantageously obtained. Dr. Joyce, in his "Names of Places," vol. i., p. 215, says: "Look-out points, whether on the coast to command the sea, or on the borders of a hostile territory to guard against surprise, or in the midst of a pastoral country to watch the fields, are usually designated by the word *coimhead* (covade). This word signifies 'watching' or 'guarding'; and it is generally applied to hills from which there is an extensive prospect."

We should therefore expect to find corresponding arrangements in the plans of the earliest monasteries and buildings intended to receive Christian communities. In Smith and Cheatham's "Dictionary of Christian Antiquities," p. 1240, in speaking of the "*Cœnobium*" of St. Euthymius, in Palestine, *circa* A.D. 328, it is stated: "The whole area was fortified with a palisade and wall, and further protected by a strong tower forming the citadel or stronghold of the whole desert, rising in the middle of the cemetery."

This tower just described was a very usual feature in the monasteries of the East, which, from their liability to attack from the predatory tribes, assumed the character of strong fortresses. The whole establishment was dominated by a lofty tower near the entrance, like the keep of a Norman castle, placed under the patronage of the Blessed Virgin Mary, St. Michael the Archangel, Apostles, or saints, to which the inhabitants might flee for protection when the rest of the buildings had fallen into the hands of the assailants (monasteries of Mount Athos). In some cases protection was still further secured by the single entrance being made many feet above the ground, only accessible by ladders, or by a bucket raised by a windlass, *e.g.*, the monastery of St. Catherine on Mount Sinai.

At page 1243, the Dictionary says: "The Irish and early Scotch monasteries of the sixth and seventh centuries, such as that of Armagh and Iona, followed the eastern model."

So far there is merely a presumption that these towers served for look-out and observation purposes; but being constructed for the safety of the community, this could only be secured by such continual observation and outlook. Moreover, another important requirement of the religious communities rendered such observations necessary, more particularly that of the heavenly bodies—that was the division of the hours of the day and of the night, for the regular occupations and offices of the community. The division of the day into hours must have been in some way arrived at, and, moreover, announced regularly to the members of the community. How the hours of the day or night were marked in the pagan and early Christian times of Ireland is not distinctly stated, so far as I can find. That the round towers or "cloictheachs" served in some way for that purpose the very name implies; and yet Petrie barely concedes that they may have been thus used. In the East, and in those latitudes wherein the sun is generally visible during the day-time, the use of the gnomon was common until the introduction of the "clepsydra," and later on of the clock; but in a climate such as that of Ireland, the sky of which is so frequently overcovered by clouds, and continuous sunshine thus exceptional, means must have been found at an early period of mechanically dividing the time of the day and of the night; and also a means of making known these divisions to the public, or to those requiring this knowledge for their daily avocations.

In the "Dictionnaire Encyclopédique de la France" (Ph. le Bas, Paris, 1843), under the heading "Horloges," p. 485, the author describes the wonderful clock or clepsydra made for the Calif of Bagdad, Haroun-al-Raschid, in A.D. 807, and presented by him to Charlemagne; and then continues: "On a donc ignoré absolument jusqu'au 12^{me} siècle, la division du temps par le moyen des roues dentées, et des pignons qui s'y engrènaient. Ce n'est que depuis ce temps, qu'on a commencé à fabriquer, pour les cloches des églises, des grandes horloges, qui fonctionnaient au moyen d'un poids attaché à la plus grande roue et faisant aller tout le mécanisme. Des ouvriers intelligents perfectionnèrent ensuite cet appareil, en y ajustant un rouage correspondant à un marteau, qui frappait sur un timbre sonore les heures indiquées par le cadran. Ce perfectionnement devint d'une grande utilité, et pour les monastères, *où avant son introduction il faillait que les religieux proposassent des gens pour observer les étoiles* *pendant la nuit afin d'être avertis des heures de l'office,* et pour les villes, où les crieurs faisaient connaître la marche du temps, usage qui se conserve dans plusieurs provinces."

"On a à tort fait descendre jusqu'au 13me siècle et même jusqu'au 14me siècle, l'invention des horloges sonnantes; elles se trouvent déjà citées dans les statuts de l'ordre de Citeaux, réunis vers l'année 1120. On voit en effet dans ces statuts un article par lequel on défend toutes sonneries de cloches, même à l'horloge, depuis la messe de jeudi saint, jusqu'à celle du samedi saint; un autre article aussi, qui enjoint au sacristan de régler l'horloge de sorte qu'elle sonne et qu'elle l'éveille pendant l'hiver, avant matines ou avant les nocturnes," &c.

This article distinctly points out the observation of the stars during the night for the fixation of the hours of office in the monasteries of the early Christian period, and such observation implies an observatory or part of the building capable of being so applied, such as a tower or elevated part dominating the surrounding parts of the building, any trees in the proximity, and having a free and extended view towards the horizon. Let it be remarked, *en passant*, that such conditions are presented by the highest story of the round towers. Another and more important requirement for the early Christian churches called for such regular observations and for corresponding observatories. It was that of the correct determination of the Easter time. It is a matter of history the difference that subsisted for nearly two centuries between the Churches of Ireland and England, and that of Rome and the East, as regards the proper period for the celebration of Easter. Dr. Healy, in his *Insula Sanctorum et Doctorum* (1890), p. 233, says: "Of course the system of computing the date of Easter in use in Ireland and in England, at the beginning of the seventh century, was that which was introduced by St. Patrick himself, and which he acquired in the schools of France and Italy. From [p. 234] the very beginning, however, much diversity of practice existed between the Churches of the East and West, and even between some Churches in the West itself, in reference to the date of Easter Day." He then gives an account of the results of the Synod of Arles in this regard, of the Nicene Synod of A.D. 325, and of the reference to the Church of Alexandria for the exact date thereof, and its notification to the Roman Church, by which it was finally made known to the other Churches. He says: "The Alexandrian usage ultimately prevailed, but was finally accepted in the Western world only about

A.D. 530, when explained and developed by Dionysius Exiguus. This, the correct system, therefore lays down three principles :—(first) Easter Day must be always a Sunday; never on, but next after, the 14th day of the moon; (secondly) that the 14th day, or the full moon, should be that on, or next after, *the vernal equinox;* and (thirdly) the equinox itself was invariably assigned to the 21st of March. Whilst, however, the continental Churches aimed at uniformity after a troublesome experience of their own errors, the Irish and British Churches, practically isolated from their neighbours, tenaciously clung to the system introduced by St. Patrick."

This citation is made in order to show the importance attached to the question in the early Churches, the differences that existed between them, the effect of their isolation from the continental communities, and the intimate dependence of the exact date on that of the vernal equinox. It is true that from a very early date a cycle of years was adopted, and brought into use for the purpose; but it is clear that the actual observation and determination of the vernal equinox were not the less necessary as a check on, and a control of the computation; and hence in the Western churches, and more particularly in those of Ireland, such means of observation must have been provided for, and have been employed from the time of St. Patrick.

In support of this point of view, it may be interesting and useful to cite the inscription which appears on the pavement floor of the north transept of the Church of St. Sulpice in Paris, in connexion with the meridian line traced on that floor. It is thus referred to in Baedeker's "Guide to Paris," 1891, p. 252 :—"St. Sulpice, Transept. —On the pavement here a meridian line was drawn in 1743 with the signs of the Zodiac. It is prolonged to an obelisk of white marble, which indicates the direction of the north; while towards the south it corresponds with a closed window, from a small aperture of which a ray of the sun falls at noon on the vertical line of the obelisk." This description, rather curt and wanting in detail, does not sufficiently describe these details, nor show the significance of this remarkable piece of scientific work. Not only is the meridian plane clearly and sharply defined by a ribbon of brass, inlaid on edge into the floor, but it is marked with signs of the Zodiac on the floor, and on the gnomon or obelisk situated in the north transept, and serving to indicate by horizontal lines traced thereon the positions which the ray of sunlight, coming from the south transept window, occupies at the various periods of the year corresponding to the inscribed signs thereon.

These refer to the equinoxes and solstices, as clearly pointed out by the inscription, which is as follows (the lines of which run across the meridian line):—

Gnomon Astronomicum
ad Certum paschalis
Æquinoctiæ Explorandum.
Quod S. Martyr Episcopus Hyppolitus
Advisus est, Quod concil. Nicæain
Patriarchæ Alexandrino, Dimandavit,
Quod Patres Constantienses et Late
ranenses, solicitos habuit. Quod inter
Romanos Pontifices Gregrorius XIII
et Clemens XI incredibile Labore et
Adhibitan Peritorum Astronomorum
industria conati sunt. Hoc Æmulator,
Stylus iste, cum sub Ductum Lin. meri
diana, puncto Æquinoctiali certis
Periodorum,—Solarium indicibus.

On the floor between the two transepts occurs the following inscription (the lines of which also run across the meridian line):—

Opus. D. O. M. Sacrum.
elaboravit
Scientiarum Academiæ nomine et consi
liis C. Cl. le Monnier Ejusdem Acad. et
London, Socius. Ad. Æquinoctiæ Autumnali
et in Hiemnali Solstitia absolvit An.
Rep. Sal. MDCCXLIII.

At the side door of the south transept entrance is placed the following inscription on a slab let into the wall :—

Obliquitas Eccliptin : Maxima.

23° : 28′ : 40″

69

Fait par Claude Langlois

Ingr. aux Galeries du Louvre

MDCCXLIV

This remarkable piece of work demonstrates, by its arrangement and inscriptions, the traditional acknowledgment of the Papal and Patriarchal admonitions as to the observation and determination of the equinoxes and solstices, in view of the correct definition of the paschal time, and of the festival connected therewith. That similar arrangements may still exist in other churches and cathedrals on the Continent, particularly in those of Rome, there is reason to believe; and considering the influence that the Continental ecclesiastical customs had on the early churches of Ireland, it is presumable that in many of these some such arrangement was provided for.

The examination of the south-eastern opening of Dalkey Town old church seems to me to point to such a use of the beams of sunlight which may pass through the upper and lower compartments of this window, of which an elevation, section, and interior elevation are submitted herewith (Pl. XVI., figs. 2, 3, 4, and 5). It will be observed that the opening is divided towards the middle of its height by a cross-piece or sill; exteriorly, this and the lower sill are of roughly-fashioned slabs of granite; but the middle sill, while showing a granite slab exteriorly, presents on the inside a mica-schist slab, which naturally offers relatively smooth surfaces and sharp straight edges.

Now the thickness of the wall, taken in conjunction with the height of the opening in the clear, determines the conditions under which sunbeams are able to pass through these openings, and the forms determined by the beams of light on the floor or opposite wall.

It is quite clear that during the winter months, or those during which the meridian sun's elevation above the horizon is low, sunlight can penetrate into the church by both compartments of the window, and show itself on the floor, or on the opposite wall, in the form of two more or less rectangular parallelograms or patches of light separated by a bar.

It is also evident that for a certain meridional elevation of the sun above the horizon, the upper portion of the window will not allow any sunbeam to penetrate which could still penetrate by the lower one, and that finally for a still higher elevation of the midday sun—that is, during the summer months—the meridian sun could send no beams into the church by either part of this window.

The dimensions that were taken of these openings allow of a sufficiently close determination of what these different elevations may be, and therefore of the periods of the year that would be indicated by the appearance of both patches of light, of one only, or finally of neither one nor other, on the floor or wall of the church. From the diagram section herewith submitted (Pl. XVII., fig. 3), it may be seen that the angle of incidence of a beam of sunlight, for which it would cease to penetrate, or would be "extinguished," in the upper compartment of the window, is 44°; while in the lower part of the window the corresponding angle is 52°. Now these angles of incidence of sunlight would occur twice in the course of the year, for each compartment, accordingly as the sun moves from one solstice to the other. For the angle of 44°, the date would be 9th April and 4th September; while for the angle of 52°, the dates are 2nd May and 11th August. (I have here to acknowledge the kindness of Sir Robert Ball, F.R.S., of the Observatory, Cambridge, for these determinations.)

It has already been pointed out that, taking into consideration the direction of orientation of Dalkey Town church, the St. Begnet or Bega to whom the church was dedicated was the virgin, venerated at Dunbar, whose festival is given on the 6th September by Alban Butler, and on the 3rd September by another authority. It may therefore be assumed that the upper compartment of this window was arranged so as to give notice or warning of the arrival of the dedicatory saint's festival.

It is probable that the under compartment of the window was intended to give some such warning or notice as regards some other festival.

Presuming, as has been already advanced, that the south-east window of the Dalkey Island church was originally similar in style to that still existing in the church of Dalkey Town, it may be presumed that it was designed to fulfil the same objects—that is, to admit sunlight and mark the arrival of some certain period of the year or festival day, or even that of the equinox. This double mode of observation of the latter—that is, by direct observation towards the horizon from the height of the belfry, on the one hand, and by the incidence of the sunbeams through the compartment of the window, on the other—in no way contradict, but rather supplement one another; since in our climate the horizon may be covered at sunrise, and the sky quite clear at mid-day. Enough, however, has been said to point out the interest that the forms, positions, and dimensions of the different openings of this class of ancient church in Ireland present, and to justify the proposition that a more careful examination and measurement of the still existing "*cills*" or oratories should be made in the expectation of very interesting and instructive results being furnished thereby. As the church on Dalkey Island is stated to have been dedicated to St. Begnet, as well as that of Dalkey Town, it might be expected that its orientation would in some way concord with such dedication. As already mentioned, however, the orientation in this case is nearly due east and west, the difference or error of direction therefrom being about 3°, as determined by a hand-compass. It might be asked is this error due to defective observation, or to imperfect means of tracing the east and west line, or rather was the direction as existing so intended from the foundation. It has been already remarked that the position of the building is such that the eastern horizon cannot be seen from its actual site, on account of the ground rising towards the east, as shown in the section (Pl. XVI., fig. 6); hence, if the orientation were made by actual observation of the sun on the true equinoctial day, and if his appearance above the ridge of rocks lying to the east of the site were awaited for the tracing of the line of orientation, there should be an error of at least some degrees to the south of the correct east and west direction intended; and such is actually the case. Hence, it is reasonable to presume that a true east and west orientation was intended; and the error of about 3° is quite in harmony with this view. Were the error to the north, it would be more difficult to reconcile with such intention, and there would be grounds for assuming that it was designed to refer to some feast-day happening close to the equinox (such as that of St. Benedict, the patriarch of the western monks), 21st March.

The presumption that the orientation was intended to be due east and west, and that the observation of the sun for equinox was one of the objects for which the building was intended, receives a certain support from the relation of position of the church to the rock-face, on which is cut the Greek cross, mentioned and figured by Wakeman in his Paper already cited. This rock is situated at 11·15 m. (about 14 yards) west of the western door; not, however, due west thereof, but north of west, a certain number of degrees (Pl. XVII., fig. 1). It had long occurred to me that the Irish crosses showing a circle with cross-arms might have some connexion with solar observations, serving, for instance, as a means of determining the position of the sun at certain periods, or rather fixing certain periods by the shadow of the pillar and cross at certain positions and elevations of the sun. I was therefore led to examine attentively the position of this cross relatively to the east and west direction of the building. On the ground that the determination of the direction of the setting sun is equally important as that of the rising sun, if accurately determined, for the fixation of the solstices or equinoxes, it might be assumed *a priori*, that some means would be found to ensure this determination; and on examining the position of the Greek cross in question relatively to the plan of the building, it was found that a line passing through the north-west edge of the building, due east and west, passes nearly through the centre of the cross; and probably if very exact measurements of the orientation and of the position of the cross relative to the sides of the building were made, this relation would be brought out more markedly. It would seem as if, when the building was completed, and observations from the belfry height could be made on to the horizon, leading to the recognition of the correct east and west direction, the cross was cut as a fiducial point which, with the north-west edge of the building, gave the true east and west direction.

The lineal measurements given in this Paper are in centimetres; and, perhaps, it may not be out of place to here offer an explanation of the use of this unit of measurement in this case, rather than of English feet and inches, usually employed in this country for such purposes. The explanation is simply that the author had been continually in the habit of employing the metre in connexion with geological and stratigraphical studies and measurements, and therefore continued to use it when measuring buildings. In consequence of this use of the metre, a very interesting observation has resulted, and a very important question arises.

Having been, when in Northern Spain, continually under the necessity of converting the "vara" or Castilian yard (the unit of measurement of the country) into metre units and *vice versa*, the relation of the "vara" to the metre became familiar to me. When, therefore, I came to examine the metric measurements of the Dalkey Island church, I soon observed that the "vara" unit seemed to have been that employed in the construction of the building.

In O'Shea's "Guide to Spain and Portugal," p. 109, he gives the following table of "*Reduction of Varas into Metres*":—

	M.		M.
1 vara	= 0·835	7 varas	= 5·845
2 varas	= 1·670	8 ,,	= 6·680
3 ,,	= 2·505	9 ,,	= 7·515
4 ,,	= 3·340	10 ,,	= 8·350 (correctly 8·3489)
5 ,,	= 4·175	11 ,,	= 9·185
6 ,,	= 5·010	12 ,,	= 10·020

Examining the pilasters or "antæ" of the building, the following were the thicknesses found: north-east, 86 cm.; south-east, 82·5 cm.; north-west, 83 cm.; and south-west, 85 cm.; the mean value of these is 84·1 cm.; a close approximation to 83·5 cm.; that is, a "vara."

Examining then the horizontal dimensions of the building, the breadths interiorly of the east and west gables give the following measurements (two for each end): 416 cm., 418 cm., 417 cm., 416 cm., of which the mean is 416·75 cm., or approximately 417·5 cm., that is, "5 varas," according to the above table, with a difference of 0·75 cm.

The breadth of the opening of the western door at the sill was found to be 82 cm., probably intended for a "vara," so that the spacing on the inner side of the gable shows the intervals of 167 cm., 82 cm., and 166 cm., that is 2 varas, 1 vara, 2 varas.

The length of the south wall on the inner face is 626·5 cm. (mean value), equal to 7½ "varas" (or 626·3 cm.).

The same dimension taken on the interior face of the north side wall is 619·5 cm., which differs sensibly from that of the south wall, and may be taken as the result of imperfect construction, since the two diagonal measurements differ; that from the south-east to the north-west measuring 750 cm. = 9 "varas" (7·515 m.); while that from north-east to south-west measures only 746 cm., that is a difference of 4 cm. (almost negligible, in a building so primitive and so ruined). The lengths of the north and south side walls on their exterior faces measure: for the north wall, 881 cm.; and for the south wall, 879 cm.; this last approximates to the "vara" measurement of 10½ varas = 876·7 cm.

The measurements for the heights cannot offer any satisfactory terms of comparison, since neither the gables nor any one of the corners of the pilasters remain in a state sufficiently complete to allow of any satisfactory comparison with "vara" measurements. The small window in the southern wall, sketched by Wakeman, and so markedly "pelasgic" in the character of its inclined jambs, presents the following dimensions:—breadth of opening at top, 27 cm. = $\frac{1}{3}$ vara (27·8 cm.); breadth of opening at sill, 30 cm. (27 cm. + $\frac{1}{9}$ = 30 cm.); height, mean value of the two sides, 55·5 cm. = $\frac{2}{3}$ "vara" (55·6 cm.). The western doorway presents on the basement course an opening of 82 cm., as already remarked, or approximately 1 "vara"; this opening under the lintel is only 80 cm., or a diminution of about $\frac{1}{41}$; while the height from the basement course to the lintel under-surface is 208 cm. = $2\frac{1}{2}$ varas (208·72 cm.).

To bring out more distinctly the "vara" relations of the different measurements, it may be convenient to present them in a tabular form as follows:—

		Mean value.	Vara value.	Differences.
	CM.	CM.	CM.	CM.
Pilasters: breadths ...	86·0	84·10	83·5	0·6
Do. do. ...	82·5			
Do. do. ...	83·0			
Do. do. ...	85·0			
E. & W. gables—interior faces: measurements of	416.0	416·75	417·5	0·75
	418.0			
Do. do. ...	417.0			
Do. do. ...	416.0			
Spacing on inner face of west gable.	167·0		167·5	0·5
	82·0		83·5	1·5
Do. do. ...	166·0		167·5	1·5
Inner face of south wall: length		626·5	626·3	0·2
Inner face of north wall: length		619·5	626·3	6·8
S.W./N.E. diagonal		750·0	751·5	1·5
N.W./S.E. diagonal		746·0	751·5	5·5
North wall: exterior face ...		881·0	876·7	4·3
South wall:—exterior face ...		879·0	876·7	2·3
Small window in south wall: breadth at top		27·0	27·8	0·8
Do. do. at sill		30·0	27·8 + 1/9 = 30·9	0·9
Do. height		55·5	55·6	0·1
Western door-way: opening on basement course ...		82·0	83·5	1·5
Do. under lintel face ...		80·0	83·5–1/41	
Height		208·0	208·72	0·72

The mean value of these various differences is 1·82 cm., or a little more than a half inch English measurement.

These several concordances between the "vara" values and the metric measurements, found for different parts of the Dalkey Island church, can hardly be fortuitous, and go far to support the assumption that Spanish masons, or builders, used to the Spanish unit of measurement, were engaged on the building of this church. This assumption would be quite in harmony with the remarks from Cheetham and Smith's "Dictionary of Christian Antiquities," cited in the paper "On the mode of ringing or sounding bells in the early churches of Northern Spain and of Ireland" (Proceedings, Royal Irish Academy, third series, vol. vi., p. 490), as to the points of resemblance between certain very ancient oratories or churches of Northern Spain and those of Ireland. It would also go to demonstrate the activity of the commercial relations between Spain and Ireland in ancient times, and the frequentation of the safest ports of the Irish coast by Spanish and Continental traders, most probably for fishing purposes, and for the trade in salt, amongst other objects.

A still more interesting question is raised by the consideration of these measurements; it is that of the *units of length which prevailed in Ireland at various periods of its history.* Up to the present, it has been customary to give the measurements of monuments, no matter what their age or nature, in standard English feet and inches. For practical purposes this is perfectly intelligible; but it is not to be supposed that all the monuments of this country were laid down as regards dimensions in the units of measurement now currently in use. It is evidently presumable that various units prevailed from time to time, according to the culture and customs of the predominating races, and that most certainly the use of British units of measurement did not generally prevail until long after the Norman invasion.

In O'Curry's Lectures, vol. iii. (Lecture XIX., "On Buildings, Furniture, &c., in Ancient Erinn"), frequent mention is made of dimensions of buildings in feet; but no indication is given as to the *absolute length* of the foot mentioned, or as to the standard implied; and the reader, accustomed only to the current English foot, naturally reads it into the measurements cited by O'Curry and others. The recovery of these ancient units is most desirable, and should be attempted, however arduous the task may prove to be; and it can only be brought about by the careful measurement with such a common unit as the metre of all our monuments, still sufficiently well preserved to allow of such measurements being satisfactorily taken, and the comparison of these with such units as are known to have prevailed in former times. This task was undertaken and carried out to a definite conclusion by Newton, as regards the Egyptian cubit or cubits used in the construction of the great monuments of that country, and by other eminent savants as regards the units of Persia, Babylonia, Greece, and Italy. It presents, therefore, a field of study which has been cultivated by men of the greatest learning, and as necessary for the proper understanding of the histories of the countries mentioned as displayed in their monuments, works, and utensils. The study of the ancient *cills* or oratories of Ireland, from this point of view, would, I beg leave to submit, furnish data of the very highest historical interest, and merits, therefore, the encouragement of the Royal Irish Academy.

EXPLANATION OF PLATES.

Plate XIII.

Fig. 1.—Western elevation of Dalkey Island Church.
Fig. 2.—E. to W. vertical section of same.

Plate XIV.

Fig. 1.—Plan of old Church on Dalkey Island.
Fig. 2.—Plan of St. Begnet's Church, Dalkey Town: showing orientation.

Plate XV.

Fig. 1.—Interior elevation of western gable wall of Dalkey Island Church.
Fig. 2.—Interior elevation of eastern gable wall of Dalkey Island Church.

Plate XVI.

Fig. 1.—Interior elevation of S.-E. window of Dalkey Island Church.
Fig. 2.—Interior elevation of S.-E. end window of Dalkey Town Church.
Fig. 3.—Vertical cross-section of this, N.-S.
Fig. 4.—Elevation of same, facing south.
Fig. 5.—Plan of same.
Fig. 6.—E.-W. vertical cross-section of Dalkey Island, to show lie of ground, and visual from Belfrey of Old Church towards eastern horizon.

Plate XVII.

Fig. 1.—Plan of Dalkey Island Church, to show relation of orientation with Greek cross on rock to the W.
Fig. 2.—Elevation of rock bearing Greek cross, Dalkey Island.
Fig. 3.—S.-E. opening in western end of St. Begnet's Church, Dalkey Town: N.-S. section, showing the angles of extinction of rays of sunlight.

XIII.

THE FIRST MOHAMMADAN TREATIES WITH CHRISTIANS.

By STANLEY LANE-POOLE, M.A., Litt.D.

Read April 27, 1903.

The early treaties of the Arabs are important documents in the history of Islām. They show us, upon evidence that cannot be disputed, the policy adopted by the conquerors towards the vanquished; and they enable us to understand in some degree the causes which contributed to the spread of the new religion. There is a very widely spread misconception on this subject. It is frequently alleged that Islām was 'propagated by the sword.' Carlyle's rejoinder, 'First get your sword', was only a partial answer to the accusation; for though the religion of Islām must have possessed other attractions to draw men to it in its hour of weakness, when there were no swords on its side, yet it would be quite natural that, when the faith had been embraced by many thousands of fighting men, the argument of the sword should be employed to bring others to the confession of the creed. Indeed, if it is held that there is but one road to salvation, it is at least arguable that forcible methods would be justified in saving men even against their own wills. But, as a matter of history, Islām was not 'propagated by the sword.' The Korán never enjoins any such principle. It does indeed exhort Muslims to 'fight in the path of God with those who fight with you,' but adds, 'if they desist, God is forgiving and merciful; . . . let there be no hostility save against transgressors.'* 'Unprovoked war is clearly contrary to the letter and spirit of the Kur-án; but war against the enemies of el-Islám, who have been the first aggressors, is enjoined as a sacred duty; and he who loses his life in fulfilling this duty (if unpaid) is promised the rewards of a martyr. . . . Of such enemies, if reduced by force of arms, refusing to capitulate, or to surrender themselves, the men may be put to death or be made slaves; and the

* *Korān*, ii., 186-9.

women and children also, under the same circumstances, may be made slaves: but life and liberty are to be granted to those who surrender themselves by capitulation or otherwise, on the condition of their embracing el-Islám, or paying a poll-tax, unless they have acted perfidiously towards the Muslims.'* In other words, unless there were exceptional circumstances of treachery or inveterate hostility, the invariable terms offered by Muslim generals were comprised in the simple formula 'Embrace Islām, or pay the poll-tax.' As this tax on non-conformity was not more than two dīnārs, or about a guinea, a head per annum, and was levied only on able-bodied men, and not on the aged or women or children, it was scarcely heavy enough to induce many to become converts on purely economical grounds.

There is no justice in the charge against Islām that it was 'propagated by the sword'; but it is easy to see how it arose. The Arabs made vast conquests, and the majority of the people they conquered became, sooner or later, Muslims; therefore, it is argued, Islām owed its extension to the sword. But this is to confound two distinct things. The Arabs were inspired to a new life and a common enthusiasm by Islām, and in their unprecedented union they set out to conquer; but the motive of conquest was gain, not proselytizing, and the sword was wielded by an expanding people, inspired, it is true, by the new faith, but not for the purpose of imposing it on others. Arab statesmen indeed clearly recognized the fact that the more converts were made to Islām the less would be the revenue from the non-conforming poll-tax; and as the Arabs have never been indifferent to money, this consideration formed a check upon a too zealous propaganda.

The early Muslim treaties are an irrefragable proof of the accuracy of what has been said about the terms offered to non-Muslim subjects. We have several records of early treaties of peace with Christians. The first is with the city of Jerusalem in 636 (A. H. 15), the text of which will be given later on. An earlier convention, of which the text is not preserved, was made on the surrender of Damascus in the previous year, by which every male adult who did not become a Muslim was to pay annually one dīnār (10*s.* 6*d.*) and one measure of corn from each field. Of the first treaty made by ʿAmr ibn el-ʿĀṣī, the conqueror of Egypt, with the Christians, we fortunately possess the complete text, as in the case of the Jerusalem treaty. The names

* Lane, *Selections from the Kur-án*, 1st ed., 70, 71.

of the witnesses are given, as in the Jerusalem document, and the name of the scribe is appended. The two treaties run on similar lines, and contain not only practically identical clauses, but even absolutely identical words and phrases. Since we find the name of ʿAmr ibn el-ʿĀṣī among the witnesses to the Jerusalem treaty, it is easily understood that he carried its terms with him, in memory or in writing, when he invaded Egypt, and that he endeavoured to accord to the Christians of Egypt the same terms, *mutatis mutandis*, as the Caliph ʿOmar had, in his presence, accorded to the Christians of Jerusalem.

The following text of the Treaty of Miṣr (or Egypt) is from Ṭabarī's *Annales*, in de Goeje's edition, part I., pp. 2588–9 :—

بسم الله الرحمان الرحيم

هذا ما اعطى عمرو ابن العاص اهل مصر من الامان على
انفسهم وملّتهم واموالهم وكنائسهم وصُلُبهم وبرّهم وبحرهم لا* يدُخَل
عليهم[a] شىء من ذلك ولا ينتقص[b] ولا يساكنهم النوب وعلى اهل
مصر ان يعطوا الجزية اذا اجتمعوا على هذا الصلح وانتهت
زيادة نهرهم خمسين الف الف وعليهم ما جنى[c] لصوتهم فان ابى
احد منهم[d] ان يجيب رفع عنهم من الجزاء بقدرهم وذمّتنا ممن[e] ابى
بريئة وان نقص نهرهم من غايته[f] اذا انتهى رفع عنهم بقدر ذلك
ومن دخل فى صلحهم من*الروم والنوب[g] فله مثل ما*لهم وعليه مثل ما[h]
عليهم ومن ابى واختار الذهاب فهو آمن حتى يبلغ مأمنه او
يخرج من سلطاننا عليهم *ما عليهم[h] اثلاثًا فى كلّ ثلث[i] جباية ثلث

ما عليهم[k] على ما فى هذا الكتاب عهدّ الله وذمّته[l] وذمّة رسوله وذمّة الخليفة امير المؤمنين وذمم المؤمنين وعلى النوبة الذين استجابوا ان يُعينوا بكذا وكذا رأسًا وكذا فرسًا[m] على ان لا يُغزَوا[n] ولا يُمنَعوا من تجارة صادرة ولا واردة شهد الزبير وعبد الله ومحمّد ابناه[o] وكتب وَردانُ وحَضَر[p]

Variae lectiones:—

a. C يدخل, Co يدخلون. *b.* IH et IK c. ض, C ينقض, IK mox ولا يساكنهم النوبة. *c.* C et IK s.p., Co حتى; C mox نصاحبهم. *d.* IH om. *e.* C om., IK فيمن. *f.* C غاننه, IH[1] عافيه, IH[2] عادبه, sed د loco rasurae. *g.* Co النوب والروم; IK rursus والنوبة. *h.* Co om. *i.* Co ثلاث. *k.* IH add. لهم; IK haec verba inde a فى كلّ om. *l.* IK om. *m.* IH add. معونةً. *n.* IK يغيّروا et mox يمنعونا. *o.* IH ابنا عمرو. *p.* IH[1] وخِضرّ, apud IH[2] punctum litterae خ erasum est.

Translation:—

'In the name of God, the Compassionate, the Merciful.

'This is what ʿAmr ibn el-ʿĀṣī granted the people of Miṣr in pledge of security for their persons and their religion and their goods, and their churches and their crosses and their lands and their waters: there shall not be taken from them anything of this, nor diminished.*

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* Or as de Sacy renders it, more freely, 'on n'attentera à leurs droits relativement à aucune de ces choses, et on ne leur fera éprouver aucun tort.' *Mémoires de l'Institut* (*Acad. des inscr. et belles-lettres*), v., 35 ff. (1821).

'And the garrisons shall not settle among them.

'And [it is binding] upon the people of Miṣr that they pay the poll-tax when they come into this Treaty of peace and the overflow of their river has subsided—fifty millions.

'And [binding] on them is what their robbers commit.

'And if any of them refuse [to come into this Treaty], the sum of the taxes shall be cut down for them [who are liable for it] in proportion to them: and our obligation towards those that refuse is quit.

'And if their river has less than its full rise, then the sum [of taxation] shall be reduced for them in proportion.

'And whoso of the Romans and garrisons shall come into their Treaty, for him is the like as for them, and on him is the like [obligation] as on them.

'And whoso refuses and chooses to go away, he shall be safe till he reaches his place of security or departs from our dominion.

'What is [laid] upon them is by thirds, at every third drawing a third of what is [laid] upon them.

'For what is in this writing [stands] the pledge and warranty of God, and the warranty of His Prophet, and the warranty of the Khalīfa, the Commander of the Faithful, and the warranties of the Faithful.

'And [it is prescribed] for the garrisons who consent [to this Treaty], that they shall assist with* so many head and so many horse that they be not plundered or hindered from commerce to and fro. Witness Ez-Zubeyr and 'Abdallāh and Moḥammad his sons. Wardān wrote that and was present.'

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* De Sacy renders this 'fournir tant d'hommes et tant de chevaux, moyennant quoi on ne portera point la guerre chez eux; ou quoi ils seront dispensés de l'obligation de faire la guerre sacrée.' The verb غزوا may be active or passive. The whole clause is obscure.

For purposes of comparison I subjoin the Jerusalem Treaty* :—

بسم الله الرحمان الرحيم

هذا ما اعطى عبد الله عمر امير المؤمنين اهلَ ايلياء من
الأَمان اعطاهم امانًا لأنفسهم واموالهم ولكنائسهم وصُلْبانهم[a]
وسقيمها وبريئها[b] وسائر ملّتها انّه[c] لا تُسكَن كنائسهم ولا تُهدَم
ولا يُنتقَص[d] منها ولا من حيّزها[e] ولا من صليبهم ولا من شئٍ من اموالهم
ولا يُكرهون[f] على دينهم ولا يُضارّ احد منهم ولا يَسكن بإيلياء
معهم احد من اليهود وعلى اهل ايلياء ان يُعطوا الجزية كما
يُعطى اهلُ المدائن وعليهم[g] ان يُخرجوا منها الرومَ واللُّصوت[h]
فمن خرج منهم فانّه[i] آمن على نفسه وماله حتى يبلغوا مأمنَهم
ومن اقام منهم فهو[k] آمن وعليه مثل ما على اهل ايلياء من
الجزية ومن احبّ من اهل ايلياء ان يسير بنفسه وماله مع الروم
ويخلّى[l] بيعَهم وصُلّبهم فانّهم آمنون على انفسهم * وعلى بيعهم وصُلّبهم[m]
حتّى يبلغوا مأمنَهم ومن كان بها[n] من اهل ارض * قبل مقتل فلان[o] فمن
شاء منهم قعد و عليه مثل ما على اهل ايلياء من الجزية و من شاء سار
مع الروم ومن شاء رجع الى اهله[p] فانّه لا يؤخذ منهم[q] شيء حتّى يَحصُد[r]
حَصادهم و على ما فى هذ الكتاب عهدُ الله [وذمّته][s] وذمم رسوله
وذمّة الخلفاء وذمّة المؤمنين اذا اعطوا الذى عليه من الجزية شهد
*على ذلك[t] خالد بن وليد وعمرو بن العاص وعبدالرحمان ابن عوف
ومعاوية بن ابى سفيان *وكَتَبَ و حَضَرَ سنةَ ١٥ [v] '

* T. I., ٢٤٠٥, ٢٤٠٦. For a similar Treaty with Lydda, see Tabarī, *ibid.* ٢٤٠٧.

Variae lectiones:—

a. Modj. ولصلبانهم *b.* Modj. et Soj. ومقيمها وبريها. *c.* Modj. et Soj. انها. *d.* Soj. تنقض. *e.* Modj. et Soj. حدّها; Cod. Leid. جزها. *f.* Codd. يكرهوا; Modj. et Soj. يكرهون. *g.* Modj. وعلى *h.* Modj. et Soj. اللصوص. *i.* Modj. et Soj. فهو. *k.* IH om.; suppl. e Modj. *l.* Modj. et Soj.; codd. om. وعلى. *m.* verba spuria? *n.* Modj. et Soj. فيها. *o.* Soj. et Modj. om. *p.* Modj. et Soj., ارضه. *q.* Modj. منه. *r.* IH[1] تحصد; Soj. يحصد, om. حتى. *s.* Modj. et Soj. *t.* Soj. بذلك. *v.* Modj. et Soj. om.

Translation:—

'In the name of God, the Compassionate, the Merciful.

'This is what the servant of God, 'Omar, Commander of the Faithful, gave to the people of Jerusalem [Īliyā] in pledge of security: he gave them security for their persons and their goods and their churches and their crosses, and its sick and its sound, and all of its religion: their churches shall not be impoverished or destroyed; nor shall [aught] of it be diminished, neither of its appurtenances nor of its crosses nor of anything of its provisions; and they shall not be forced against their faith, and not one of them shall be harmed.

'And none of the Jews shall dwell with them in Jerusalem.

'And [it is binding] on the people of Jerusalem that they pay the poll-tax as the people of el-Medāïn pay it;

'And that they expel the Romans and robbers from it [Jerusalem]: and whoso of them goes forth he shall be safe as to his person and property until they reach their place of safety; and whoso of them stays, he shall be safe and on him [is binding] the like of that which [is binding] on the people of Jerusalem, a poll-tax.

'And whoso of the people of Jerusalem prefers to go away, himself and his property, along with the Romans, and leave their churches and crosses, they shall be safe in person [and churches and crosses ?] until they reach their place of safety.

'And whoso of the people of the land was in it [Jerusalem] before the fighting, if he wish to settle, on him [is binding] the like as what [is binding] on the people of Jerusalem, a poll-tax, and if he wishes to depart with the Romans or to return to his own people, nothing shall be taken from them [i.e. in poll-tax] until the harvest is reaped. And for what is in this writing [stands] the pledge and warranty of God, and the warranty of his prophet, and the warranty of the Khalīfas, and the warranty of the faithful, provided they pay what is due of the poll-tax. Witnesses to that, Khālid ibn Welīd, and 'Amr ibn el-'Âṣī, and 'Abdu-r-Raḥmān ibn Auf, and Mu'āwiya ibn Abī-Sufyān. And wrote and was present [x], year 15.'

The close similarity between the two documents will be seen at the first glance. In both we find an assurance of security for the person, goods, religion, churches and crosses, of the conquered people. In both we have the imposition of a poll-tax on those who do not conform to Islām. In both we have the undertaking that a dominant, or once dominant, people shall not dwell among them, in the one case the Jews, in the other the Romans. In both the Romans, as rulers, are to depart, yet if any of them choose to remain as subjects, they are to enjoy the same privileges and bear the same burthen of tax as the native Christians. Both end with pledges of warranty and the names of witnesses, and the formula كتب وحضر, 'wrote and was present,' only the name of the scribe is given in the Egyptian treaty but not in that of Jerusalem. It is evident that we have here two formal documents, drawn up on a standard model; and I do not think there can be any doubt of their textual accuracy, subject to minor variations in different manuscripts. These variants I have appended to the texts.

It will be noticed that the Egyptian Treaty, with which I am chiefly concerned, does not in so many words impose a capitation tax (جزية) at so much a head, but states a fixed tribute of fifty millions. It does not say millions of what coin, but it must evidently be dirhems. Abū-Ṣālih,* writing about A.D. 1200, says that 'Amr imposed an annual tax of 26⅔ dirhems (i.e. 2 dīnārs), on all, but made the rich pay three ardebbs of wheat in addition, and this is the universal tradition. The conditions annexed, that the tax is to be paid after the inundation, i.e., in harvest time, and that it is to be reduced if the Nile is lower than the average, seem to point to a tax upon land-produce; but if, as is clear from all authorities, there was only one tax, by whatever name it was called, it would in any case fall upon the land in an agricultural country like Egypt; and as at the conquest the whole population was Christian, the Arabs forming an insignificant minority, the poll-tax would in reality be a land-tax. In fact there is no evidence that any land-tax was imposed at the conquest (except at Alexandria), beyond the statement that three ardebbs were levied from the richer class. The land-tax (خراج) was imposed somewhat later. It seems probable therefore that the fifty millions (of dirhems), equal to three and one third million dīnārs, represent a rough guess at the sum which would be produced by a poll-tax of two dīnārs a head on adult males. It was, as a matter of fact, too low an estimate, for the poll-tax soon brought in twelve millions; but at the time of the treaty, when only a small part of the country was subdued, and most of the Delta was still in Roman hands, it was impossible to take an accurate

* *Churches and Monasteries of Egypt*, ed. and tr. Evetts, f. 22*a*.

census of population. It is recorded that ʿAmr only raised one million dīnārs in the first year, two millions in the second, and four in the third year of his occupation of Egypt; and however we may distrust this geometrical progression, it indicates at least that at the beginning the revenue from the poll-tax was incomplete.

Another point in the Treaty which is of the first importance relates to the Roman garrisons. 'The garrisons shall not settle amongst them': but 'whoso of the Romans and garrisons shall come into their treaty, for him is the like as for them.' I wish to draw particular attention to these clauses because my translation differs from all previous versions. Hitherto the word *nub* نوب has been translated 'the Nubians,' and in my *History of Egypt in the Middle Ages* I followed the received version. But the introduction of Nubians into a treaty made with the people of the Egyptian Delta at a time when the Arabs had not even penetrated into Upper Egypt struck me from the first as curiously unnecessary. We read nothing in history about Nubian influence or Nubian settlements in Egypt, at least since the Ethiopian dynasty of thirteen hundred years before. A passage in Ṭabarī* set me on what I think is the right path. He says, in reference to ʿAmr's arrival at Heliopolis (ʿAyn Shems), 'and the dominion (or rule, مُلْك) was between the Copts and the *Nub*.' This apparent omission of the Romans as the ruling power points clearly to some other meaning of *Nub*. It could not be stated seriously that the government of Egypt was shared between Copts and Nubians. The phrase puzzled the copyists, for two transcripts (I H) have a marginal note to *en-Nub*, 'perhaps the Romans,' لعله والروم.

Now I need scarcely explain to you that Arabic MSS. seldom give the vowel-points, and that a word without vowel-points may mean several different things. Nūb certainly means Nubian, but put

* De Goeje's text, I. 2587.

the vowel-sign fetḥa over the و , and it becomes *nuab* نُوَب , the plural of *nauba*. In the text of the treaty in two places we find the variant *en-nauba* النوبة in place of النوب ; and النوبة occurs throughout in the text of the treaty printed by de Sacy from Abū-l-Maḥāsin (quoting Ibn-Kethīr) in his *Second Mémoire sur la nature et les revolutions du droit de propriété territoriale en Egypte.** *Nauba* means primarily a 'turn'; hence what is done in turns or takes turn-about, a 'sentinel,' a 'guard'; and so it comes to mean a 'garrison.' This last meaning is common in later literary Arabic; and Dozy cites it, s. v. نوب , as used by el-Bekrī in the eleventh century. I believe, therefore, that the true translation of النوبة and النوب in the Treaty is 'garrison' and 'garrisons.' This rendering makes the whole document intelligible. There was no reason to suppose that the Nubians were disposed to settle in Lower Egypt; there was certainly no foundation for the statement that they shared the dominion with the Copts; and there seems no object in connecting them closely with the Romans. But as soon as you substitute 'garrisons' for 'Nubians' the whole sense becomes clear. 'The garrisons shall not settle among' the people of Egypt: this was the chief desire of the Copts, for whom the Roman garrisons were the symbol and agents of that Melekite or 'Chalcedonian' persecution which had made the Roman rule intolerable to the monophysite church to which the great majority of Egyptian Christians belonged. Yet, if the Roman soldiers chose to become peaceful citizens, they might enjoy the privileges of the treaty and pay the poll-tax: 'whoso of the Romans and garrisons shall come into their [i.e. the Copts'] treaty, for him is the like as for them, and on him is the like as on them.' It would be quite unnecessary for the treaty to lay down such a rule for the Nubians, whose inclusion was at that time scarcely probable. Precisely the same policy is laid down in the Jerusalem Treaty, which enacts that the Romans are to depart,

* *Mém. de l'Institut* (*Acad. des inscr. et belles-lettres*) v, 1 ff.

but that, if any of them prefer to stay, they shall be protected, and have the same conditions as the people of Jerusalem : وعليه مثل ما علىَ اهل ايلياء ; compare the words in the Treaty of Miṣr, فله مثل ما لهم وعليه مثل ما عليهم .

The last clause relating to the garrisons, which comes like an afterthought between the citation of the warranties and the names of the witnesses, is not very intelligible. It is translated by Weil* in the following sense : 'And [it is binding] upon the garrisons who consent [to this Treaty] that they shall help [the Muslims] with so many men [*lit.* heads] and so many horses that they [the Nub] be not attacked nor hindered from trading coming and going.'† I do not see what other meaning can be made out of يُعينوا . Even if we disregard the vowel-point, and take the word as the Ist form imperfect of عين , instead of the IVth of عون , يعينوا would mean 'scout' instead of 'help,' and would come to much the same thing. يغزوا again may be taken either as active or passive—to 'attack' or 'be attacked.' The clause may be understood to provide for a limited escort of friendly Romans to protect the caravans trading between Egypt and Syria; but such a provision appears extremely improbable. The Arabs would scarcely trust the Romans with sufficient forces to guard the caravan routes, and would undoubtedly prefer to guard (or plunder) the commerce themselves. It is not clear from the text whether it was the trade of the Romans or the trade of the Arabs that was to be protected; but if the former, the clause would seem to suggest that the Romans were to be allowed a small force in self-defence; and this appears to be the more probable interpretation of the sentence.

I have called this document the Treaty of Miṣr throughout, not the Treaty of Egypt, because, although Miṣr means 'Egypt,' it also means the middle capital of Egypt, successively known as Memphis,

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* *Geschichte der Chalifen*, i. 112. † De Sacy's rendering is given above, p. 231.

Fusṭāṭ, and Cairo. That there was at the time of the Arab conquest a city called Miṣr, and known to the Greek historians as Babylon, the successor of the partly ruined city of Memphis, is evident from all the authorities, though its extent is doubtful. We know only that it was dominated by the fortress of Babylon which gave its name to the city in both earlier and later times, and supported by at least two other forts. To judge by other treaties, such as those of Damascus, Jerusalem, and Lydda, it was the custom of the conquering Arabs to make treaties with a city, not with a country as a whole. It may be urged against this view, that the amount of tribute is altogether out of proportion to a single city, and must refer to Egypt at large; and the reference to 'lands and waters' also suggests a wider meaning than Miṣr the city. But the same occurred in the case of the Treaty of Lydda, which was made to include the neighbouring people of Palestine, but was formally contracted with the town of Lydda. I think ʿAmr made the treaty with the capital of the Copts (ignoring the as yet unconquered Roman capital, Alexandria), and made the capital responsible for all the rest of the country. Ṭabarī's phrase, however, 'So the people of Miṣr, all of them, entered into that and accepted the Treaty, and horses were collected,' فدخل فى ذلك اهل مصر كلّهم وقبلوا الصلع واجتمعت الخيول, seems to imply a general acceptance. The double meaning of Miṣr is a perpetual cause of confusion, and it would be rash to insist on either interpretation.

It is abundantly evident, however, that this was a treaty with the Copts, not with the Romans. The Roman garrisons are mentioned, but only in a subordinate manner. The people of Miṣr, not the Roman army of occupation, still less the emperor Heraclius, were the contracting parties on the other side. As there is no indication in the treaty itself that the Romans were consulted in the matter, we must conclude that this treaty was made behind their backs; that it was a compact between the Copts and the Arabs without the authority of the Roman garrison, though these had the option of accepting the same terms. Mr. A. J. Butler, in his recent learned work on *The Arab Conquest of Egypt,* labours under the extraordinary impression that this treaty is really the treaty of capitulation of the Roman garrison of Alexandria. His words* are: 'But the text of the treaty is actually given by Ṭabarî, who by a strange confusion calls it the Treaty of 'Ain Shams, instead of the Treaty of Alexandria.' Mr. Butler unfortunately gives a very inaccurate translation, and then appends the curious footnote: 'This treaty is preserved by Ibn Khaldûn, who quotes it from Ṭabarî; but it does not seem to occur in Ṭabarî's extant account of the conquest of Egypt; see Zotenberg's edition, vol. iii, pp. 461 seq.' Mr. Butler's valuable work is vitiated in many places by his references to the Persian abridgment of Ṭabarī, which not only does not contain a great deal of the most important passages of the original Arabic work, but introduces errors by compression, and even adds mere legends from Persian tradition. As we have seen, the original Arabic text of the treaty does occur in de Goeje's edition of Ṭabarī; but it is not there called the Treaty of 'Ayn Shems, and it could not possibly refer to the capitulation of Alexandria. According to the earliest, indeed the almost contemporary Christian authority — though unhappily we possess it only at third hand, and in a distractingly dislocated order— John of Nikiu's Chronicle, cited by Mr. Butler from a translation of the Ethiopic version of the Arabic translation of the Coptic or Greek original, the capitulation of Alexandria included an armistice of

* *Arab Conquest of Egypt.* Oxford: at the Clarendon Press, 1902, p. 324.

eleven months, at the expiration of which the Roman garrison of Alexandria was to quit the city and depart by sea; no Roman army was to return or attempt the recovery of Egypt; hostages were to be given by the Romans for the due execution of the treaty; and the Jews were to be allowed to remain at Alexandria. There is not a word of all this in the Treaty of Miṣr; and it obviously has no connexion with the capitulation of Alexandria.

It was, as is evident from its contents, a treaty with the Copts of the city of Miṣr as against the Romans, rather than with the Romans. The questions now arise, when could it have been concluded, and by whom? Now the Arab historians—upon whom alone we have to rely for events between the capture of the city of Miṣr and the fall of the fortress of Babylon, for there is a gap here in John of Nikiu's Chronicle—are full of reports of negotiations between the Copts and the Arabs with a view to a peace, which was strongly opposed by the Roman garrison in the fortress, then the chief position of Roman power at the apex of the Delta. According to Ṭabarī, after the Arabs had reached Babylon, there came to meet them, on the part of of el-Muḳawḳis (the name they give to the governor of Egypt), a patriarch (*gāthalīk*, catholicus) and a bishop, who, after some fighting (قاتلوه), were invited by ʿAmr to discuss terms: this was before reinforcements had reached the Muslims, and ʿAmr and his 4000 men were apparently in a precarious position. The discussion was of a friendly nature in regard to the Copts, for whom, it was said, the Prophet Moḥammad and the Muslims had always entertained a kindly feeling, on the atavic ground of the Arabs' descent from the Egyptian bondmaid Hagar. ʿAmr offered the usual terms: those who embraced Islām should be the equals of the conquerors and enter the universal brotherhood of the Muslims, and those who refused should pay the poll-tax (*jizya*). The two ecclesiastics were disposed to accept, and returned to el-Muḳawḳis to report the negotiations. But Aretion (ارطبون in the Arabic, happily emended as ارطيون by Mr. Butler —Aretion had previously been governor of Jerusalem), the Roman governor of the fortress, rejected the proposals absolutely and gave orders for an attack. The patriarch and bishop then said to the people of Miṣr: 'We will try to ward off evil from you, but we cannot return till four days hence.' They had to go to Alexandria, one presumes, to consult el-Muḳawḳis, and apparently they brought him south with them, for he was present in the fort when the Arabs laid siege to it. Meanwhile ʿAmr joined by reinforcements under ez-Zubeyr and others camped at Heliopolis (ʿAyn Shems). Ṭabarī does not mention the battle of Heliopolis by name in this connexion; but he afterwards speaks of the encounter of ʿAmr and el-Muḳawḳis at ʿAyn Shems, and John of Nikiu gives a detailed account of the battle, which, he records, was followed by the fall of Tendunyas (Umm Duneyn), a fortified place on the site of the later mediæval Maḳs and the modern Ezbekīya quarter of Cairo; and this involved the fall of the city of Miṣr, which is recorded by John of Nikiu merely in the heading of a chapter. Ṭabarī goes on to relate how the people of Miṣr, alarmed at the approach of the Arabs, entreated their ruler (ملكهم) to make terms with them, but he refused; 'and this was the fourth day'; so there was a battle (فقاتلوهم), and after the victory ez-Zubeyr scaled the wall and opened a gate—Ṭabarī does not say of what city or fortress—whereupon the people came to sue for peace, and the Treaty of Miṣr was concluded.

The mention of the fourth day, when the patriarch and bishop were expected to return, points to an armistice, and shows that the Romans were awaiting the return of the ambassadors. It is not recorded that the ecclesiastics took part in the treaty, but Ṭabarī mentions their reappearance immediately afterwards to arrange about the prisoners. Who they were it is impossible to say. Ṭabarī and other Arabic writers give them the impossible names of Abū-Maryam and Abū-Maryām; and Mr. Butler regards Abū-Maryam as a corruption of Abū-Miyāmīn, which itself is an Arabic perversion of Benjamin. Is it possible that Benjamin, the monophysite patriarch who had been driven into hiding by Cyrus, the Melekite patriarch of Alexandria, but who was still alive, and was afterwards reinstated, came out of his retreat near Ḳūṣ in Upper Egypt to help his people to throw over the Roman yoke? Or was Abū-Maryam Cyrus himself?

Ṭabarī's story fits perfectly with the contents of the treaty, which is thus shown to be a treaty with the Egyptian people against the wish of the Roman army of occupation. The authority of Ṭabarī as a careful compiler of attested traditions is very great, indeed almost absolute in Muslim acceptation: and this story rests on a chain of traditionists running up from es-Sarī through Shuʿeyb and Seyf to Abū-Ḥaritha and Abū-ʿOttimān (كتب الىّ السرى عن شعيب عن سيف عن ابى حارثة وابى عثمان قالا الخ). It is not a record to be lightly set aside.

The most widely accepted story of the surrender, and the most detailed, is given by el-Makrīzī.* It must not be inferred from the lateness of Makrīzī's date (he wrote about 1420) that his account is necessarily of little authority. He was a laborious compiler from good sources; and he had at his disposition manuscripts of early works which have since disappeared. His account rests upon traditions which may go back—some certainly do—to early times, and it is

* *Khiṭaṭ*, i. 289–294.

confirmed by much earlier writers. Maḳrīzī first relates the story in brief, and then gives a detailed narrative. Probably these two accounts come from different sources, for it was the usual habit of Arabic chroniclers to set down the different accounts one after the other with little or no attempt to reconcile them. These two accounts in Maḳrīzī, however, agree. The short account says that after ʿAmr had been reinforced by a body of 12,000 men under ez-Zubeyr he laid siege to the fortress; that ez-Zubeyr scaled the wall and captured the fort (حصن),* and seized a gate; and that el-Muḳawḳis in alarm sued for peace, which was concluded on the basis of a tribute of two dīnārs a head from the Copts. His is practically Tabarī's account. The longer narrative relates how el-Muḳawḳis, after a month's fighting, discouraged by the perseverance and energy of the Arabs, left the fortress of Babylon in company with the leaders of the Copts, and took up his position in the opposite island, now called er-Rawḍa, cutting the bridge of connexion. Then fearing that the fortresses would fall, he opened negotiations with the Arabs. He urged that the Romans were far more numerous and better equipped than the Muslims; that the Nile was high and hemmed in the invaders; and that their wisest course would be to come to terms before the Romans overwhelmed them. His object was evidently to get easy terms before the decrease of the inundation set the Muslims free for wider operations. ʿAmr kept the envoys two days and nights, and then sent them back with the usual alternatives: embrace Islām and be our brothers; or pay the poll-tax and be our inferiors; or else fight till God decides the issue. El-Muḳawḳis asked the envoys to describe what they had seen during their two days' visit to the

* Not necessarily the Castle of Babylon.

Muslims' camp; and they answered, 'We saw a people who love, every one of them, death more than life, and set humility above pride, who have no desire or enjoyment in this world, who sit in the dust and eat upon their knees,* and their commander is like all the rest; you cannot distinguish the strong from the weak, nor the master from the slave.' This report increased the dread which the Arabs inspired. The negotiations were continued on the island of er-Rawḍa; but el-Muḳawḳis could obtain no modification of the terms. Fighting with the garrison of Babylon was accordingly renewed; but finally el-Muḳawḳis persuaded the people that resistance was hopeless, and ʿAmr's terms were accepted—a poll-tax of two dīnārs a head, except from old men, children, and women, with three days' maintenance for the Muslims.

In spite of superficial differences, Maḳrīzī's story tallies with Ṭabarī's. In each there is the contrast between the willingness of the Egyptians to treat and the stubborn resistance of the Roman garrison. In each we find the capture of a fort and gate to be the decisive event which hastened the conclusion of the Treaty. In each it is essentially a treaty with the Copts, not with the Romans, though Romans who submitted were included. Maḳrīzī's statement that the negotiations took place during high Nile, coupled with the remark that they began after there had been a month's fighting at the fortress, though it does not agree with Ṭabarī's "four days," shows that this treaty must have been made about October, 640. It cannot therefore refer to the final evacuation of Babylon, which is definitely fixed at 9 April, 641. The capture of the fort, الحصن, must evidently be distinguished from the fall of the castle, القصر, and must represent

* Mr. Butler's translation of على ركبهم, 'on horseback,' is obviously a mistake.

only a partial lodgment of the Arabs in the fortifications or even in a neighbouring fortress. It has generally been assumed that there was but the one castle of Babylon to be taken; but it is clear that this was but a part of the fortifications of Miṣr. We have already seen that, according to John of Nikiu, Tendunyas (Maḳs) was a fortified post; and it is possible that ez-Zubeyr's scaling of the fort may refer to what Mr. Butler describes as the second capture of Tendunyas. Maḳrīzī mentions another fortress besides Ḳaṣr esh-Shema' (the well-known fortress close to Cairo which is generally identified with the Castle of Babylon); and this other fortress, which was situated on a rocky hill to the south-east of Ḳaṣr esh-Shema', and was within the city, was particularly called the fortress or palace (قصر) of Babylon. Remains of this other fortress may possibly be represented by the massive walls on the southern part of the hill, afterwards known as 'Antar's Stable.*

We have seen, therefore, that this Treaty of Miṣr was concluded between 'Amr and el-Muḳawḳis on behalf of the Copts about the month of October, 640. It was a treaty of surrender for the whole country, but the Roman garrisons remained unsubdued. Hence the clause 'The garrisons shall not settle (or dwell) among the people of Miṣr,' a clause to which the Romans were obviously no party. Maḳrīzī, however, now enters upon a fresh division of the subject, introduced by a fresh chain of tradition,† dating back through Ibn Lahī'a to Yaḥyā ibn Meymūn. According to this tradition, el-Muḳawḳis stipulated for the Romans that they might choose whether they would stay in Egypt on the same terms as the Copts, or whether they would rather go to their own country, which they

* See Lane, *Cairo Fifty Years Ago*, 146, 147.

† *Khiṭaṭ*, i. 293.

were free to do, including the Romans of Alexandria and the parts round about. And it was agreed in writing that el-Muḳawḳis should write to the emperor to inform him of what he had done; and if he accepted, the treaty was good. Heraclius's reply was naturally a repudiation of the treaty. He pointed out the small numbers of the Arabs compared with the Romans and the Copts, and ordered hostilities to be resumed. Upon this el-Muḳawḳis, convinced that resistance was useless, went to ʿAmr, and begged of him three things: first, 'do not break faith with the Copts, but count me as one with them, and on me be binding what is binding on them, for my word and theirs agreed upon what thou didst covenant, and they are fulfilling towards thee what thou wishest; secondly, if the Romans after this sue for peace, make no peace with them till thou hast made them confiscate and slaves; . . . and thirdly, I beg of thee when I go to my rest to have me buried at St. John's at Alexandria." And ʿAmr agreed to these requests. It is true that Maḳrīzī, in another part of his work,* gives the same three requests of el-Muḳawḳis in slightly varied words, on the authority of Ibn ʿAbd-el-Ḥakam, in connexion with the conquest of Alexandria. Such confusions are unhappily too common in regard to many events in the Arab invasion of Egypt. But the three requests, to whichever date they belong, show clearly enough that el-Muḳawḳis and ʿAmr held by the Treaty of Miṣr which had been concluded with the Copts, and that the Romans put themselves outside the treaty. The ninth-century writer, Ibn ʿAbd-el-Ḥakam's account of that treaty, as cited by Maḳrīzī, closely agrees with what has already been related, and the learned geographer

* *Ibid.*, i. 163. Mr. Butler says, 'Here we get back to an earlier version': but Ibn ʿAbd-el-Ḥakam is a hundred years *later* than Ibn Lahīʿa († 164 A.H.) The latter moreover was a famous traditionist, as well as chief Ḳāḍī of Fusṭāṭ.

Yāḳūt, a Greek, who wrote his great work in 1225, uses the identical words employed by Maḳrīzī in parts of a practically identical narrative, so far as it goes.* He adds that the Treaty was made by el-Muḳawḳis for the Copts and the Romans; but while the Romans had the choice of assenting to it or not, according as their emperor should decide, *the Copts had no such choice* (و اما القبط فبغير خيار).

This treaty with the Copts, which both the Arabs and the Copts upheld against the Romans, is, as we have seen, ascribed by Maḳrīzī, and by much earlier writers, such as Ibn 'Abd-el-Ḥakam and el-Belādhurī, to el-Muḳawḳis as representative of the Copts. Maḳrīzī describes him as over both the Copts and Romans (الروم واكابر ... القبط ورؤسائهم و عليهم المقوقس).† Who this Muḳawḳis was has been a puzzle to all historians. He is called, by Arabic writers, either 'the Roman' الرومى or 'the Greek' اليونانى, and his name is given either as 'George son of Mīnā' جريج بن مينا, or 'son of Ḳurḳub' بن قرقب. Ṭabarī and Belādhurī give him no name beyond el-Muḳawḳis—a word which is explained as meaning 'ring-dove' in Arabic, but which is probably not Arabic—and John of Nikiu does not mention him by name. Professor Karabaček‡ interprets the names as George, son of Mīnā Parkabios, makes him both strategos and pagarch, and thinks the title Muḳawḳis may represent the Greek μεγαυχής—a title, however, which he has invented on a rather loose analogy with titles, such as ἐνδοξότατος, found in papyri of the Roman period. Mr. Milne§ identifies him with George the prefect mentioned by John of Nikiu. Professor Bury|| follows Karabaček, but not in the

* Mu'jam-el-Buldān, s.v. الفسطاط, iii. 894–5. † *Khiṭaṭ*, i. 290.
‡ *Pap. Erzherzog Reiner*, i. 1–11.
§ *Egypt under Roman Rule*, 224.
|| Ed. of Gibbon, v. appendix, 540.

acceptance of the assumed Greek title μεγαυχής. Finally, following the lead of the Portuguese scholar Pereira, Mr. Butler, in his *Arab Conquest of Egypt*, after an elaborate examination of the authorities,* has come to the conclusion that el-Muḳawḳis was none other than Cyrus, the Melekite patriarch of Alexandria.

The evidence he relies upon for this theory consists partly in statements by Coptic writers; partly in coincidences between acts attributed to el-Muḳawḳis by one set of historians and acts attributed to Cyrus by another set of authorities. The statements of Coptic writers are these:

1. Severus, bishop of Ushmūneyn in the latter part of the tenth century, in an Arabic work on the lives of the patriarchs, which has not yet been printed, says, 'When Heraclius had recovered his territories, he appointed governors in every place. To us in the land of Egypt Cyrus was sent to be governor and patriarch together.' Referring to the ten years' persecution of the monophysites, he says, 'These were the years during which Heraclius and Al Muḳauḳas were ruling Egypt'; and again, 'When the ten years of the reign of Heraclius and the misgovernment of Al Muḳauḳas were over.' He speaks of 'the misbelieving governor, who was both prefect and patriarch of Alexandria;' and he makes the ex-patriarch Benjamin speak of 'the time of the persecution which befell me when Al Muḳauḳas drove me away." It should be added that the Greek historian Theophanes (9th c.) also makes Cyrus at once patriarch and prefect.

2. The Coptic Synaxarium, quoted by Amélineau, says, 'The Muḳauḳas was head of the faith of Chalcedon, and had been made

* *Arab Conquest of Egypt*, App. C, 508–526. He uses the Ethiopic vocalization Muḳawḳas, instead of the Arabic Muḳawḳis.

ruler and patriarch over Egypt'; and the Ethiopic Synaxarium contains the words 'The Mukaukas, that is to say, the governor and archbishop of Alexandria and all the land of Egypt.'

3. In the Coptic life of Samuel of Kalamūn, of which a tenth-century fragment is preserved in the Bodleian, and of which the original would appear from internal evidence to have been composed before the death of Cyrus, a curious story is told of the patriarch's visit to a monastery; and incidentally he is described as ⲡⲕⲁⲩⲭⲓⲟⲥ ⲡⲉⲡⲥⲉⲩⲇⲟⲁⲣⲭⲏⲉⲡⲓⲥⲕⲟⲡⲟⲥ, or 'the *kauchios*, the false archbishop.' In this Coptic word—if it be Coptic—*kauchios* Mr. Butler, following Amélineau and Pereira, sees the original of the title Mukawkis. The explanation is a case of *obscurum per obscurius*, for no satisfactory meaning has so far been found for *kauchios*; and Mr. Butler himself hazards three distinct conjectures—'Caucasian,' 'Cholchian,' and 'paederastian.' The obscurity of the meaning, however, does not affect the argument; if *kauchios* be the original of Mukawkis, then this Coptic document makes Mukawkis and Cyrus one person. But it is far from certain that *kauchios* is the Coptic original of the Arabic or Arabicized title Mukawkis.

Supposing these translations to be accurate, and supposing the MSS., which are chiefly late, to be faithful transcripts of early authoritative documents—a matter which I am not qualified to decide—these extracts taken together show that Cyrus and the Mukawkis were one and the same person in the opinion of the writers. This can hardly be contested. The only question is whether the writers were authoritative. Severus was ignorant of Coptic, and not very trustworthy,* and he wrote late in the tenth century, later by a hundred

* Butler, *Arab Conquest*, xiv, xvii.

years than Belādhurī, and fifty or sixty years than Ṭabarī. By himself, I do not think his evidence counts for much. The Synaxaria are thus described by Mr. Butler:* 'Every [Coptic] church has specially attached to its service a book called in Coptic "sýnaxár,' *i.e.* *συναξάριον*, or lives of the saints, from which a portion is often read at matins, in accordance with a very ancient custom sanctioned, for instance, at the third Council of Carthage in 397 A.D. This book corresponds closely to the passional of our English churches, from which the lessons at matins were sometimes taken, or to the martyrology, which was read at the end of prime-song. The sýnaxár is confined within the sacred walls, and there is no copy of it in any private person's possession. It has, of course, been rendered into Arabic for use at service: and the legends printed at the end of this work, which are from the Arabic version, will serve to give an idea of the miraculous traditions to which the faithful still listen with unquestioning reverence.' This does not give a very high position to the synaxaria as historical authorities; but, as in the case of Severus, it is possible that genuine historical data may be included among much legendary garbage.

Such is Mr. Butler's positive evidence. The coincidences upon which he also relies are the statements on the one hand that Cyrus, on the other that el-Muḳawḳis was Governor of Egypt under Heraclius; the statements of the Greek historians and John of Nikiu that Cyrus made peace with the Arabs, and those of the Arabic historians that el-Muḳawḳis made peace with them. But these coincidences may be explained by the hypothesis that el-Muḳawḳis was the sub-governor who made the peace, and Cyrus the patriarch

* *Coptic Churches of Egypt*, ii. 259, 260.

and supreme governor who accepted his subordinate's arrangement and reported it to the emperor.

The whole question really turns on the respective credibility of the two or three Coptic authorities and the whole series of Arabic historians. Now Mr. Butler himself admits* that 'the historical value of these Coptic documents is not very great. The writers were set upon recording matters of Church interest—the more miraculous the better —and their minds were almost closed to the great movements of the world about them.' And referring to Severus, he adds that this historian mentions 'that he had recourse to some Copts to get Greek and Coptic documents turned into Arabic, as the two former languages even then were unknown to most Christians. This is interesting as showing the state of decay reached by Coptic and Greek, and as showing Severus' own ignorance of both languages. Indeed the evidence as regards Coptic is so remarkable as to seem barely credible.'† It is clear, then, that the Copts as a rule got their historical information through the Arabic. In studying Arabic chroniclers Severus would find that el-Muḳawḳis made a treaty of surrender to the Arabs; if he read Ṭabarī, as he probably did, for Ṭabarī's work was a standard authority in the Fāṭimid library at Cairo, and Severus was a *persona grata* at the Fāṭimid caliph's court, he would also find that a *catholicos* came to ʿAmr and treated for peace. He might naturally put the two statements together, and being a Jacobite bishop not averse to believing every evil of a 'Chalcedonian' patriarch, he might very well saddle Cyrus with the shame of betraying Christian Egypt to the Muslims. As soon as we realize that the Arabic sources were older than Severus, and were probably under his eye, and that he

* *Arab Conquest*, x.

† *Ibid.*, xiv.

could not read any language but Arabic, it is easy to see how he might pervert or misunderstand the sufficiently confused and obscure narratives of the Arabic chroniclers. Whether the same argument would apply to the Synaxaria depends upon their dates, on which we have at present no information.

If we had nothing but these Coptic and Ethiopic data to go upon, the identification might perhaps be taken as proved. But when we look at the long series of Arabic writers, not only those whose works survive, but many who are cited by survivors, but whose original writings are lost, and when we fail to find the slightest hint that any one of them suspected el-Muḳawḳis and Cyrus to be the same person, I confess that their evidence, negative as it is, seems to me overwhelming. How is it that not one of them says that el-Muḳawḳis was a priest, much less an archbishop? Why do they give him the name of George son of Mīnā or son of Ḳurḳub, if his real name was Cyrus? Why does Abū-Ṣālih, who was a Christian, and wrote about 1200 A.D., state that Heraclius placed the government of Egypt under 'George the son of Mīna el-Muḳawḳis,' and also cite 'the book of el-Janāḥ' for the fact that 'the bishop of the Romans at Miṣr and Alexandria was named Cyrus'? How is it that not a single historian of Egypt, Muslim or Christian, has ever said in so many words 'el-Muḳawḳis was a title or nickname given to the patriarch Cyrus'? It is incredible that such an identity—surely a striking fact if true—should have escaped them all. And against this solid wall of negative evidence that no Muslim historian, no Christian historian, not even the almost contemporary John of Nikiu, mentions this identity, are we to accept two jottings in two church office-books, the date of which is not given, and a not very definite incidental statement of a tenth-century Copt who did not know Coptic?

Moreover, if el-Muḳawḳis was Cyrus, who was not sent to Egypt until 631, what becomes of the mission which the Prophet Moḥammad sent in 628 to 'el-Muḳawḳis, lord of Alexandria'?* Mr. Butler thinks that this is merely a case of applying a later name to an earlier governor by mistake; but it must be remembered that in reply to Moḥammad's mission, el-Muḳawḳis sent him presents, including two Egyptian girls, one of whom, Mary, was received into the Prophet's ḥarīm and bore him a son. There was every reason for preserving accurately the name of the man who gave a wife (or concubine rather) to the Prophet; and Mary herself and her fellow-slave would not be likely to forget it or to fail to make it known. The Muḳawḳis of 628 may very well be the same person as the Muḳawḳis of 640, but he cannot be Cyrus.

Apart from this silence of the chief authorities, the inherent improbability of the hypothesis must be considered. Cyrus was patriarch and civil governor, but not military prefect: yet we find him (if he be el-Muḳawḳis) commanding at the battle of Heliopolis. When the treaty was repudiated by Heraclius, el-Muḳawḳis, according to the Arabic tradition (reported by so early an authority as Ibn-Lahīʿa), threw in his lot with the Arabs; but Cyrus, according to the Greek historians, was recalled to Constantinople and castigated. That he should have returned at all to Constantinople, knowing what he had to expect, after making his peace with the Arab conqueror, seems preposterous. Cyrus finally came back to Egypt, and arranged the capitulation of Alexandria in October or November, 641; he had now accomplished the insidious plan attributed to him by Mr. Butler, and he lived five months longer: why do we hear nothing of his

* Ṭabarī, i. 1559–61. Ibn-Hishām, Wüstenfeld's trans., 318.

reward for his treachery from his Arab ally? On the contrary, according to Mr. Butler, the only request made by Cyrus to ʿAmr was apparently refused. Certainly the ambitious patriarch took little by his treachery, if indeed treachery it was. Looking at the transaction in the cool light of history, it has more the aspect of wise submission to the inevitable.

Admitting, as we must, that Cyrus was recalled and reprimanded for concluding the Treaty of Miṣr, is it necessary to hold that he was the sole negotiator? Supposing that the catholicos who according to Ṭabarī came to ʿAmr and treated for peace was Cyrus, we are told that he went away to report the negotiations to el-Muḳawḳis. Now if el-Muḳawḳis was the military prefect, or *comes limitis Aegypti*,* it was essential that he should be consulted by the civil prefect before peace could be concluded. According to Mr. Butler, who follows the indications of John of Nikiu, Theodorus the military prefect was at Alexandria at the time of the Arab invasion; was then brought to Babylon by Cyrus; and commanded at the battle of Heliopolis. Now this is exactly what is related of el-Muḳawḳis by Ṭabarī. El-Muḳawḳis was absent from Babylon when the catholicos was treating with ʿAmr. He appeared at Heliopolis, where the catholicos also appeared after the battle. He was the commander who corresponded, so far as we can see, with the military prefect. So far as the Arabic evidence goes, except for his names, el-Muḳawḳis may have been Theodorus.

This only illustrates the extreme doubtfulness of any identification of the mysterious Muḳawḳis. Until further evidence is obtained,

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* This is the later title of the military commander formerly styled *dux Aegypti*. See Milne, *Egypt under Roman Rule*, Note VIII, 215, and cp. 181.

such as we may hope for from the constantly increasing discoveries of papyri of the Roman period, it seems rash to attempt to fix his identity. That he was a military governor of high rank, and that he concluded the first treaty between Muslims and Christians in Egypt, with the concurrence of the patriarch Cyrus, is all that can be affirmed with certainty.

XIV.

SOME MONUMENTS OF THE LA TÈNE PERIOD RECENTLY DISCOVERED IN IRELAND.

By GEORGE COFFEY.

Read November 9, 1903.

[Plates XVIII.–XXII.]

The late Sir A. W. Franks was the first to distinguish in a definite manner the antiquities of what he called the Late Celtic Period. The term "Late Celtic" was introduced by Franks with reference to Britain, to denote the period preceding the permanent occupation of that island by the Romans, dating from about 200 B.C. to the middle of the first century A.D. It cannot be strictly applied to the Continent or to Ireland. Franks' conclusions were published in Kemble's "Horæ Ferales" in 1863. He then wrote that in this class of antiquities "the British Islands stand unrivalled; a few ancient objects, analogous in design, may be found in various parts of the Continent, and more extended researches in local Museums may bring others to light, but the foreign contributions to this section are scanty when compared with those in our own country."[1]

Since that was written our knowledge of the antiquities of the period has been greatly extended, especially on the Continent. The "foreign contributions" are no longer scanty; and although the magnificent Late Celtic shields found in the rivers Witham and Thames are still unrivalled, the foreign finds far exceed in number those of Britain. This we should naturally expect to be the case, for, speaking generally, the style may be described as Gaulish, and represents on the Continent the period of the historical Celts dating from about 400 B.C. to the Roman conquest of Gaul.

On the Continent the period is known as "La Tène," so called from the site of a Helvetian *oppidum* on the Lake of Neuchatel—La

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[1] "Horæ Ferales," p. 172. Franks took a wider view of the subject in a later paper, Archæologia, vol. xlv., p. 265.

Tène: the Shallows—where this class of antiquities first attracted prominent notice.

A threefold division of the period is now recognised into Early, Middle, and Late La Tène (or, as M. Reinach has proposed, for brevity, La Tène I., La Tène II., and La Tène III.), dated approximately: Early, 400–250 B.C.; Middle, 250–150 B.C.; Late, 150 B.C., to the beginning of the Christian era.[1]

In Early La Tène the treatment of the ornament is much freer than in the later periods, and the influence of classical elements, especially the Greek anthemion, may be traced. In the middle and late periods a progressive geometrical conventionalization is apparent, until in the late period the classical elements are completely absorbed or are eliminated.

In England the Late Celtic style was submerged by Roman art, but not wholly destroyed; it reacted on Roman art locally, and re-emerged as a native style in Saxon times, reinforced from Ireland and Scotland. In Ireland its history is continuous into the Christian period.[2]

It has been a habit of mind with English archæologists to regard the periods in Ireland as later than, and the styles as derived from, Britain. This view was expressed in an extreme manner in a resolution passed by the Society of Antiquaries of London, November 28th, 1901, in connexion with the recent controversy over the gold antiquities found at Broighter, County Londonderry. The resolution contained the statement that these antiquities, which were ascribed to the close of the La Tène period, were "remains of the art of the ancient Britons," and had "only an accidental connexion with Ireland."[3]

We need not take this attempt to make archæology by resolution seriously. The general impression, on the subject of which the reso-

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[1] Tischler, "Uber Gliederung der La Tène-Periode," in Correspondenz-Blatt der deutschen Anthropologischen Gesellschaft, 1885, pp. 157–172: Montelius: Cong. Préhistoriques, Paris, 1900, p. 353. Also p. 427.

[2] In Gaul important political changes appear to have occurred between La Tène II. and La Tène III. Continuity of burial customs is broken, inhumation and chariot burial is replaced by cremation. A similar difference has been noted in Britain. The earlier class of Late Celtic interments are represented by burials such as at Arras. Yorkshire, where the skeleton was laid with the chariot and horses, and the later by the Late Celtic urn-field at Aylesford, Kent. See "Note sur l'oppidum de Bibracte," Congrès Préhist., Paris, 1900, p. 418; and Evans, "Late Celtic Urn-field at Aylesford," Archæologia, vol. lii., p. 386. We have not yet any information from Ireland on this branch of the subject.

[3] *The Times*, Nov. 29, 1901.

lution is an expression, is based on the assumption that Ireland being more remote from the Continent than Britain, was less within reach of Continental influence in early times. I have combated this view elsewhere.[1] The fact that Danubian types, such as the conical caldron and late Bronze Age swords, are so well represented in Ireland, in itself contradicts the assumption. The geographical argument must be used with caution and knowledge. Trade does not necessarily follow the lines of nearest geographical contact. It is chiefly determined by the objects desired, and convenience of transit and of market centres. The frequent intercourse between Ireland and Gaul in early Christian times, fifth–seventh centuries, need not be insisted on. The chief point of landing appears to have been the river Loire. The central lands of France, to which the Loire gives ready access, were much frequented by the first Irish Christians. We hear of them at Auxerre, at Autun (close to the ancient Bibracte), at Luxeuil.[2] It was from Nantes that St. Columbanus was deported to Ireland in a ship "*quæ vexerat commercia cum Hibernia*."[3] In Roman times Ireland was believed to lie between Britain and Spain, and is mentioned as "favourably situated as regards the Gallic Sea."[4]

The Hallstatt sword can be traced westward across Gaul, and has lately been found as far west as Poitou.[5] We have possibly an indication here that the Loire was a point of departure for Ireland as early as the end of the Bronze Age.

It is not, however, the purpose of this Paper to discuss the question of trade routes, but to describe a new class of La Tène monuments recently discovered in Ireland, the first examples of La Tène carving in stone, I believe, which have been brought to light.

Some two years ago Lord Walter Fitz Gerald showed me a rubbing of a stone he had discovered at Mullaghmast, in the County Kildare. The carving on the stone was of the form we are accustomed to call in Ireland trumpet-pattern, and I was at once struck by its early character. As the stone had been removed from its original position, I urged on Lord Walter the importance of securing such an interesting monument for the Museum. He gladly undertook to do so if possible. At his instance the stone was presented to the Royal Irish Academy

[1] Journ. R.S.A.I., 1895, p. 23.
[2] Margaret Stokes, Trans. R.I.A., vol. xxx., p. 286.
[3] Reeves's "Adamnan," p. 37.
[4] Tacitus, "Agricola," cap. 24.
[5] Revue Archéologique, 4 ser., vol. ii. (1903), p. 56.

by the daughters of the late S. W. Haughton, of Carlow, owners of the property, and has been placed in the National Collection.

Last year Mrs. Coote, of Carrowroe, Roscommon, sent me photographs of a stone at Castle Strange, near Roscommon, which she thought might be of interest. Here was another stone carved with trumpet-pattern. This time the La Tène character of the ornament was unmistakable. This stone appeared to me to be so important that I forthwith determined to visit it, and make a cast of it for the Museum. Mr. Coote gave me every assistance; and with his help I was able to take a mould of the stone in plaster, from which a cast has been placed in the Museum. I should mention that Mr. John Byrne, the present tenant of Castle Strange, spared no trouble for us, and most kindly undertook the packing and forwarding of the mould after we had left.

I had heard some time previously of a stone near Loughrea, in the neighbouring county of Galway, which was said to have carving on it of spirals. I had endeavoured to get a photograph of the stone, but had not been successful.

On seeing the stone at Castle Strange, I lost no time in visiting the one at Loughrea, on the chance that it might be of the same class. I was surprised to find that it was the most remarkable example of the three, richly carved with La Tène ornament in bold relief. Mr. Dolphin, the owner, readily consented to a cast being taken, which has been placed in the Museum.

It will be convenient to describe these stones in reverse order of discovery. I shall therefore take the Loughrea stone first.

It stands in front of Mr. Dolphin's house at Turoe, about three miles from Loughrea, Ordnance map, 6-inch sheet 97. It was moved to its present position by Mr. Dolphin's father some fifty years ago. A small fort a short distance to the west of Turoe House was pointed out to me as the place from which the stone had been taken. It was said to have been inside the fort. Subsequently an old man, said to be the oldest inhabitant of the locality, brought me to the exact spot, as well as he could remember, from which it had been taken. This proved not to be within the fort, but some distance to the west of the fort, towards the bottom of the slope on the top of which the fort is placed. The old man's recollection was quite clear that the stone was outside the fort. There is, therefore, no reason to suppose that the stone had any connexion with the fort.

In its present position it stands 4 feet above ground, and measures 3 feet and 2 feet 4 inches at the sides. It is an erratic boulder of granite. The carving is very distinct and well preserved. The ornament does not require description; it is fully shown in the accompanying illustrations (Plates XIX., XX., XXI., fig. 1). These are from photographs of the cast in the Museum, painted in parts to bring out the pattern. An untouched photograph of the stone itself is shown (Plate XVIII.).

The carving of this stone is, I think, distinctly early. The treatment of the ornament is free, not constrained geometrically as in late La Tène, especially the examples found in Britain and Ireland. The derivation from the Greek anthemion can still be traced.

The fret pattern is rarely associated on the same object with La Tène ornament. In the preceding or Hallstatt period, the fret occurs frequently. It is usually simplified to plain rectangular forms.

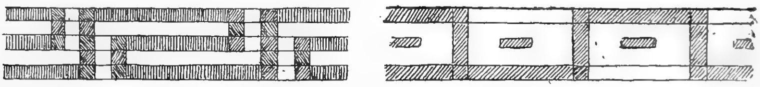

Fig. 1.—Fret-patterns from bronze vessels, Hallstatt cemetery; the fret is also found on Hallstatt pottery.[1]

Again, on a sword-sheath of La Tène I., found at Halstatt, we find the simplified fret.[2] The simplified fret, often in the form of fragments consisting of single steps, occurs also on the pottery found in the Gaulish cemeteries of the Marne. There it appears to be a pottery tradition, and the period is abundantly established as La Tène I.–II., chiefly La Tène I. The higher forms of the fret are not found on the Marne pottery; so that these single-step patterns, or fragments of meanders, may be considered as a feature of the Gaulish style in that district, fig. 2 (1–6).[3] Several examples of these fret-forms have been found in Ireland, and must, I think, have reached our island as early as the close of the Hallstatt period, or in La Tène I.

We see the form on a bronze spear-head found near Boho, Co. Fermanagh, fig. 3, in which there appears to be a mixture of Hallstatt and La Tène elements. Good examples of this class of fret were also found in the crannog of Lisnacrogher, Co. Antrim, associated with swords of La Tène I. They occur on the bronze bands of

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[1] Von Saken, "Das Grabfeld von Hallstatt," Pls. 23 and 26.

[2] Munro, "Bosnia-Herzegovina," fig. 151.

[3] Morel, "La Champagne Souterraine," Pls. 6, 19, 20, 41; Moreau, "Album Caranda," iii., Pl. 133; Revue Archéologique, 3 s., xli. (1902), p. 196.

spear-shafts, fig. 4. The blades of the spears were of iron.[1] An iron spear-head, found at Corofin, Co. Clare, likewise shows the fret-form; the borders of the openings in the blade are inlaid with bronze,[2] fig. 5.

The fret-pattern at the bottom of the Turoe stone, it will be observed, is similar in treatment to those on the Marne pottery. It is, in fact, the same as fig. 2, no. 4, brought closer together. Again, the scroll-work may be compared with that of the torques figured by Morel, pl. 37. The feeling of the work is very similar. A relationship of the highest interest is thus established between the Turoe stone and the style of the Marne district. Our knowledge of the La Tène

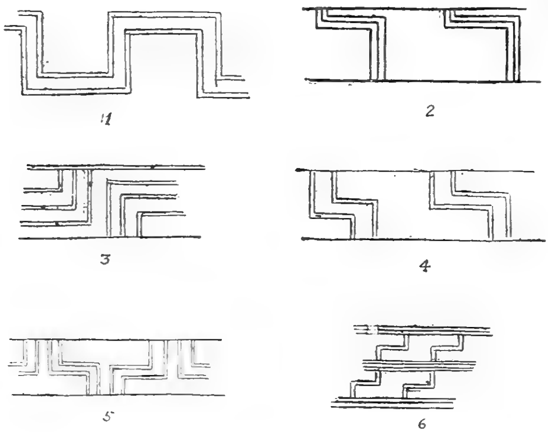

Fig. 2.

period in Ireland is still very imperfect. We cannot say whether Tischler's classification holds good for Ireland or not, or how far we have to allow for survivals. But the preceding considerations preclude, in my opinion, a late date being assigned to this stone, and induce me to place it as early at least as La Tène II., or possibly the later half of La Tène I.

The Castle Strange Stone.—This stone is also an erratic, of the same class of granite as the Turoe stone. It is at present in the demesne

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[1] Journal R. Soc. Ant. Ir., vol. xvi., p. 395. One of the sword-sheaths from Lisnacrogher is figured by Lindenschmit, "Alt. u. h. Vorz," iii., Heft. iii, Taf. 3, from the specimen in the British Museum. It is erroneously stated to be from the Thames.

[2] This specimen is the property of Mr. Mark Patterson, of Corofin, and has not been published before.

of Castle Strange, a few yards to one side of the principal avenue. There are no remains near it with which it can be associated, and it has probably been moved from its original site and placed beside the avenue as an ornamental stone. No traditions are attached to it. I could learn nothing about it, save that it had been in its present position as long as the oldest people remembered. Its dimensions are 3 feet by 2 feet 3 inches by 2 feet. The carving is not in relief, but incised. The under side is not carved; the natural surface of the stone has there been left untouched. Figure 6, an end view of the stone, shows the form of the under side: the drawing is from a photograph taken when the stone was raised to examine the under

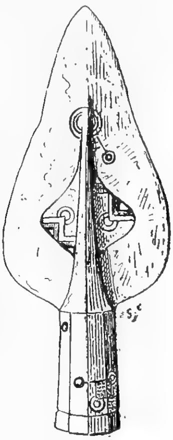

Fig. 3 (½).

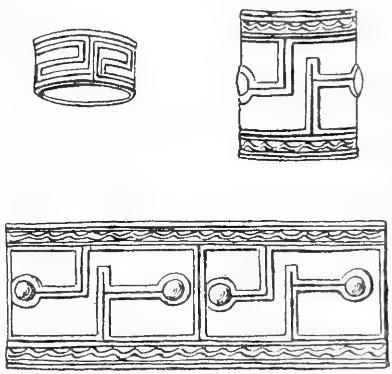

Fig. 4.

side. The style of the ornament is similar to that on the Turoe stone, and it must be referred to the same period. The illustrations (Plate xxi., figs. 2, 3) are from the cast in the Museum. The stone has suffered somewhat from weathering on the top and at one side.

The Mullaghmast Stone.—This stone is a compact limestone. It measures, in its present condition, 3 feet by about 1 foot 3 inches at the sides. It is approximately square in section. The history of the stone, as far as Lord Walter FitzGerald could ascertain, is that at the time the Haughton family demolished the FitzGerald castle of Mullaghmast, which formerly stood in a field on the hill called "Oldtown," this stone was found in the walls, and it was then removed to the haggard of the farm of Prospect House, on Mullaghmast hill, which was built out of the materials of the castle.

Pieces of the stone have been broken off at each end, as if an attempt had been made to square it at the ends for building. There is nothing to show whether this was done at the time the castle was

Fig. 6.

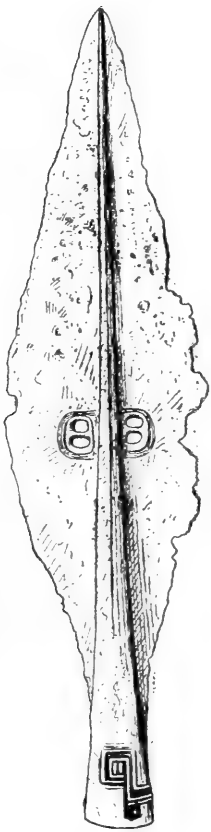

Fig. 5 (½).

Fig. 7.

built or when the stone was removed to Prospect Farm. If the stone was built into the wall of the castle at the time it was erected, it was probably done with the idea that some virtue or power attached to the stone on account of its ornament.

The carving of this stone is later in treatment than the preceding stones. It is more geometrical, the incised patterns in particular being of the interlocked C-scheme order frequently found on our early Christian monuments.

When I first saw a rubbing of this stone, I was on that account inclined to regard it as belonging to the Christian period, and conjectured that it might be a practice-piece or specimen of work. On seeing the stone I abandoned that opinion. The monument is complete in itself, and there is nothing of a Christian character about it to connect it with the Christian period.

It is necessary to describe the carving in some detail. On the slanting top of the stone a characteristic Celtic whorl of the triskele type is carved in relief; it is probably symbolic in intention. The principal face, which we will call *a*, is carved in relief, with the exception of the bottom panel. The upper half of the face is occupied by a pointed oval panel enclosing two spirals, set obliquely on the stone. The treatment of the spaces in this panel is characteristic of La Tène III. Below this panel is a band of ornament which has unfortunately suffered much from weathering and injury; the late La Tène character of the design is, however, apparent. Below this is a curious zigzag fret, and below that is a panel divided ×-wise by incised lines. The stone is a good deal injured, and the surface flaked off at the left side, but the restoration of the design, fig. 7, is probably fairly correct.

Taking the faces in order from left to right, face *b* is the next. Nearly half this face has been broken off at the right side. The design appears to have been an oval panel filled with incised trumpet pattern. At the top and at the bottom traces of carving in relief are noticeable, and the border framing the oval was also in relief.

Face *c* has lost nearly all its carving. Large pieces have been split off it, leaving only a portion of the upper end intact. Here a single spiral is carved in relief. The carving on this face was, no doubt, chiefly in relief, and it should be noticed that it is opposite to *a*, also carved in relief.

Face *d*.—Here again we have an arrangement after the manner of face *b*. The centre is covered with incised trumpet-pattern, while above and below the carving is in relief. The upper carving consists of a triangular panel, injured by cuts where the stone has been used as a sharpening stone; the lower is a good piece of La Tène ornament.

It is not certain whether or not the incised patterns are finished, or were intended to be carved in relief. But however that may be, there is no doubt that, notwithstanding their late look, they are contemporary with the rest of the carving; the ornament of the stone is a completed scheme. The bands round the base show that it was intended to be set upright, and was in fact a *stele*. As already stated, there is nothing Christian about the monument. The incised panels, however, lead into the Christian period, when the use of the trumpet-pattern organized as a system of interlocking spirals becomes frequent for the filling of panel spaces. The Mullaghmast stone must, therefore, be placed towards the end of the pre-Christian period in Ireland, or in the overlap of the Pagan and Christian periods.

It may now be asked, what light do these stones throw on the general question of a La Tène period in Ireland? I think it may be claimed that they show that the La Tène style had taken deep root in Ireland before the Christian period, and that the La Tène antiquities found from time to time are not to be accounted for simply by trade or raid from Britain and the Continent.

That the La Tène style was widely spread in Ireland I have held to be probable, chiefly on the ground that the derived La Tène ornament, which forms so marked a feature of early Christian ornament in Ireland, presumed an extensive use of the La Tène style previous to the introduction of Christianity. These stones go far, I think, to confirm that opinion. It must be borne in mind that the ancient inhabited sites of Ireland have not been excavated. The great period of Tara and of Emania, in our heroic literature, was from a century or two B.C. to the third century A.D. From Emania, some very beautiful La Tène brooches are known, and there can be no reasonable doubt that if either of these sites were excavated, numerous antiquities of the La Tène style would be brought to light.[1]

In conclusion, I desire to express my indebtedness to Mr. A. McGoogan, of the National Museum, for much kind assistance in the preparation of the photographs to illustrate this paper.

[1] The fibula, "Horae Ferales," Pl. XXI., fig. 1, is stated to be from Navan Rath, Co. Meath. This is an error for the Navan Rath, near Armagh, the site of the ancient Emania (*an Eamhuin* = *nEamhuin*, pronounced Navan, and now known as the Navan Rath, or Navan Fort). Two other examples from the same site are in the National Collection. Wilde's Catalogue R.I.A., p. 568. Petrie Collection, No. 612.

XV.

"THE ANCIENT FORTS OF IRELAND." BEING SOME FURTHER NOTES ON A PAPER OF THAT NAME, ESPECIALLY AS TO THE AGE OF MOTES IN IRELAND.

By THOMAS JOHNSON WESTROPP, M.A.

Read November 30, 1903. Published January 23, 1904.

When I laid before the Academy a Paper[1] on the extensive and as yet most imperfectly known subject of the ancient forts of Ireland, I was well aware of the many limitations of my work. I was also prepared for the detection of many errors in its pages, and have been the more agreeably surprised at the consideration it has received from other antiquaries. I would confine this paper to giving certain corrigenda and addenda of my own had not one criticism been published, which, though friendly, affects not the details, but the broad deductions of one section of my paper. I wish therefore to reply to this one point, lest my silence should be misinterpreted; for I believe the following facts will justify and bear out my views in the above-mentioned paper.

It has been stated that, from being unacquainted with an essay by a certain English antiquary, I have adopted the view of the pre-Norman and, in some cases, prehistoric origin of Irish motes, the fact being (it is alleged) that they are confined to the English Pale and were only of Norman origin.

First, to avoid error—for the word "mote" or "moate" is sometimes applied by Irish antiquaries to the low rath or liss—I use the word "mote" exclusively for the high flat-topped "mount," with or without a lower side-platform or "bailey," and girt with one or more rings and fosses. When without the base court, I use the term "simple mote"; otherwise, the term "complex mote."[2]

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[1] Trans. R. I. A., xxxi., p. 579. I have also dealt with the mote question in a paper read November, 1902, before the R. S. A. I.

[2] As only one Thing mote is recorded at any of the Danish settlements, I do not deal with any but the residential motes in this paper.

Let me first state that I was (necessarily) fully aware of the trend of antiquarian opinion as to the exclusively (or at least usually) Norman origin of the English motes. I had read the essay alluded to[1] before my paper even went to press; but I decided not to alter or add notes in press, nor to modify my statement as regarded Irish motes, for the following reasons. These, so far as I can see, prevent the English theory from being as sweepingly applied to Ireland as has been done on very slight authority in the aforesaid essay. My reasons are, first, the term "English pale" is most variant, vague, and misleading; but even allowing it to include all districts (even when occupied for the shortest time by the Normans, from 1170 to 1250) the motes exist outside it, and are non-existent in very important districts colonised by the Normans. It is only by ignoring all Irish field-work and history that this base of the theory as applied to Ireland could be maintained. Turning from more general objections to details, let us note[2]:—

1. Motes do not occur at the recorded sites of many important early Norman castles, *e.g.* Kells, Killare, Ardfinnan, Limerick, Tristledermot, Imleach, Karkinliss, Iniskefti, Castro-Iconing, Kilmallock, Birr, Rindown, Athlone, Carrickfergus, Caoluisge, Carlingford, Thurles, Croom, Dungarvan—all earlier than 1217. Motes are not found on the chief manors, and "vills" of the great colonies in Eastern Limerick,[3] Central Connaught,[4] and Cork, or in the important settlements in Thomond.

2. While they occur in places never held by the Normans or not occupied by any castle during the earlier generations after the invasion, *i.e.* before 1250. Several of these are noted in sections 128 and 134.

3. Several motes, and those of the first importance, occurring at the site of Norman castles, represent forts recorded as at those places long before the Norman invasion. For example: the sheet-anchor of the

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[1] Mrs. Armitage, in Journ. Soc. Ant. Scotland, xxxiv (1899-1900), p. 276.

[2] I use the short forms as usual—C. S. P. I., Calendar of Documents (or State Papers) relating to Ireland; R. S. A. I., Roy. Soc. Antiqq., Ireland.

[3] Castles of Escluen, Castleconnell, Wethney, Croom, Askeaton, Castle Robert Goer, Castle Robert Doondonnell, Newcastle, Caherconlish, Adare, and Kilmallock; or the vills of Aney, Bruree, Rathkeale, Mahoonagh, Athlacca, and Corcomohide. In this large district there are only two small and probably sepulchral tumuli near Aney. Neither Shanid nor Kilfinnane figures among the early castles; but motes are found there alone.

[4] See for this colony the important papers by Mr. H. T. Knox, in Journ. R. S. A. I., xxxi., p. 179, &c.; and xxxiii., p. 58, &c.

theory, so far as English writers apply it to Ireland, is the fact of the making of motes at Slane and Trim in County Meath, as mentioned in "The Song of Dermot and the Earl." No mote remains at Trim; and the Slane mote was levelled soon after its construction in 1176. Slane has a fine simple mote on the hill-top near the Abbey. But the "Life of St. Patrick," by Murchu Macci Mactheni (who was a friend of Aedh, Bishop of Sleibhthe, before 698, and which work is preserved in the Book of Armagh, 807–812), mentions great earthworks and fosses on the Hill of Slane, and evidently near St. Patrick's Camp. Now the abbey is supposed, on early tradition, to occupy the site of St. Patrick's foundation, and bears his name. The mediæval castle stood down the slope, near the Boyne, where the present castle stands,[1] and possibly there (and not at the Abbey) did Flemyng make his mote. Mactheni says that, even in his day (some 500 years before the Norman invasion), the Slane earthworks were attributed by "a fabulous story" to the slaves of Feccol Ferchertni, a pre-Christian prophet of "Bregia."[2]

The Normans made a castle of earthworks, palisades, and a long wall at Downpatrick or Dun da leathglas in 1177. But the Annals of Tighernach, who died in 1088, mention "expugnatio Duin leath glaise" under 496. The Annals record the storming of the same fort in 733. The "Annals of Ulster" mention it in 1009: "Dun da leathglas was burned both the *fortress* and a third of the town (the lay part) by lightning." Under its other name Rathceltchair, it figures in the pre-Norman "Book of Leinster," and the earlier Lives of St. Patrick, its legendary founder belonging to the earlier heroic cycle of the Red Branch heroes.[3] As will be noted, Jocelin of Furness, before 1186, attributes this fort to a period earlier than St. Patrick, and accurately describes Dun da leathglais as a "neighbouring mote" (monticulus) near St. Patrick's Church at Down, "surrounded by marshes of the sea."

The Normans built a castle at Knockgraffan, County Tipperary, in 1192.[4] The place possesses a fine complex mote, with the ruins of a stone castle in its bailey. But the fort of Graffan is reserved to

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[1] See the maps in the Down Survey, where the Flemyngs' Castle is shown in detail.

[2] Mactheni (Ed., Rev. A. Barry, 1895), p. 19.

[3] "Book of Leinster," p. 118.

[4] Ann. F. M., noticed in C. S. P. I. vol. i., No. 169, as granted to W. de Burgo, 1201-2.

the King of Munster in the "Book of Rights,"[1] which claims to be of the fifth century, dates in its present form from its compilation or revision before 902, and is found in pre-Norman manuscripts. The fort, in fact, is connected in early legend with the mother of the pre-Christian King Fiacha Muillethan.

Naas, County Kildare, was fortified by the Normans in 1186. It has a mote which figures both in early legends (such as the pre-Norman Dindsenchas) from 277, and in the Annals from the fifth to the ninth century. It is mentioned as the "Dun of Naas," in the "Tripartite Life" (tenth century),[2] as being visited by St. Patrick, who camped "on the green of the fort to the east of the road"; "to the north of the fort is his well." As the chief fort of the Kings of Leinster it was deserted in 904.

These legends, at least, prove the forts to be long pre-Norman.

These examples from four out of the five ancient provinces (there being, so far as I am aware, no case of a mote and early Norman castle "coming together" in Connaught) may suffice to show my reasons for adopting the view that some residential motes in Ireland are pre-Norman and even prehistoric.

4. Such motes occur in places where no early Norman castle is known to have stood; but where in some cases early forts are recorded.[3]

Again confining ourselves to a few examples :—

The great mote of Kilfinnane, County Limerick, with triple fosses and rings, is evidently (from the identification of the surrounding great forts of Clare, Duntrileague, &c., &c.) the Treada na riogh or triple fort of the kings named in the "Book of Rights," *ante* 902.[4]

The complex mote with two great fosses at Donaghpatrick, County Meath, appears in the "Annals of Tighernach," in 746, as being stormed; and six of the prisoners taken in it were crucified.

The "rath" of Magh Adhair, County Clare, lies some miles distant from the bounds of the almost nominal borderland of the

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[1] "Leabhar na gCeart" (Ed. O Donovan), pp. 87–89.

[2] Ed. Whitley Stokes, p. 185.

[3] Those who hold the Norman origin of Irish motes ought first to establish records of castles being built (say) before 1250, at the vast majority of forts, in the long list of motes named in my paper, pp. 708-712. Our records and state papers at least are silent. Mrs. Armitage's remarks suggest an acquaintance with Wright's 'Louthiana,' but no knowledge of motes outside the Pale.

[4] *Loc. cit.*

English colony in Tradree.[1] It figures as the place of inauguration of the Dalcassian princes from 877, when King Flan Sunach was defeated on its green, to 1313, and is a good example of the simple mote. This is not only mentioned in the Annals, but in the pre-Norman "Wars of the Gaedhil with the Gaill."

5. The type of such motes is prehistoric. It occurs in Austria and Bosnia with Early Bronze Age "finds." A bronze axe was found near the mote of Dromore, County Down, and early urn-burials in the mote of Skeirk, Queen's County, not in the mount, but in the "bailey." I fully recognise the great difficulty in Ireland (if not elsewhere) of disentangling the sepulchral elements. For example, there is no reason either to doubt that a pre-existing sepulchral tumulus may have been adapted for residence and defence by the addition of a bailey and fosses, or that the practice of burial in residential forts was so little unusual, that the discovery of sepulture in a mote (as at Greenmount) in no way disproves the residential nature of the earthwork.[2]

6. If English antiquaries are right in applying the fact of the ascertained Norman "origin" of English motes to Ireland, there should be evidence forthcoming in the abundant records[3] of the early Norman colonies. This is not so: save for the "motes" of Trim and Slane—and I may add a third example (not given by the English writers), the mote at Roscrea—the evidence rather runs to the contrary. English antiquaries have apparently made no use of the most obvious and, in this matter, most reliable authority, Giraldus Cambrensis. He was a contemporary, a relative of some of the chief actors in the Norman invasion of Ireland, and visited the country during the events he records in 1183 and 1186. He mentions the erection of many forts and camps: the Normans use an ancient fort, or make fortifications of sods, and boughs, stakes, &c.;[4] but he only

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[1] Save for the short-lived Castle of Quin, 1280-85, the nominal English lands north of Dromoland, and beyond Finlough, were uncolonised and lay waste. See C.S.P.I., 1287, and "Wars of Turlough." No English castles, save Quin, Clare, and Bunratty, are recorded in that part of Thomond; no mote occurs at their sites or in the English settlement.

[2] For burial in various types of forts, see my paper, Trans. R. I. A., section 44.

[3] The making of only one mote appears (so far as I have found) in the great mass of records cited in the "Cal. Doc. relating to Ireland," and at the Dublin Record Office.

[4] Giraldus' (Ed. Bohn) "Topography," p. 194; "Conquest," Book x., sections xi. and xiii.

once mentions the motes, not as built in his day, but as having been made before 838, by Turgesius, who "erected castles; . . . they were surrounded with deep ditches, and very lofty, being also round, and most of them having three lines of defence."[1] If his contemporaries made similar structures at all the places where motes and Norman castles exist, his silence is very unaccountable; if the pre-existing motes were, like the raths and cahers of earth and stone, utilized by the Normans, his silence speaks very plainly indeed. The evidence of Jocelin also tells against the exclusively Norman origin of our greater motes. He was a monk of Furness, and wrote in the time, and at the suggestion, of Thomas, Archbishop of Armagh (1181-1201). He probably compiled his work before 1186, as he does not allude to the translation of the remains of the three Patrons, at Down, in that year. He mentions "a work called a rayth," *i.e.* "a wall," and other earthworks; but his one allusion to a mote is to attribute it to the fifth century or earlier. He tells how the hostage of Dichu was starved and ill-treated by his detainer, and of his liberation by St. Patrick. The saint then placed the broken chains, as a remembrance, "one in a place at Down, where now is erected the church of St. Patrick; and the other on a neighbouring mote (monticulus) surrounded by a marsh of the sea," which was still called in Jocelin's day, Dun da leathglas.[2] Seeing how hastily made and easily destroyed were the motes of Slane and Trim; how the Roscrea mote was "run up" so hastily, that the leave of the Bishop of Killaloe, on whose lands it stood, could not be obtained before its completion[3] (though only thirty miles distant from his see); we cannot readily believe that even these motes were structures such as are found broadcast all over Eastern Ireland in and outside Norman territory, and rarely elsewhere even in the early English colonies.

In view of the continuance of "fort"-making, both of the stone caher and the ring mound with fosses, down to very late times, I am theoretically inclined to believe in the late construction of motes in

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[1] *Ibid.*, "Topog.," ch. xxxvii. and xxxviii.

[2] Jocelin's "Life of St. Patrick, chapter xxxvii.: "In loco ubi nunc in Dun ædificata est ecclesia S. Patricii . . . in monticulo vicino circumcluso palude pelagi . . . a catenis confractis vocabulum, scilicet Dun da leathglas, sortitus est." See also "Ecclesiastical Antiquities of Down, Connor, and Dromore," Dr. Reeves, 1847. Note that with Jocelin "rath" meant "rampart"; and "dun," "a mound or mote."

[3] C. S. P. I., vol. i., No. 2760.

Ireland. I do not deny that some of these motes may have been made by the Normans;[1] but the evidence is (so far as I have found in the records or on the field) non-existent in any save three cases, and these have left no trace. I merely show that the attempt to include Ireland in any theory requires local study and local knowledge, and that the "rule" laid down for Irish motes by some English antiquaries ought not to be held "proved by its exceptions," though the exceptions are endless.

The facts certainly show the necessity of great caution before theories founded on facts lying outside this island can be sweepingly applied to monuments within its shores, and accepted without further examination.

The "confusion" between sepulchral tumuli and motes also calls for further notice. In my paper (section 128) I wrote of simple motes, "It is very easy to confuse this form with tumuli; but the mistake is of less moment that certain defensive motes contain burials, and certain sepulchral motes have been adapted for fortification." This has naturally called forth criticism, which leads me to add a little to what appears above on p. 271. The "confusion" exists in the monuments themselves. We have some reputed sepulchral mounds girt with fosses and rings evidently for residence. The "mound" of Donaghpatrick, and that of Morristown Biller (so familiar to travellers from Dublin to Kildare), are round-topped[2]; but in each case we find a large, and evidently residential, entrenched annexe or "bailey." This, and the allusion in our history to the capture of Donaghpatrick, show that, even where the mote is not flat-topped, we cannot lightly declare it to be sepulchral. The mote of Magh Adhair is the traditional grave of a mythical Firbolg prince, the "rath," and eventually the mound of inauguration, of more historic chiefs. Here we have a complete confusion of tomb, residence, and thingmote in one earthwork. So far as I can find, there is no evidence for the existence of thingmotes at any Norse colony, except at Dublin. This being so, may not this latter mound have been an earlier fort used by the "Danes," or even a sepulchral tumulus, like those at Clontarf and other places round the city? In view of all this, I should have "darkened knowledge,"

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[1] The only cases I have collected where a recorded Norman castle stands near or at a mote, and at which no pre-Norman mention of a fortress is discoverable, amount to eight. I have twenty-seven early castle-sites from Giraldus, the Annals, and State Papers, where no record or traces of motes remain.

[2] So, however, are the defensive motes shown on the Bayeux Tapestry.

and started erroneous theories, had I ventured to distinguish between these structures, and to lay down boundaries where the old mearings were lost, as some would have had me to do.

One other objection is made—that I regard the forts of the Irish types over central Europe as the work of one (presumably Celtic) race. This is met by a passage in my paper overlooked by my critics (*loc. cit.*, p. 580):—"I use the term 'Celtic' as a mere symbol for the types prevailing in Ireland. Many forts of these types were most probably constructed by tribes to which even the loosest users of the term would never think of applying the word 'Celtic.'"

Addenda and Corrigenda.

I may add the following additions and corrections to my paper, giving first the page of Transactions, then (in brackets) that of the reprint:—

Page 593 (15). As Duncriffin appears to have been near the sea, but on the side of Howth, next Meath, it was more probably the destroyed fort near the martello tower, above the harbour, than the "Dun Hill," and was certainly not the promontory fort at the Bailey, which bears its name on the Ordnance Survey.

Page 618 (40), page 678 (100). The wall of Grimspound is 10, not 20, feet thick; and the well is, I am told, merely the inflow of a stream.

Page 620, note (42). For "Doronman" read "Downman."

Page 626, note (48). For "902" read "802."

Page 642, note (64). The description of this monument has since been published by Mr. P. Lynch in "Journal Royal Society Antiquaries, Ireland, vol. xxxii., pp. 330-332.

Page 644 (66). Add the Island Killeen, County Waterford, as containing an ogham-inscribed pillar of a descendant of NetaSegamon.

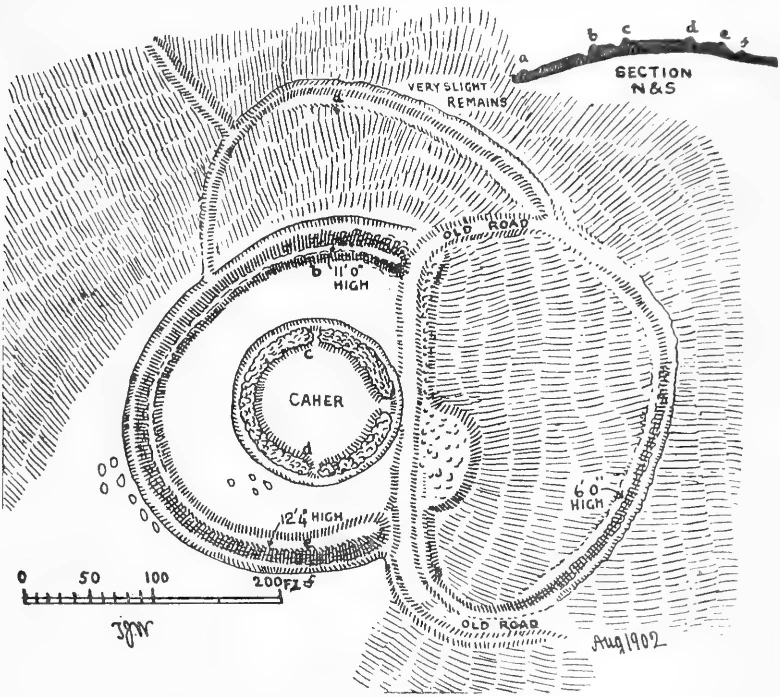
Page 648 (70). The fort of Langough is now thickly overgrown; and long reaches of the foundations cannot now be traced.

Page 693 (115). Add to section 85. The great stone fort of Oughtmama, on the hill south of Corcomroe Abbey, Clare, is over 700 feet across.

Page 696 (118), and opposite page after "Dunconor," for "Inishere," read "Inishmaan."

Page 698 (120). Add to section 96: "Middens in Cashlaun Gar and Cahercommaun have since yielded bones of deer and oxen, and (in the latter) iron fragments."

Page 701 (123). Kilbradran. The fort is stone-faced, 100 feet in diameter, with curved annexes to the north, west, and south-east; of these the western is the chief, with a deep fosse and earth-works, 6 to 11 feet high, and is 50 to 70 feet across its "half-moon" girth. The north annexe is much defaced, 118 feet across, with fosse and earthworks, 5 feet high. The eastern annexe is nearly levelled; two ancient roads wind round it to the central caher; it is 187 feet



The fort of Kilbradran, County Limerick.

across, and its earthwork is rarely over 4 or 5 feet high, the fosse being nearly filled up.

Page 704 (126). Add to the promontory forts of Waterford, "Island Hubbock 'entrenchment.' It has two deep fosses and a mound, and is on a sheer headland."

Page 705 (127). Add to "descriptions" of Dunnamoe that by Rev. Cæsar Otway, in "Erris and Tirawley (1841)," p. 67.

Page 708 (130). Add to the simple motes—"*Limerick*, Shanid Castle (O. S. 19)."

Page 711 (133). Skirk or Skeirk is placed by mistake among the simple motes. The mount is 16 feet 6 inches high, and 43 feet across the top; the annexe is 5 feet high, and 160 feet by 220 feet; the fosse 12 to 14 feet wide; one of the pillar-stones is still standing.

Page 713 (135), line 1. For "within the circuit" read "about the circuit."

Page 717 (139). Section 156, for "ancient forts" read "ancient roads"; and add, "The view is most probable in the lines in Kerry, Limerick, and Waterford." The above misprint took place after the proofs had left my hands; and it completely reverses the meaning of the whole paragraph.

In section 158, Mercator shows the "Raduffe" as having a central mound, with a fosse on each side.

Fig. 1.

Fig. 2.

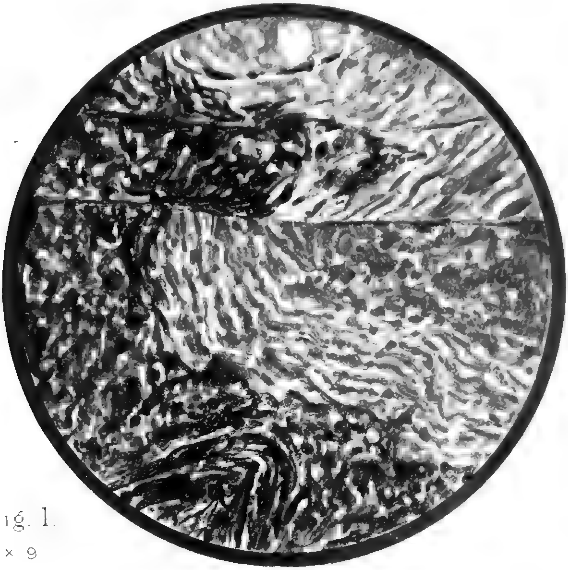


Fig. 1.
× 9

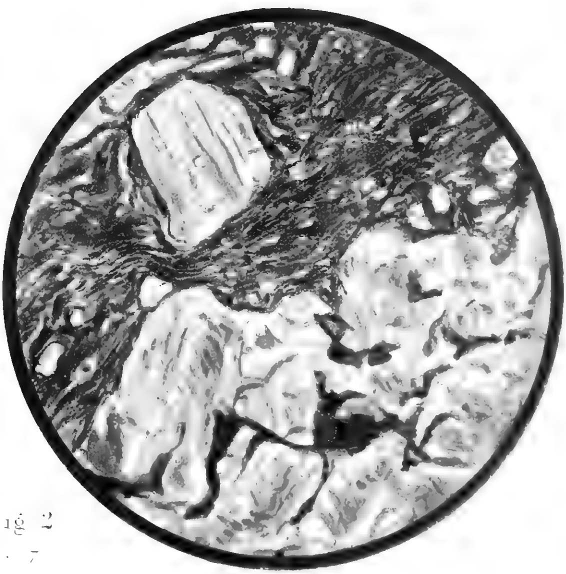
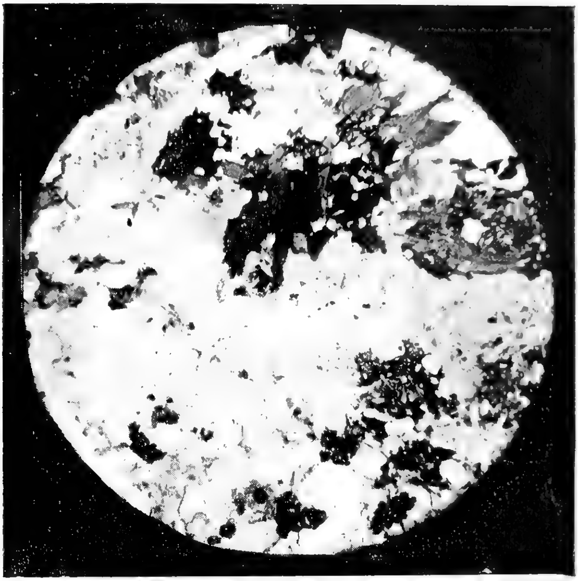


Fig. 2
× 7

G. A. J. Cole, del.



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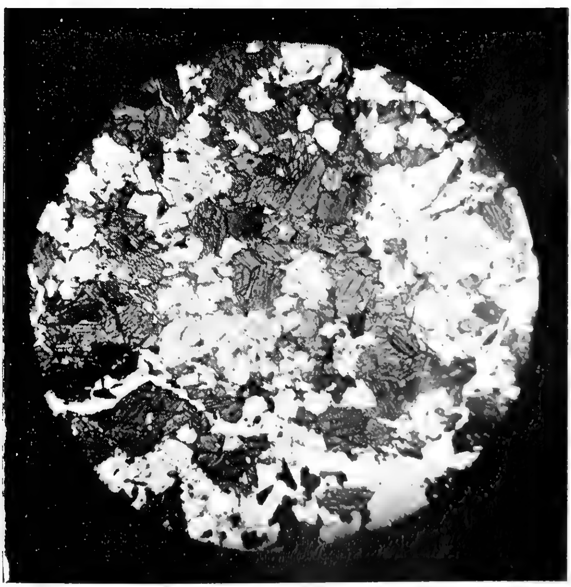

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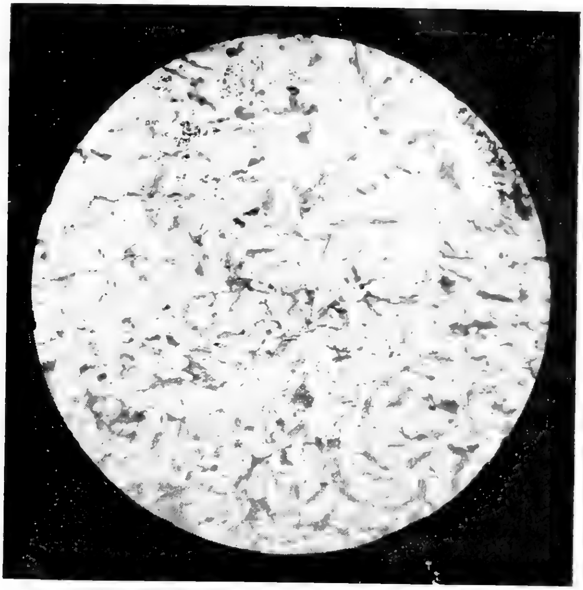

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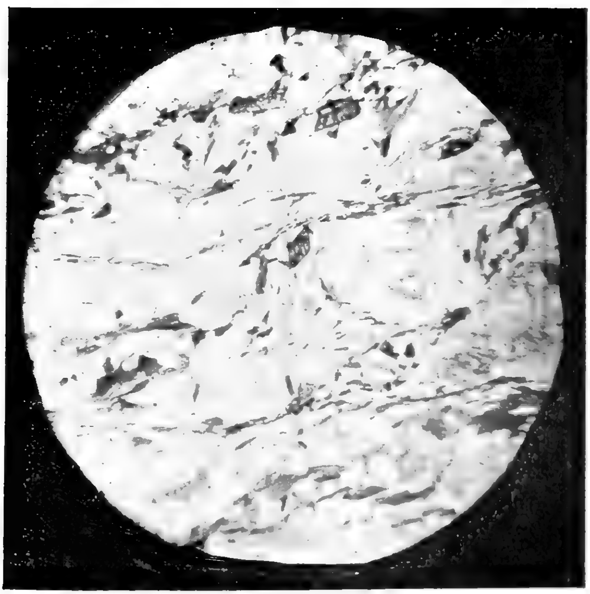

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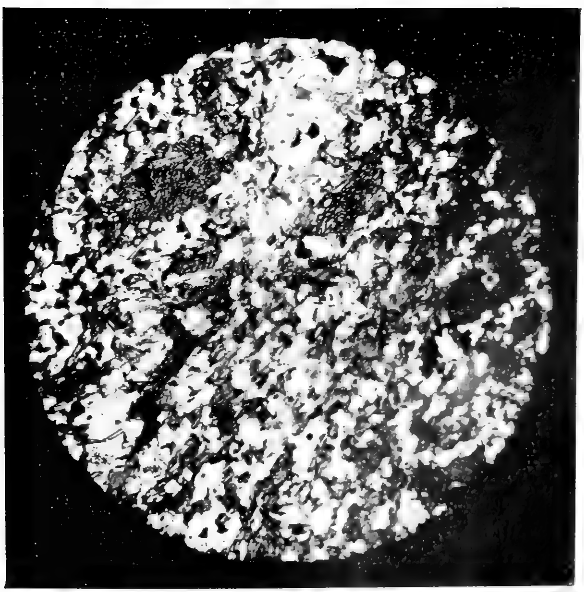

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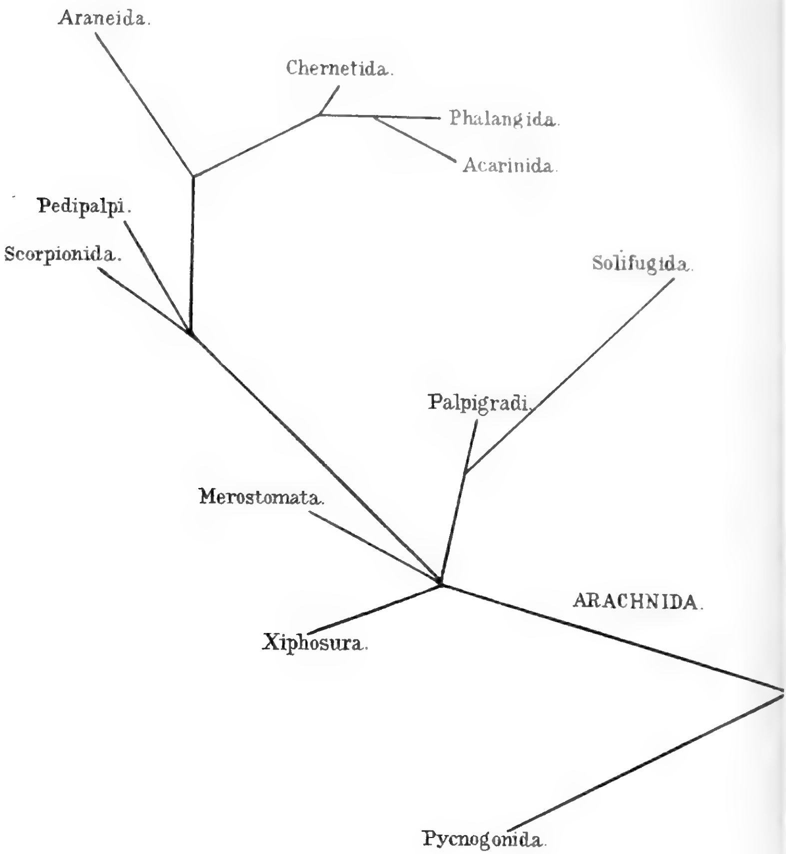
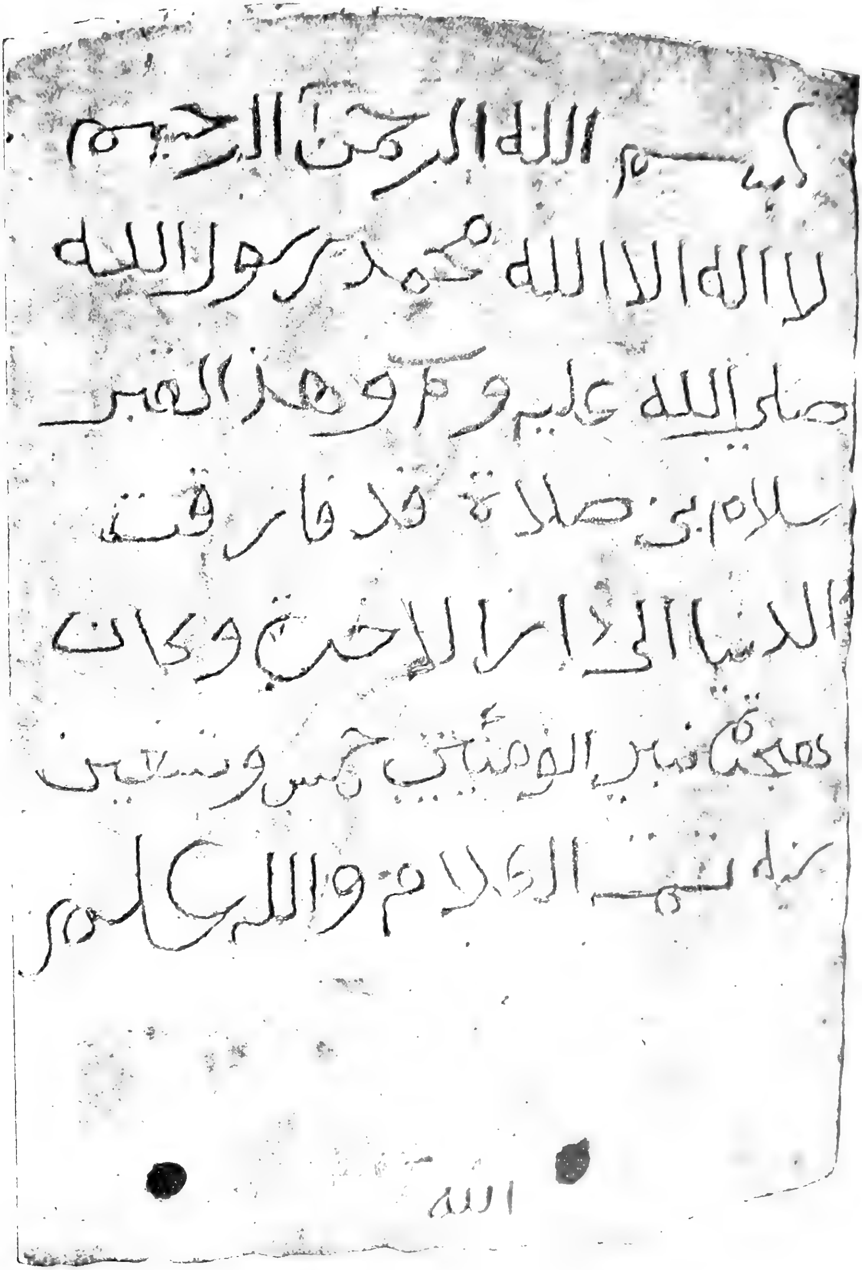
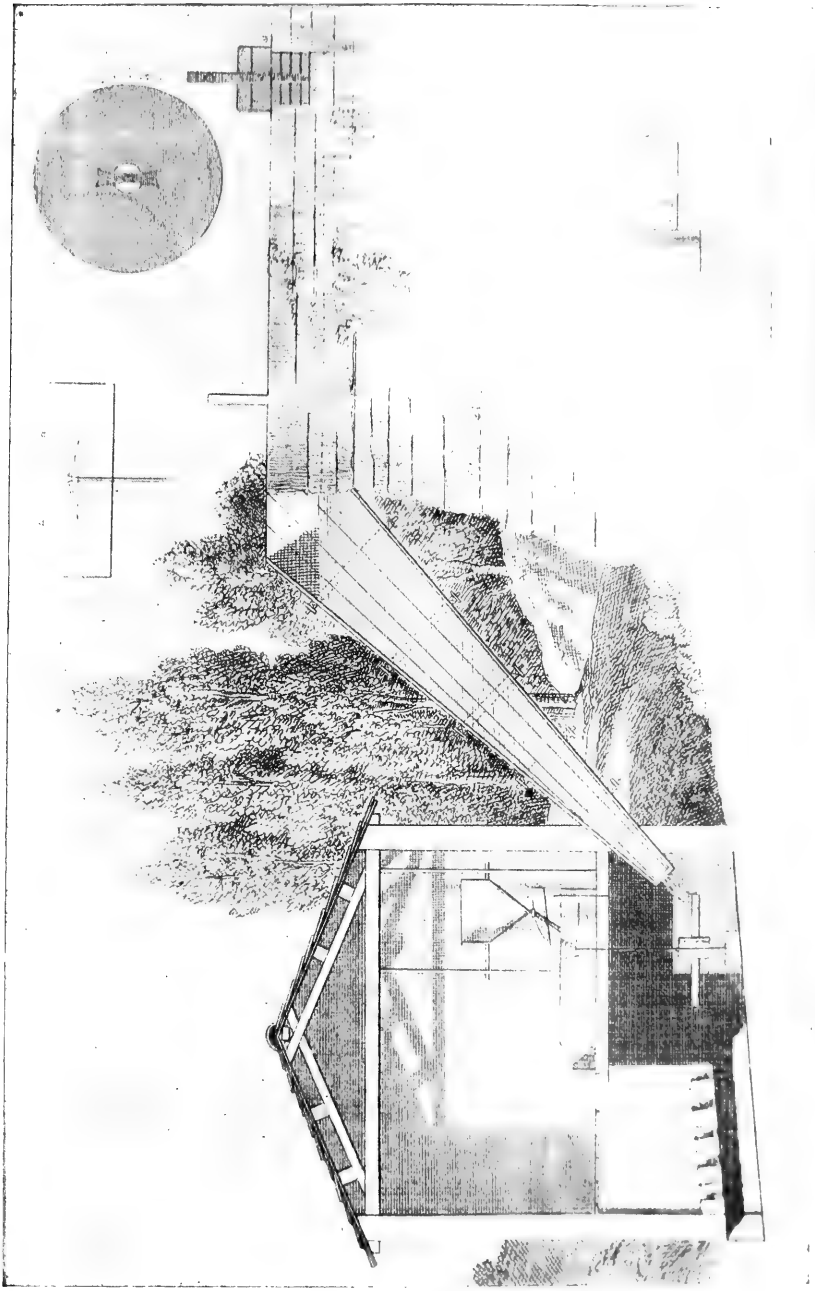


Suggested Relationships between the Arthropod Classes and their principal Orders.

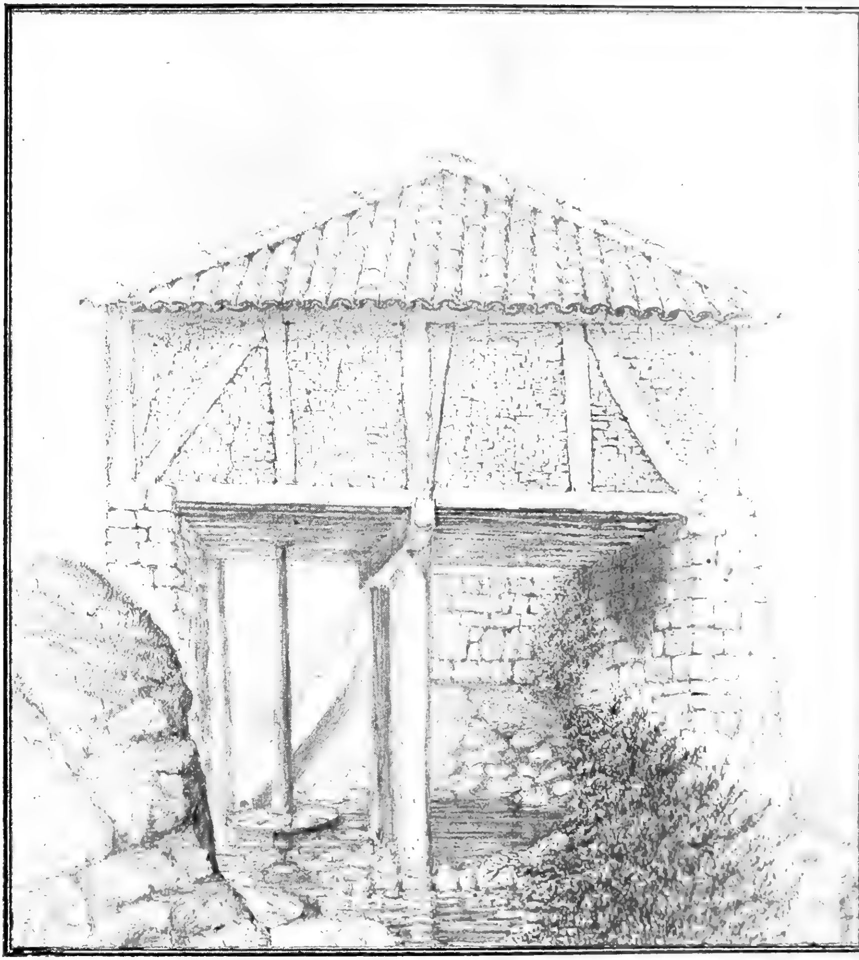


ARABIC INSCRIPTION FROM RHODESIA.

Dated A.H. 95 (A.D. 713–4).



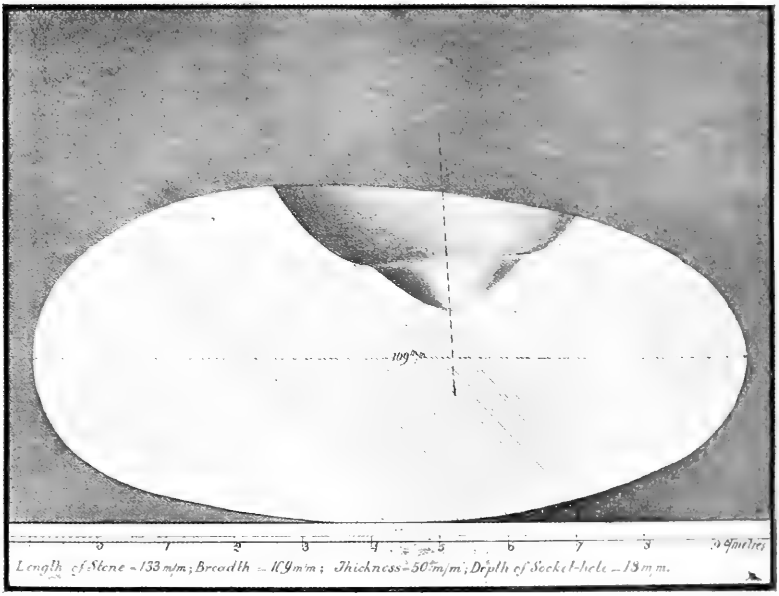
Horizontal Water-mill, Lampsaki, Dardanelles.
(Castellan, *Lettres sur Constantinople, &c.*, 1808, p. 95).



J. P. O'Reilly.

Water-mill with Horizontal Wheel.

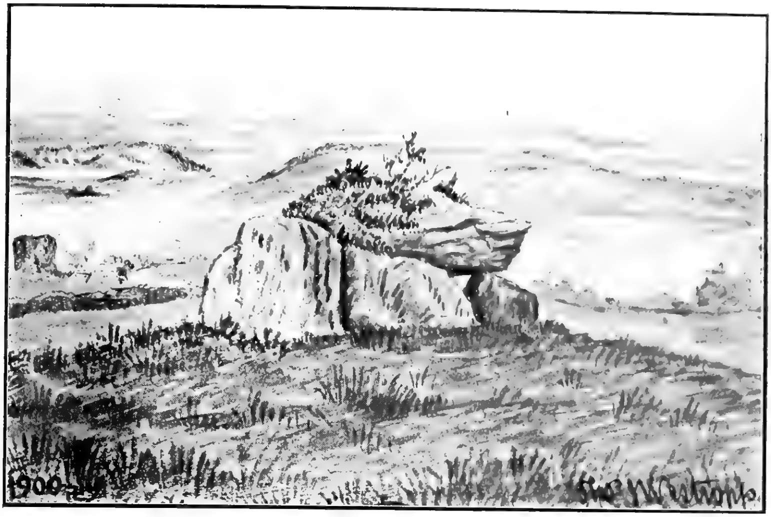
Two miles W. of Comillas, Province of Santander, N. Spain, 1859-60.



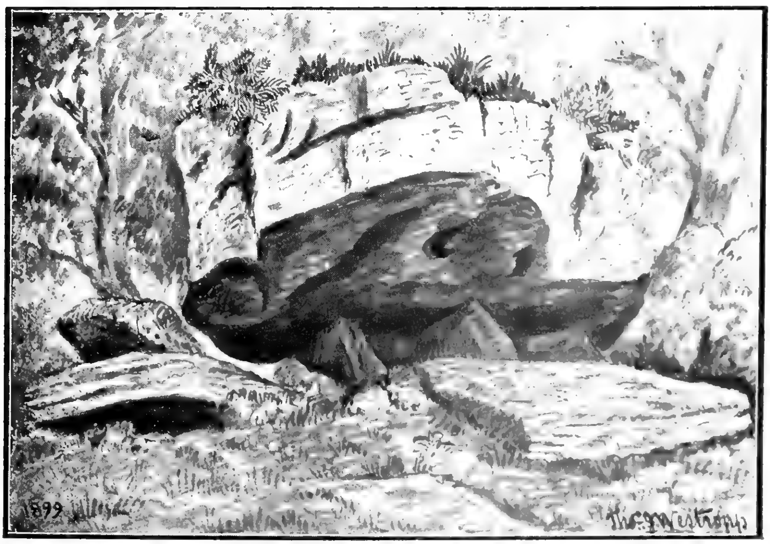
SOCKET-STONE OF AN IRISH HORIZONTAL WATER-WHEEL.

1. Caheraphuca, Crusheen.

2. Knocknafearbreaga, Clooney.

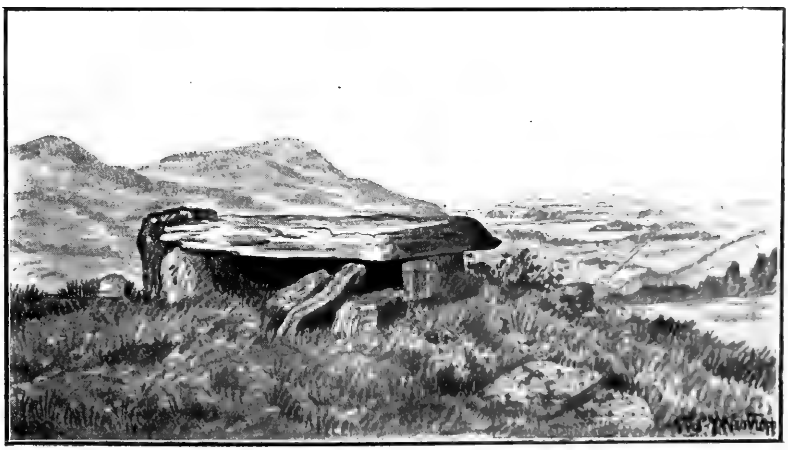


1. Knocknalappa, Sixmilebridge.

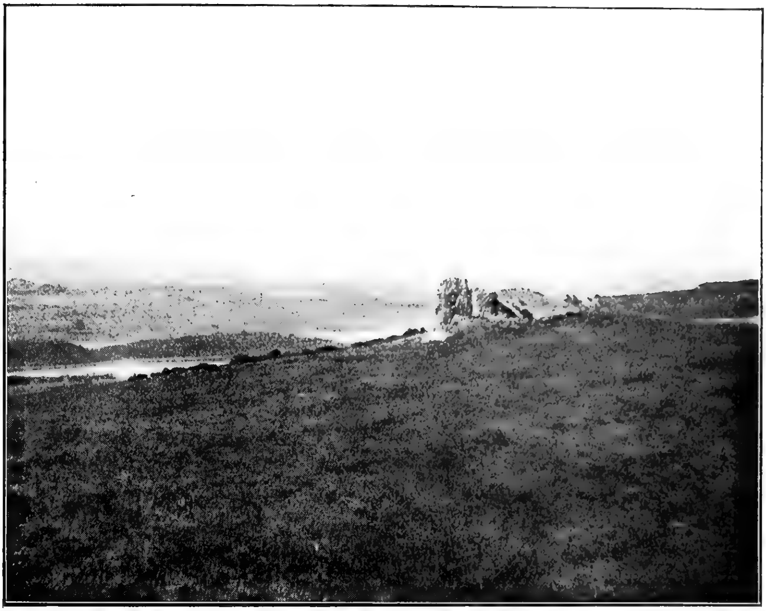


2. Derrymore, Tulla.

1. Cappaghbane, Scariff.



2. Cloonyconrymore, Broadford.

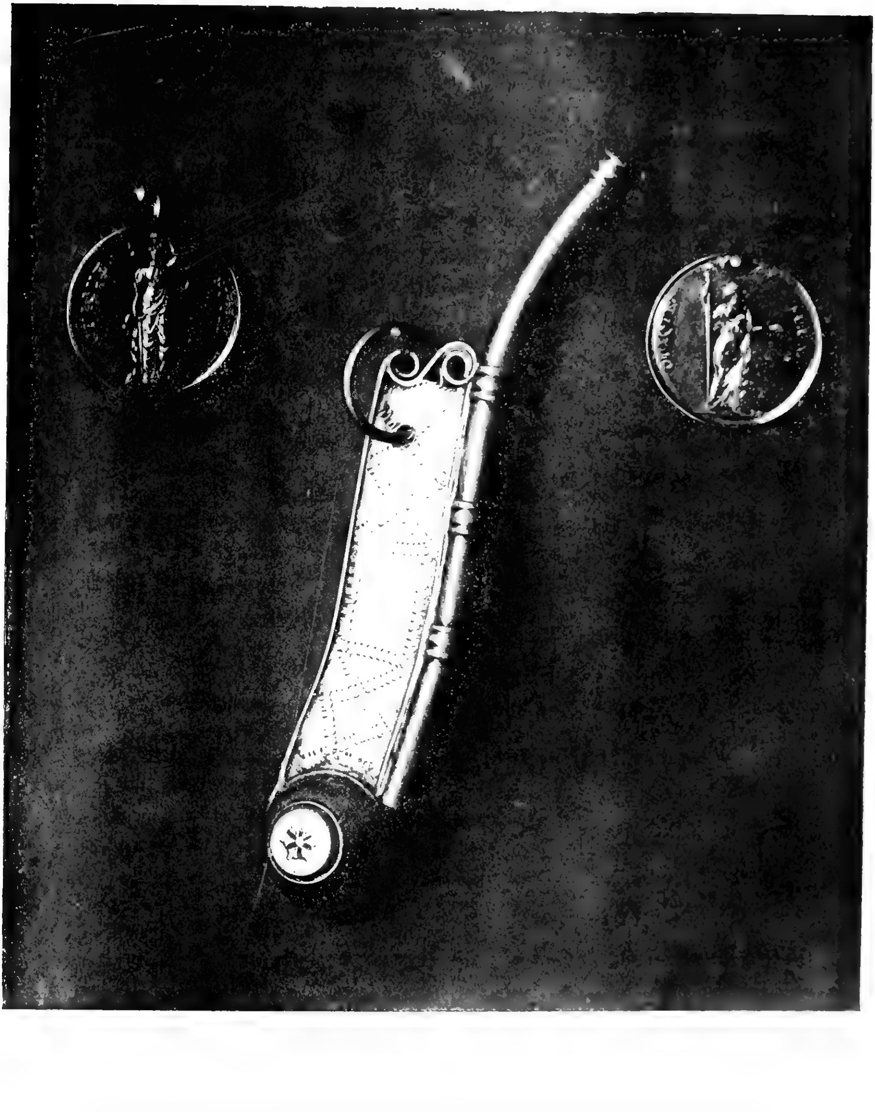


1. Ballykelly, Broadford.

2. Knockshanvo, Broadford.

Glass Loving-cup of Ouzel Galley Society.

Glass Loving-cup of Ouzel Galley Society.



Boatswain's Whistle and Reverse of Medals of Ouzel Galley Society.

Boatswain's Whistle and Obverse of Medals of Ouzel Galley Society.

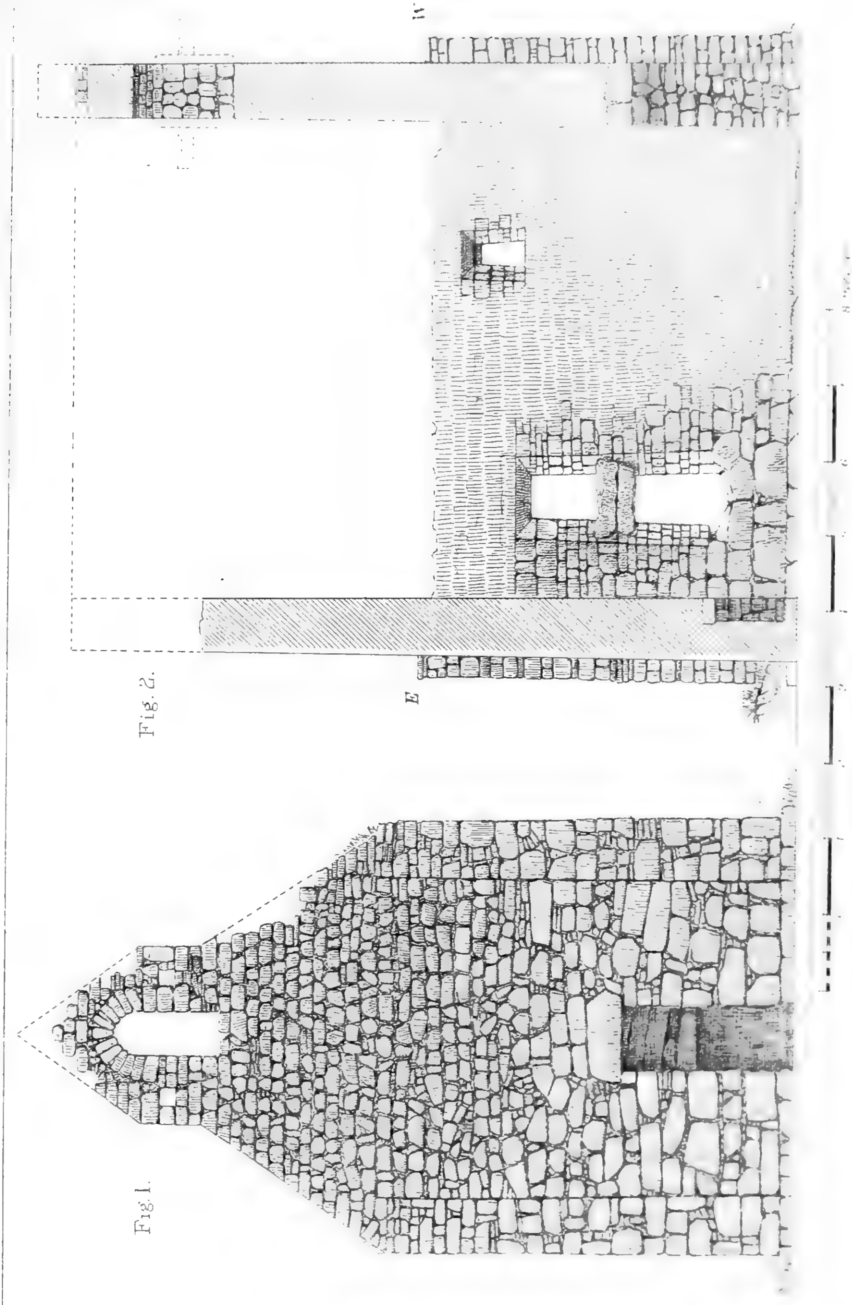
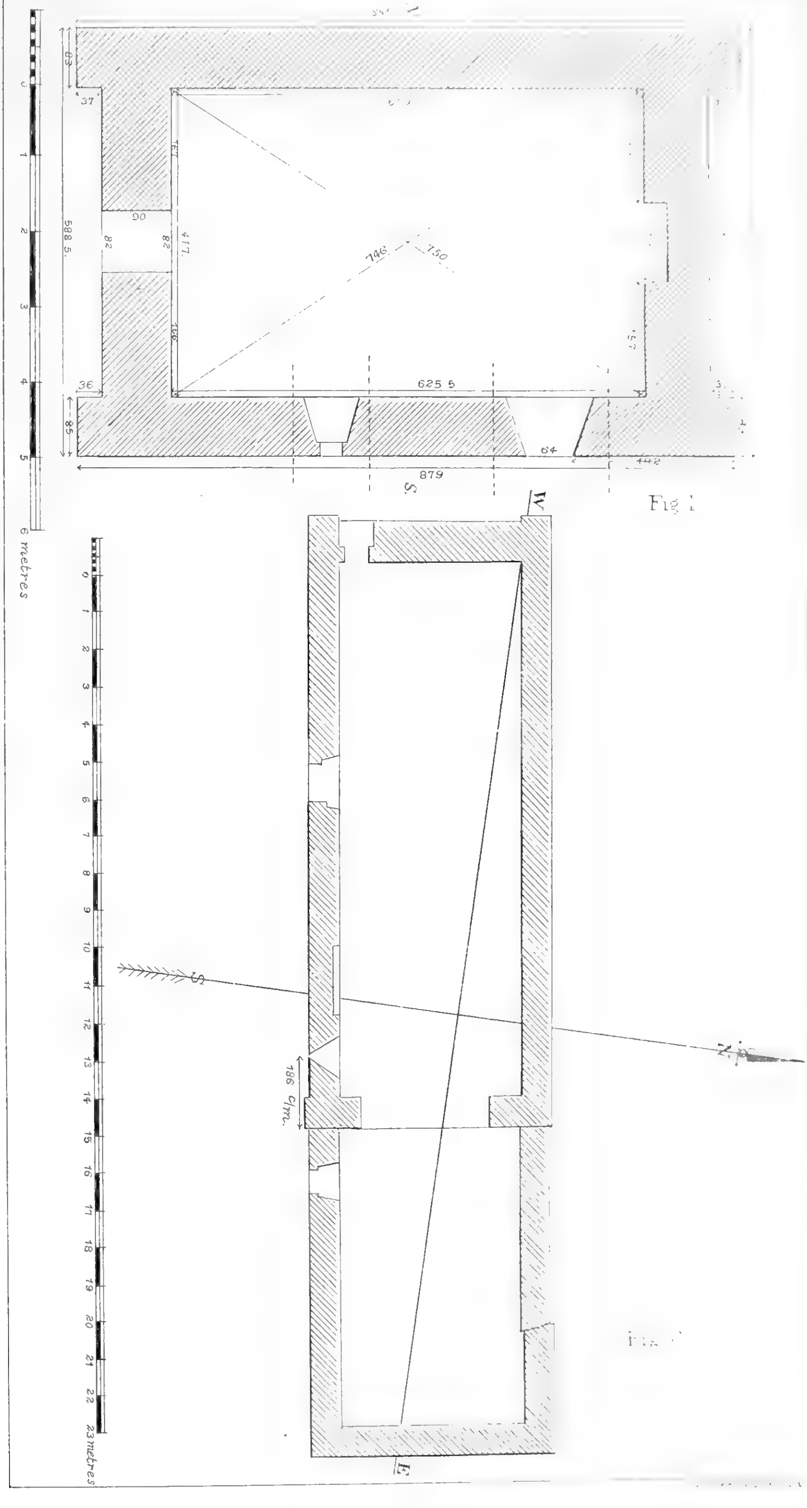


Fig. 2.

Fig. 1.



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90
588 5.
82
82
417
746
750
36
625 5
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64
879
442
S.
Fig. 1
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S
N
E
23 metres

Fig. 2.

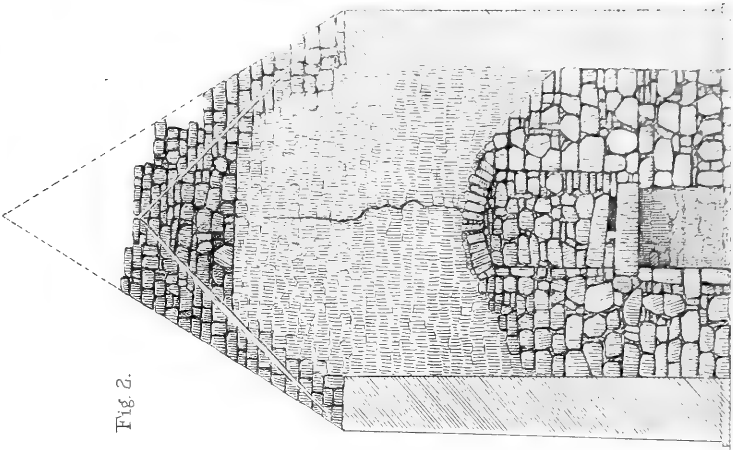
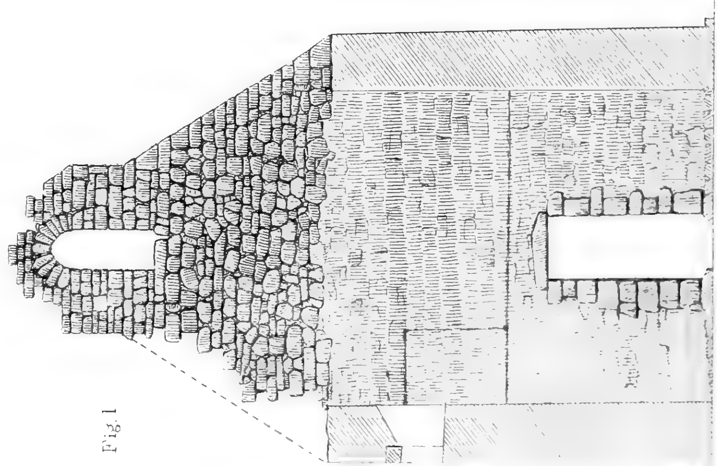


Fig. 1



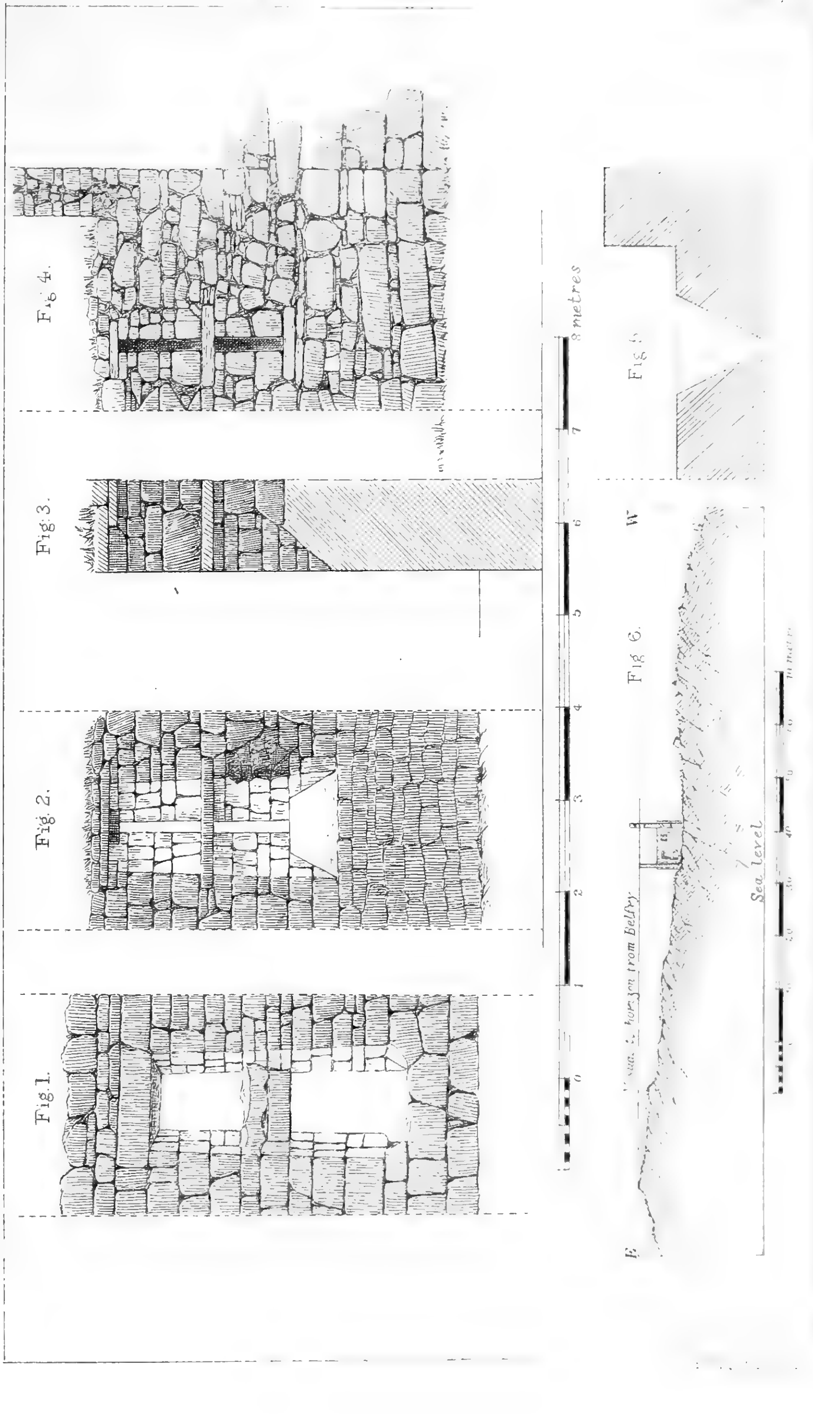


Fig 4.
Fig 3.
Fig 2.
Fig 1.
8 metres
Fig 5
W
Fig 6.
Sea level
E

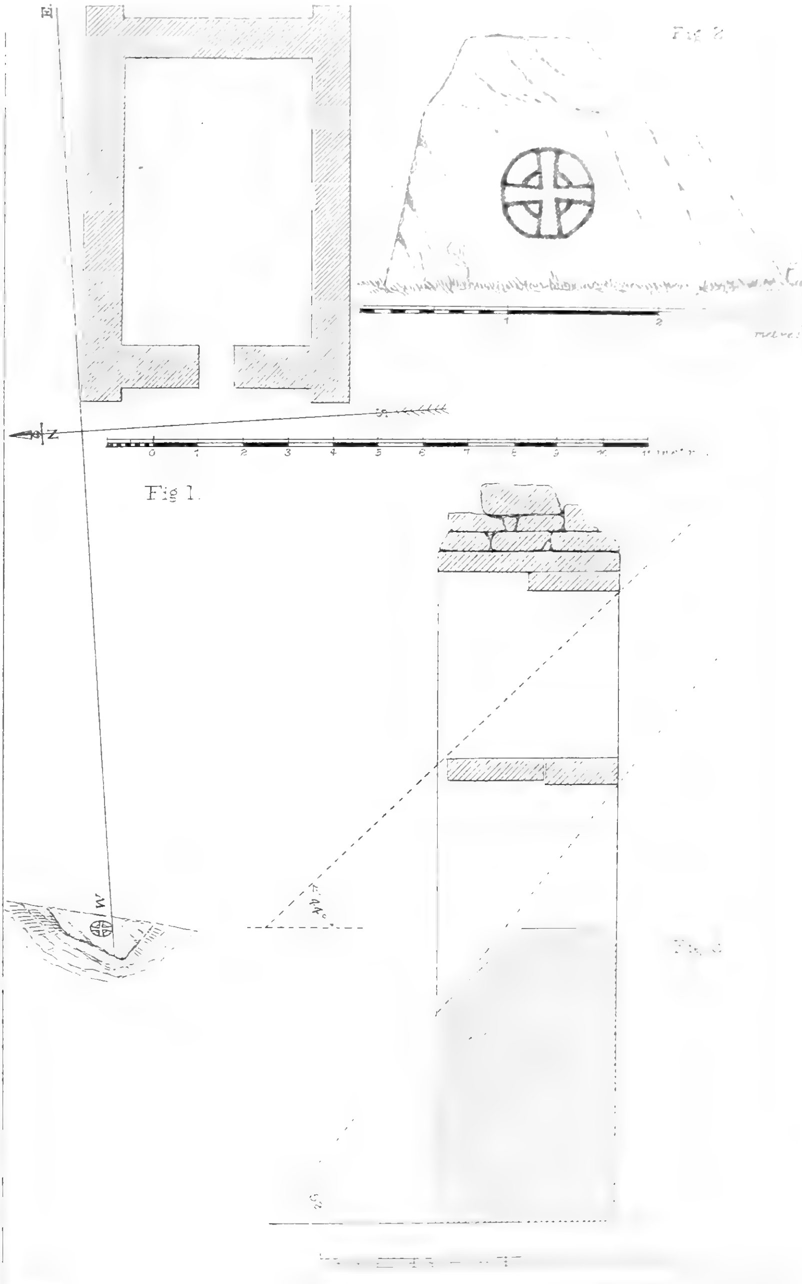


Fig 2
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7
8
9
10
Fig 1.
W
44°

LA TÈNE MONUMENTS.—The Turoe Stone.

Fig. 1.

Fig. 2.

LA TÈNE MONUMENTS. -The Turoe Stone.

Fig. 1.

Fig. 2.

LA TÈNE MONUMENTS. The Turoe Stone.

Fig. 1.—Top of Turoe Stone.

Fig 2.

Figs. 2 and 3.—The Castlestrange Stone.

LA TÈNE MONUMENTS.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

LA TÈNE MONUMENTS.—The Mullaghmast Stone.

AUGUST.] [1902.

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