TRANSACTIONS

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OF THE

PERTHSHIRE SOCIETY OF NATURAL SCIENCE.

I.—*Note on a Rare Myxomycete.*

BY JAMES MENZIES.

(Read 8th November, 1918.)

LINBLADIA EFFUSA ROST.

I found a group of this curious looking species during the past autumn on an old sawdust heap at Kinfauns. The largest of the group was seven of eight inches long by about four broad, the Plasmodium presenting the appearance of a mass of tar poured out on the sawdust, the surface rough and reflecting the light. This black mass was seated on a tough hypothallus by which it could be moved without apparent injury. Visiting the spot a month later I found the sporangia closely compacted together, brownish in colour, and breaking up into a dusty mass when handled. By the end of October they were greatly disorganised and, in some instances, the hypothallus bore a crop of Stilbum orbiculare B. and Br.

There is no record of Linbladia effusa having been found previously in Perthshire. In Stevenson's Mycologia Scotica it is only mentioned as having been found at Aboyne by the late Rev. James Keith.

II.—*A List of the Discomycetes of Perthshire.*

By JAMES MENZIES.

(Read 11th April, 1919.)

In the following list we have attempted to bring together all the species of Discomycetes which have been found or recorded as occurring in the county.

For a number of years Mr. Charles M'Intosh of Inver and myself have devoted special attention to these fungi, and I have on several occasions contributed to the Transactions of the Society an account of my discoveries in the neighbourhood of Perth. Previous to this nearly all records of these fungi occurring in Perthshire was the work of Dr. Buchanan White. In the year 1880, Dr. White published in the "Scottish Naturalist" (vol 5) his Preliminary List of Perthshire Fungi, which included about one hundred Discomycetes with the localities where they were found.

Ten years later Professor James Trail of Aberdeen published in Vol. 10 of the "Scottish Naturalist" a revision of the Scottish Discomycetes, and an additional contribution was made to this list by Dr. White. As this list is arranged according to River Basin Areas no particular locality is usually given.

In the present list all these previous records are noted. In all instances when the plant has been re-discovered the new record will take precedence. Those from the Preliminary List are marked P.L., and if deemed rare the locality given those from Professor Trail's list are marked, Rev. of Scots. Disco. Tay. Unless otherwise stated all records from the Dunkeld district are the work of Mr. Charles M'Intosh, all of which I have been privileged to examine. Those from the Perth district and various parts of the county have been found by myself. New species discovered or species not hitherto found in Britain have been recorded and described in the Transactions of the British Mycological Society and these records are here referred to.

The nomenclature and arrangement is that given by Boudier in his "Histoire et Classification des Discomycetes de Europe" as set forth by Mr. J. Ramsbottom, M.A., F.L.S. in the Transactions of the British Mycological Society. My thanks are due to Mr. Carleton Rea, B.C.L., M.A., for much kindly help in the identification of the species. I am also indebted to Mons. E. Boudier for his kindness in dealing with a number of the more critical ones.

Operculeae.

Morchellacea.

MORCHELLA, Dill.

M. vulgaris (Pers.), Boud.
P.L. as M. esculenta. Inver and Invermay. On the ground.

Helvellaceae.

PHYSOMITRA.

P. esculenta (Pers.), Boud.
Balgarvie, Murthly, Dunkeld, Falls of Moness, Crieff. J. W. Kippen, Ardblair; A. Gray. P.L. From various parts of the County. On the ground, often about old stumps.

HELVELLA, Linn.

H. crispa (Scop), Fr.
Not uncommon on bare or grassy ground in woods, also on road scrapings and scourings of ditches. P.L.

H. lacunosa, Afz.
Occurs under the same conditions as the previous species, although not quite so common. P.L. Rannoch.

LEPTOPODIA, Boud.

L. elastica (Bull), Boud.
Kinnoull, Bonhard, and Almond Mouth. P.L. Moncrieff. On the ground in woods.

L. pulla (Holmsk).
Scone Woods, on the ground.

Pezizaceae.

ACETABULA, Fuck.

A. vulgaris, Fuck.
P.L. Glen Tilt, on the ground.

A. ancilis (Pers.), Boud.
Kinfauns, Murrayshall, and Scone. Occurs at Dunkeld. On the ground about pine stumps and in old sawdust heaps.

MACROPODIA, Fuck.

M. Macropus (Pers.), Fuck.
Not uncommon. P.L. from various localities. On the ground.

Rhizina, Fr.

R. inflata (Schaeff), Karst.

Not infrequent on burned ground near pine stumps. Rev. of Scots. Disco. Tay.

Disciotis, Boud.

D. venosa (Pers.), Boud.

P.L. Banks of the Almond.

Var. reticulata Grev.

Near Almond mouth, amongst Petasites vulgaris. Aberdalgie, on grassy ground.

Aleuria, Fr.

A. vesiculosa (Bull), Boud.

Frequent on dung heaps and rich soil. Rev. of Scots. Disco. Tay.

A. cerea (Low), Gill. Rev. of Scots. Disco. Tay.

A. repanda (Pers.), Gill.

Kinnoull, Scone, and Alyth. On the ground under beeches. Rev. of Scots. Disco. Tay.

A. sterigmatizans (Phill), Boud.

Muirward of Scone. On bare damp soil.

A. subrepanda (Cook et Phill), Boud.

Tullymet, on road scrapings. C.M. and I.M.

A. sepiatra (Cook), Boud.

Not infrequent near Perth. On damp soil and road scrapings. Occurs at Dunkeld.

A. violacea (Pers.), Gill.

Occurs about Perth on clay banks. More frequent on char heaps. Dunkeld on char.

A. umbrina, Boud.

Dunkeld on char heaps.

Galactinia, Cook.

G. badia (Pers.), Boud.

Common on damp bare soil. Occurs in almost incredible profusion around the wooded margin of Methven Bog. P.L.

G. succosa (Berk), Sacc.

Scone, Kinnoull and Alyth. On bare heavy soil and road scrapings.

G. pustulata (Hedw), Boud.

Not infrequent about Perth on char heaps.

G. Phillipsii (Cook), Boud.

Quarrymill, several seasons. On damp sandy soil.

PLICARIA, Fuck.

P. leiocarpa (Curr), Boud.
Kinfauns, Scone, Muirward of Lethendy. On char heaps. Occurs at Inver on char.

P. trachycarpa (Curr), Boud.
Kinnoull, Scone, and Inver. On char heaps and burnt ground.

P. Persoonii (Cr.), Boud.
Not uncommon in the neighbourhood of Perth. On clay banks, in quarries, and shady situations.

PACHYELLA, Boud.

P. depressa (Phill), Boud. Humaria Oocardii Sacc.
Not uncommon in the smaller streams near Perth. At Methven Bog, Craighall, and the Alyth Burn. On sodden wood.

OTIDEA, Pers.

O. onotica (Pers.), Fuck.
Distributed. P.L. from various parts of the county. On the ground in woods.

O. leporina Batsch (Fuck).
Not uncommon. P.L. Rossie Priory. On the ground in woods.

O. cochleata (Linn), Fuck.
Not uncommon. P.L.

O. phlebophora, B. et Br.
Scone. On the ground by the side of the high road.

PUSTULARIA, Fuck.

P. cupularis (Linn), Fuck.
Bonhard, Scone, and Quarrymill. P.L. Moncrieff. On damp soil in woods and ditches.

P. patavina (Cook et Sacc), Boud.
Kinfauns. On char and burnt ground. New to Britain. Trans of Brit. Mycol. Soc., vol.4, p. 194.

GEOPYXIS, Pers.

G. carbonaria (Alb. et Schw), Sacc.
Not uncommon about Dunkeld and Perth. On old char heaps.

PEZIZA, Dill.

P. aurantia (Pers.).
Common. P.L. from various localities. About old stumps and saw-dust pits; also on damp clay soil.

P. luculenta (Cook), Bonhard.
P.L. Inver. On the ground.
P. rutilans, Fr.
Kinfauns, Scone, Pitlochry, and Blair Athol. P.L. Rannoch. On the ground with species of Polytrichum moss.
Var. vivida Nyl.
Campsie Linn. On soft sandy soil with Polytrichum moss. P.L. as Peziza vivida, Rannoch.

SARCOSCYPHA, Fr.

S. coccinea Iacq, Fr.
Glenalmond. A. S. Reid. On oak sticks. Rev. of Scots. Disco. Tay.

LEUCOSCYPHA, Boud.

L. nivea (Rommell), Boud.
Banks of the Farg, near Barley Mill. On bare clay soil in deep shade.

TRICHARIA, Boud.

T. gilva, Boud.
Gannochy, on clay. Scone, on road scrapings. Dunkeld, on an accumulation of rubbish in a field horse stall.
T. cretea (Cook), Boud.
Kinfauns, Dunkeld ,and Cairnies. On char heaps.

LACHNEA, Fr.

L. hemispherica (Wigg) Gill.
Not infrequent near Perth, on damp bare soil under oak trees. Pitlochry and Alyth, on road scrapings under oaks. P.L. Moncrieff.
L. cirmabarina (Schwein), Mass et Crossl.
Scone, on the scourings of a ditch. Dunkeld, on sandy soil.

SEPULTARIA, Fr.

S. foliacea (Schaeff), Boud.
Quarrymill, Muirward of Scone, and Buckie Braes. On damp sandy soil with the finer mosses. New to Britain. Trans. of the Brit. Mycol. Society, vol. 4, p. 195.

Humariaceae.

TRICHOPHAEA, Boud.

T. gregaria (Rehm), Boud.
The Hermitage, Dunkeld. Not uncommon in the neigh-

bourhood of Perth, Glenfarg, and Gask. On bare heavy soil.

T. Woolhopcia (Cook et Phill), Boud.
Quarrymill, Bonhard, Cherrybank, and Dunning. On bare heavy soil, rarely on burnt ground or char.

DESMAZIERELLA, Lib.

D. acicola, Lib.
Kinfauns and Inver. On the leaves of fallen or cut branches of Pinus sylvestris.

CILIARIA, Quell.

C. scutellata (Linn), Quell.
Common. On damp soil and rotten wood. P.L.

C. umbrata (Fr.), Quell.
Old Scone road on heaps of road scrapings.

C. umbrorum (Fr.), Boud.
Frequent near Perth. On damp soil and road scrapings. Occurs at Dunkeld.

C. hirta (Schum), Boud.
Scone, Kinfauns, and Cherrybank. P.L. Moncrieff. On damp soil.

C. setosa (Nees), Boud.
Not uncommon near Perth. On fallen trunks and stumps. Dunkeld on saw-dust.

C. brunnea (Alb. et Schw.), Boud.
Scone. On old char heaps.

C. trichispora (B. et Br.), Boud.
Not uncommon near Perth, Methven Wood, and Glenfarg. P.L. Moncrieff and Craighall. On damp clay soil.

C. confusa (Cook), Boud.
Falls of Tummel, Dunkeld, Scone and Kinnoull. On char heaps amongst Funaria hygrometrica.

C. Phillipsii (Mass.), Boud.
Kinfauns two seasons in succession. On the fine ash of a char heap.

CHEILYMENIA, Boud.

C. theleboloides (Alb. et Schw.), Boud.
Whinnymuir and Muirton. On heaps of town's refuse carted to the fields. Rev. of Scots. Disco. Tay.

C. subhirsuta (Schum), Boud.
Inver on sandy soil.

C. dalmeniensis (Cook), Boud.
Not rare near Perth, Methven Woods, Glenfarg, Dunkeld, Moulin, and Alyth. On damp soil amongst nettles.

C. stercorea (Pers.), Boud.

Not uncommon on horse and cow dung in shady pastures. Rev. of Scots. Disco. Tay.

C. coprinaria (Cook) Boud.

Parkfield hill pastures, several seasons. A small form of this species occurring on rabbit dung in spring, is not uncommon near Perth and at Dunkeld. Rev. of Scots. Disco. Tay, Rannoch.

C. ascoboloides (Bert.), Boud.

Muirhall, on the ground where manure had lain.

MELASTIZA, Boud.

M. miniata (Fuck), Boud.

Scone, on road scrapings. Appeared in extraordinary profusion at Inver, on sandy soil, August, 1917.

ANTHRACOBIA, Fr.

A. nitida, Boud.

Kinfauns, on the fine ash of a char heap. New to Britain. Trans. of the Brit. Mycol. Soc., vol. 4, p. 196. This species has now been found to be of common occurence in Perthshire.

A. maurilabra (Cook), Boud.

Not infrequent and often accompanying the previous species, on the char heaps.

HUMARIA, Fr.

H. Humosa (Fr.), Sacc.

Kinfauns, Campsie Linn, and Alyth. On the ground amongst moss. Rev. of Scots. Disco. Tay.

H. fusispora (Berk.), Sacc.

Rev. of Scots. Disco. Tay.

H. aggregata (B. et Br.), Sacc.

Rev. of Scots. Disco. Tay.

H. Roumegueri (Karst), Sacc.

Kinnoull and Kinfauns. On mossy ground. Var., carnosissima Phill—Dunkeld, on old bleached cow dung and other dead vegetable matter.

H. convexula (Pers.), Quell.

Muirward of Lethendy. On sandy soil amongst moss.

H. semimmersa (Karst), Sacc.

Parkfield and Inver. On old cow dung.

H. leucoloma (Hedw.), Sacc.

Kinfauns and Pitlochry. On sandy or moorish soil amongst moss.

H. pilifera (Cook), Sacc.

Scone, and at the Hermitage, Dunkeld. On old char heaps.

H. rubens, Boud.

Not uncommon on the Sidlaws, on the ground sometimes amongst moss. Muirward of Lethendy and Inver, amongst char.

H. Wrightii (Berk et Cook), Boud.

Not infrequent near Perth on char heaps. Occurs at Dunkeld on char.

H. tetraspora (Fuck), Boud.

Muirward of Lethendy. On very old char heap amongst moss, August, 1917. New to Britain. Trans. of Brit. Mycol. Society, vol. 6, part 2, p. 62. Collected also by Mr. M'Intosh and myself on the Haughs at Ballinluig, August, 1913, on which occasion, however, we failed to identify the plant.

LAMPROSPORA, de Not.

L. miniata (Cr.), de Not.

Kinnoull and Campsie Linn. On sandy or moorish soil.

L. astroidea (Hazsb.), Boud.

Scone and Kinnoull. On bare soil.

L. modesta.

Not uncommon near Perth, Glen Lednock, and Dunning. On wet soil.

COPROBIA, Boud.

C. granulata (Bull.), Boud.

Not uncommon on cow dung in shady pastures. P.L.

PULVINULA, Boud.

P. cinnabarina (Fuck), Boud.

Kinfauns, on sandy soil amongs moss. Kinnoull, amongst soil atached to the roots of an upturned tree.

P. constellatio (Cook), Boud.

The Hermitage, Dunkeld, Cherrybank, and Kinfauns. On damp soil.

P. lecithina, Cook.

Not infrequent in the Annaty Burn on sodden wood.

P. myrothecioides (B. et Br.).

P.L. Craighall.

Ascobolaccaea.

ASCOBOLUS, Pers.

A. denudatus, Fr.

Quarrymill, on damp clay. Scone, on road scrapings.

A. Crouani, Boud.

Dunkeld, on sodden paper. Kinfauns, on rotten wood.

A. stercorarius (Bull), Schroet.

Frequent on cow dung. P.L. Rannoch.

A. ærugineus, Fr.

Whinnymuir. P.L. Glenshee. On cow dung.

A. vinosus, Berk.

Not uncommon near Perth and Methven Woods. On rabbit dung.

A. viridulus, Phill et Plow.

Dunkeld, on grouse dung.

A. glaber, Pers.

Not infrequent on cow, sheep, and rabbit dung. P.L.

A. viridus, Curr.

Frequent near Perth and Glenfarg. On damp heavy soil.

A. atro-fuscus.

Kinfauns, Parkfield, Balgarvie, Stanley, and Glenfarg. Around the margins of burnt ground

A. Carletoni, Boud.

Dunkeld, on grouse dung. New species, Trans of Brit. Mycol. Soc., vol. 4, p.62.

A. crenulatus, Karsten.

Phillips, Brit. Disco., p. 292. P.L. Rannoch on grouse dung.

Dasyobolus, Sacc.

D. immersus (Pers.), Sacc.

Not uncommon on cow dung. P.L. as Ascobolus.

Sphaeridiobolus, Boud.

S. hyperboreus (Karst), Boud.

Var: niveus Quell. Parkfield, on hedge prunings cut green and gathered into heaps, undergoing a partial fermentation. First British specimens, Trans. Brit. Mycol. Soc. (Vol. 4, page 317). Found a little later at Dunkeld under the same conditions.

Saccobolus, Boud.

S. Kerverni (Cr.), Boud.

Dunkeld, on cow dung.

S. violascens, Boud.

Kinfauns and Parkfield, on rabbit dung.

Boudiera, Cook.

B. areolata, Cook et Phill.

Muirhall Quarry, on wet soil around the margin of the pool.

ASCOPHANUS, Boud.

A. carncus (Pers.), Boud.
Not uncommon amongst the refuse from the City carted to the fields. On cotton rags lying in damp places. Dunkeld, on horse dung.

A. hepaticus (Batsch.), Boud.
Kinnoull, Kinfauns, and Inver. On and amongst rabbit dung.

A. cervarius (Phill.), Boud.
Balgarvie, on rabbit dung.

A. testaceus (Moug.), Phill.
Whinnymuir, on feathers. Parkfield, on woollen cloth.

A. microsporus (B. et Br.), Phill.
Inver, on cow dung.

A. granuliformis (Cr.), Boud.
Not infrequent near Perth and Dunkeld, on cow dung.

A. argenteus (Curr), Boud.
P.L. Rannoch, as Ascobolus.

LASIOBOLUS, Sacc.

L. ciliatus (Berk.), Sacc.
P.L. Rannoch, as Ascobolus.

L. equineus (Mull.), Karst.
Frequent on dung of horses, cows, and sheep.

Var. pilosus, Fr.
P.L. Rannoch, as Ascobolus.

L. macrotrichus, Rea.
Dunkeld, on sheep dung.

RHYPAROBIUS, Boud.

R. albidus, Boud.
Parkfield, on twigs of Cytisus scoparius in a heap of prunings which had been cut green. First British specimens. Trans. Brit. Mycol. Soc. (Vol. 4, page 317).

R. crustaceus (Fuck), Rehm.
P.L. Rannoch, as Ascobolus Cookei.

R. dubius, Boud.
Dunkeld, on cow dung.

Var. lagopi, Boud.
Dunkeld, on grouse dung. New to Britain. Trans. of the Brit. Mycol. Soc. (Vol. 3, page 378).

Pyronemaceae.

PYRONEMA, Carus.

P. omphalodes (Bull.), Fuck.
Not infrequent near Perth, Dunkeld, and Pitlochry. On char heaps.

P. domesticum (Sow), Sacc.
Gannochy, on burned cabbage stalks.

Exoasceae.

TAPHRINA, Fr.

T. aurea (Pers.), Fr.
Not uncommon near Perth. Occurs at Dunkeld. On livng leaves of Populus.

EXOASCUS, Fuck.

E. Pruni, Fuck.
Dunkeld, on fruits of Prunus Padus. P.L. Glen Tilt and St. Fillans.

E. alnitorquus (Tul.), Sadeb.
P.L. Kinfauns, on leaves of Alnus glutinosus.

Inoperculeae.

Geoglossaceae.

TRICHOGLOSSUM, Boud.

T. hirsutum (Pers.) Boud.
Scone and Stanley, on the ground. P.L. Dunkeld.

GEOGLUSSUM, Pers.

G. glutinosum.
P.L. Dunkeld.

G. ophioglossoides.
Not uncommon. P.L. from various localities. In pastures and open grassy spots in woods.

G. difforme, Fr.
Kinnoull and Muirward of Scone. P.L. From various parts of the county. On the ground in woods and pastures.

LEPTOGLOSSUM, Cook.

L. tremellosum, Cook.
P.L. Rannoch.

MICROGLOSSUM, Gill.

M. viride (Pers.), Gill.
Scone, Kinnoull, and Inver. P.L. Falls of Lochay. On damp heavy soil in woods.

Leotiaceae.

SPATHULURIA, Pers.

S. clavata (Schaeff), Sacc.
Dunkeld. P.L. from various parts of the county. On the ground in woods.

MITRULA, Fr.

M. phalloides (Bull), Chev.
Not uncommon. On dead pine leaves in pools and ditches. P.L.

M. cucullata (Batsch), Fr.
Kinfauns and Kinnoull. On dead leaves of Pinus sylvestris.

M. sclerotipus, Boud.
Quarrymill, on boggy ground, amongst Chrysosplenium appostifolium. New to Britain. Trans. of the Brit. Mycol. Soc., vol. 3, p. 378.

LEOTIA, Hill.

L. lubrica (Scop), Pers.
Not uncommon. On the ground in woods. P.L.

CUDONIA, Fr.

C. circinans (Pers.), Fr.
Dunkeld, on the ground, amongst pine leaves. Rev. of Scots. Disco. Tay.

C. confusa, Bries.
The Hermitage, Dunkeld. In the vicinity of beech trees and Tsuga Canadensis. First British specimens. Trans. of the Brit. Mycol. Soc., vol. 1, p. 168.

CUDONIELLA, Sacc.

C. acicularis (Bull), Sohroet.
Inver Wood. On oak stumps amongst moss.

VIBRISSEA, Fr.

V. truncorum (Alb. et Schw.), Fr.
P.L. Ballinluig.

V. microscopia B. et Br.
P.L. Blackwood, Rannoch.

APOSTEMIDIUM, Karst.

A. Guernisaci (Cr.), Boud.
Not uncommon near Perth, Methven Bog, Pitlochry, Aberfeldy, and Alyth. On rotten wood in streams and ditches.

Ombrophilaceae.

OMBROPHILA, Fr.

O. clavus (A. et Schw.), Cook.
Not uncommon near Perth, and the Alyth Burn. On rotten wood in streams and ditches. Rev. of Scots. Disco. Tay.

O. faginea (Pers.), Boud.
Not uncommon about Dunkeld and Perth. On beech mast and twigs. Rev. of Scots. Disco. Tay.

O. alniella (Nyl.), Karst.
Kinfauns and Quarrymill. On female catkins of Alnus glutinosis lying in damp places.

O. imberbis (Bull), Boud.
Stormontfield, Scone, and Dunkeld. On dead wood.

O. Nigripes (Pers.), Boud.
Kinnoull, on dead leaves of Pinus sylvestris and Abies pectinata. First British specimens. Trans of the Brit. Mycol. Soc., vol. 4, page 197.

O. megalospora, Rea.
Dunkeld, on dead leaves of Carex in a stagnant pool. New species. Trans. of the Brit. Mycol. Soc., vol. 5, page 256.

Pachydisca, Boud.

P. ochracea (Grev.), Boud.
Quarrymill, on dead twigs of hawthorn and willow.

P. brunnea (Phill.), Boud.
Comrie, on dead stems of Carex ampullacea in a dried up pond.

P. scoparia (Cook), Boud.
Rev. of Scots. Disco. Tay. As Helotium.

P. marchantiæ (Berk.), Boud.
Scone and Muirward of Lethendy. On fading leaves of Marchantiæ polymorpha.

P. laburni (B. et Br.), Boud.
Dunkeld, Bonhard, and Almond mouth. On dead branches of Laburnum.

Calycella, Fr.

C. citrina (Hedw.), Quell.
Not uncommon. P.L. on dead wood.

C. lenticularis (Bull), Boud.
Rev. of Scots. Disco. Tay, as Helotium .

C. claroflava (Grev.), Boud.
Rev. of Scots. Disco. Tay, as Helotium .

C. sublenticularis (Fr.), Boud.
Scone, on stumps and twigs of birch.

C. pallescens (Pers.), Quell.
Not uncommon about Perth and Dunkeld. On dead wood. P.L., as Helotium.

C. uliginosa (Fr.), Boud.
Cherrybank and Kinfauns. On dead wood in pools.

C. Humuli (Lash), Boud.
Bamff Den, Alyth. On dead stems of Humulus.

DISCINELLA, Boud.

D. purpurascens (Pers.), Boud.
Muirward of Scone, on the ground.

D. exidiformis (B. et Br.), Boud.
Kinfauns, Scone, and Muirward of Lethendy. On char heaps. Often mixed with Anthracobia nitida and A. maurilabra.

D. Menziesia, Boud.
Muirhall Quarry, on clay soil about the roots of broom bushes. New species. Trans. of the Brit. Mycol. Soc., vol. 4, page 62.

MELACHROIA.

M. terrestris (Niessl.), Boud.
Muirward of Lethendy, Kinfauns, and the wooded margin of Methven Bog. On the humus formed of pine and larch leaves.

Bulgariaceae.

CORYNE TUL.

C. sarcoides (Jacq.), Tul.
Not uncommon about Dunkeld and Perth. On dead wood. Rev. of Scots. Disco. Tay as Ombrophila.

C. urnalis (Nyl.), Sacc.
Kinfauns and Kinnoull, on stumps and branches.

BULGARIA, Fr.

B. inquinans (Pers.), Fr.
Common, especially on oak trunks and branches. P.L.

BULGRIELLA, Karst.

B. pulla (Fr.), Karst.
Not uncommon about Dunkeld. On dead wood.

Calloriceae.

CORYNELLA, Boud.

C. atro-virens (Pers.), Boud.
Not uncommon at Dunkeld and near Perth. On rotten wood. Rev. of Scots. Disco. Tay as Ombrophila.

POLYDESMIA, Boud.

P. pruinosa (B. et Br.), Boud.
Common on dead wood and bark. P.L. as Helotium.

CALLORIA, Fr.

C. fusaroides (Berk.), Fr.
Common on dead stems of nettle in shady places. P.L. as Phialea.

C. cornea (B. et Br.), Phill.
Dunkeld, Kinfauns, and Almond mouth. On dead stems of Phalaris and other grasses.

ORBILIA, Fr.

O. rubella (Pers.), Karst.
Dunkeld and near Perth. On dead wood of oak, willow, and rose.

O. vinosa (Alb. et Schw.), Karst.
Not uncommon. On dead wood, bark, and rags. Rev. of Scots Disco. Tay as Calloria.

O. lutea-rubella (Nyl.), Karst.
Near Perth. Occurring on dead wood in ditches and banks of streams.

O. coccinella (Somm.), Fr.
Kinnoull, Bonhard, and Cherrybank. On wood and bark.

O. leucostigma, Fr.
Not uncommon on decayed wood. P.L. Dupplin.

O. zanthostigma, Fr.
Not uncommon on decayed wood. Rev. of Scots. Disco. Tay.

Cibroiaceae.

CIBORIA, Fuck.

C. caucus (Rebeut), Fuck.
P.L. Moncrieff. On fallen catkins of poplars.

C. amentacea (Balb.), Fuck.
Not uncommon near Perth. On fallen female catkins of the alder in autumn. P.L. Moncrieff, on catkins of willow, spring.

C. Sydowiana, Rehm.
Not uncommon near Perth. On petioles and midribs of oak leaves, in damp places.

SCLEROTINIA, Fuck.

S. tuberosa (Hedw.), Fuck.
Balgarvie and Almond mouth. Crieff, J. W. Kippen. Rev. of Scots. Disco. Tay. Arising from selerotia produced in the Rhizomes of Anemone nemorosa.

S. Curreyana (Berk.), Karst.
Parkfield hill pastures, frequent. From selerotia pro-

duced in the pith of Juncus effusus and J. glomeratus. P.L. Methven Bog.

S. Libertiana, Fuck.

Quarrymill, Taybank near Woody Island, and Almond mouth. From selerotia produced in the stems of comphrey, butter bur, and Myrrhis odoratat.

PHIALEA, Fr.

P. echinophila (Bulb.), Quell.

Bamff Road, Alyth. On husks of Spanish chesnut.

P. firma (Pers.), Gill.

Common. On dead oak wood. Rev. of Scots. Disco. Tay.

CHLOROSPLENIUM.

C. aeruginosum (Oeder.), de Not.

Common, especially on oak, but occuring on alder, ash, and elm. Rev. of Scots. Disco. Tay.

HELOTIUM, Fr.

H. albidum (Rob.), Pat.

Not uncommon about Perth, Stormonfield, and Dunkeld. On petioles of dead ash leaves.

Var. aesculi, Phill.

Dunkeld, on petioles of horse chesnut.

H. herbarum (Pers.), Fr.

Common on herbaceus stems. Rev. of Scots. Disco. Tay.

H. phyllophilum (Desm.), Krast.

Balgarvie. On beech leaves.

H. subtile, Fr.

Kinnoull. On the leaves of cut or fallen branches of Pinus sylvestris.

H. advenulum, Phill.

Dunkeld. On dead larch leaves.

H. amenti (Batsch) Fuck.

Dunkeld. On fallen willow catkins.

H. sparsum, Boud.

Quarrymill and Kinfauns. On the mid ribs and veins of dead oak leaves lying in damp places. First British specimens. Trans. Brit. Mycol. Soc., vol 4, page 317.

H. rhodoleucum, Fr.

Not uncommon in several old quarries near Perth. On dead stems of Equisetum arvense.

H. lutesceus (Hedw.), Fr.

Not uncommon near Perth and at Dunkeld. On dead wood. Rev. of Scots. Disco. Tay.

H. phyllogenon, Rehm.
Darry Island and Inver. On ribs and veins of poplar leaves.

H. rhizophilum, Fuck.
Inver, on roots of grasses.

H. fructigenum (Bull.), Fuck.
Common on dead acorns, hazel nuts, and beech mast. Rev. of Scots. Disco. Tay.

H. pygmaeum (Fr.), Karst.
Balthayock, Glenfarg, and Campsie Linn. On partially buried wood and twigs of Cytisus scoparius.

H. flexuosum, Mass.
Muirhall, on the outer decayed leaves of the root stock of Dactylus glomerata.

H. epiphyllum (Pers.) Fr.
Not uncommon about Perth. On dead beech leaves. Rev. of Scots. Disco. Tay.

H. rubescens, Cr.
Quarrymill, on stumps of beech, ash, and hazel. First British specimens. Trans. Brit. Mycol. Soc., vol. 3, page 281.

H. salicellum (Hazb.), Fr.
Not uncommon near Perth. On dead wood of willow, elm, and ash. Rev. of Scots. Disco. Tay.

H. cyathoidcum (Bull), Karst
Common everywhere. On dead herbaceous stems. P.L. Dupplin.

H. urticæ (Pers.), Karst.
About Perth and Dunkeld. On dead nettle stems.

H. axillaris (Nees), Boud.
P.L. Rannoch, as Phialea.

H. scutula (Pers.), Karst.
Common everywhere. On dead herbaceous stems. Var: Rudbeckia, Phill. Abundant on dead stems of Rudbeckia lacinata. Naturalised on the banks of the Tay below Perth.

H. virgultorum (Wahl.), Karst.
Not uncommon on dead twigs and branches. Rev. of Scots. Disco. Tay.

H. calculus (Sow.), Berk.
Quarrymill, on dead willow.

H. moniliferum (Fuck), Rehm.
Quarrymill, on the cut face of beech stumps with Bispora moniliodes. P.L. Dupplin.

H. strobilinum (Fr.), Fuck.
Dunkeld, on fir cones.

H. terrigenum, Cook et Phill.
Kinfauns, on dead herbaceous stems and other fragments

of vegetation, partially buried or under stones. Scone, on bare soil under beeches.

H. tetraacosporum, Rea.

Balgarvie, on dead stems of Phalaris. New species. Trans. Brit. Mycol. Soc., vol. 3, page 129.

STAMNARIA, Fuck.

S. Equiseti (Hoffm.), Sacc.

Dunkeld (Loch of the Lowes). On dead stems of Equisetum. Rev. of Scots. Disco. Tay.

CYATHICULA, de Not.

C. coronata (Bull.), de Not.

Not uncommon. On dead herbaceous stems. P.L.

C. inflexa (Bolt), Sacc.

Rev. of Scots. Disco, as C. coronata. Variety, inflexa, Tay.

C. alba (Pat.), Sacc.

Scone, on damp clay soil. First British specimens. Trans. of the Brit. Mycol. Soc, vol. 3, page 289.

BELONIDIUM, de Not.

B. vexatum, de not.

Not infrequent near Perth. On dead stems Dactylus glomerata.

B. Clarkei, Mass et Crossl.

Kinnoull, Stormontfield, and Falls of Moness. On dead wood

B. Ierdoni, Cook et Phill.

Not uncommon at Dunkeld and the neighbourhood of Perth. On the leaves of cut or fallen branches of Scots fir.

BELONIUM, Sacc.

B. excelsius (Karst), Boud.

Kinfauns, on dead stems of Arundo. Methven Loch, on rotten stems of Typha. Not rare.

B. filisporum (Cook.), Sacc.

Kinnoull. Not infrequent on dead culms and leaves of Brachypodium sylvaticum.

B. arctii (Phill.), Sacc.

Tay bank at Stormontfield. On dead stems of Arctium lappa.

Lachnellaceae.

DASYSCYPHA, Fr.

D. virginea (Batsh), Fuck.

Common everywhere. On dead herbaceous stems and leaves, etc. P.L.

D. globuligera, Fuck.
Dunkeld. On dead wood. First British specimens. Trans. Brit. Mycol. Soc., vol. 3, page 230.

D. bicolor (Bull), Fuck.
Murthly. On dead oak wood. C.M. P. L. Dunkeld.

D. crucifera (Phill.), Sacc.
Dunkeld (Loch of the Lowes). On dead twigs of Myrica gale.

D. laetior, Karst.
Barnhill siding. On dead stems of Rubus ideus.

D. scintillans, Mass.
Balgarvie Den. On oak leaves.

D. ciliaris (Schrad.), Sacc.
Dunkeld and Kinnoull. On oak leaves.

D. patula (Pers.), Sacc.
The Hermitage, Dunkeld. On oak leaves.

D. acuum (Alb. et Schw.), Sacc.
Perth and Dunkeld. On the leaves of cut or fallen branches of Pinus sylvestris.

D. perplexa, Boud.
Muirhall. On roots of Dactylis glomerata. Killed by drought the previous summer. First British specimens. Trans. Brit. Mycol. Soc., vol. 4, page 197.

D. rhytismatis (Phill.), Sacc.
Kinfauns. On dead leaves of Acer with Rhytismatis acerinum.

D. cerina (Pers.), Fuck.
Dunkeld, Falls of Moness, Stormontfield, and Kinnoull. On dead wood. Rev. of Scots. Disco. Tay.

D. calyculæformis (Schum.), Rehm.
Falls of Moness and Inver. On dead branches of hazel.

D. fuscesens (Pers.), Rehm.
Dunkeld and Scone. On dead oak leaves.

D. clandestina (Bull), Fuck.
Frequent on dead stems of Rubus and herbaceous stems of various kinds. Rev. of Scots. Disco. Tay.

D. patens (Fr.), Sacc.
Parkfield and Muirhall. On dead stems of Deschampsia cæspitosa.

D. campylotrichi, A. L. Sm.
Balgarvie. On dead stems of Carduus arvensis. New species. Trans of Brit. Mycol. Soc, vol. 3, page 112.

Erinella, Sacc.

E. apala (B. et Br.), Sacc.
Frequent on dead wet rushes. P.L.

LACHNELLA, Fr.

L. sulphurea (Pers.), Quell.
P.L. Dupplin.
L. corticalis (Pers.), Fr.
Rev. of Scots. Disco. Tay.
L. canescens (Phill.), Cook.
Quarrymill. On dead wood.
L. spadicea (Pers.), Phill.
Muirhall and Scone. On cut stems of Cytisus scoparius.
L. siparia (B. et Br.), Phill.
Kinnoull, Stormontfield, and Craighall. On dead elm wood.
L. nidulus (Schm. et Kunze.), Quell.
Quarrymill, Balgarvie, and Falls of Moness. On dead stems of meadow sweet and Epolibium hirsutum.
L. albo-testacea (Desm.), Quell.
Muirhall and Balgarvie. On dead stems of Phalaris and Dacytilis.
L. prasina, Quell.
Balgarvie. On dead stems of Phalaris.
L. Nylanderi (Rehm.), Boud.
Several spots near Perth and at Little Dunkeld. On dead nettle stems.
L. setulosa (Mass. et Crossl.), Boud.
Muirhall of Scone and Inver. On dead stems of Calluna.
L. leucophæa (Pers.), Boud.
Not uncommon near Perth. On dead herbaceous stems.

TRICHOSCYPHA, Boud.

T. calycina (Schum.), Boud.
Common on larch bark and twigs.
T. subtillissima (Cook), Boud.
Common on bark of Pinus sylvestris and Abies pectinata.
T. resinaria (Phill.), Boud.
Inver. On resin exuding from larch wood.

ARACHNOPEZIZA.

A. aurelia (Pers.), Fuck.
Kinnoull on oak leaves. Rev. of Scots. Disco. Tay.

HALOSCYPHA, Boud.

H. hyalina, (Pers.), Boud.
Common on dead wood and bark. Rev. of Scots. Disco. Tay.

MICROPODIA, Boud.

M. chrysostigma (Fr.), Boud.
Dunkeld and Perth. Not uncommon. On dead stems of Pteris.

M. dumorum (Desm.), Boud.
Not uncommon near Perth. On dead bramble leaves.
M. grisella (Rehm.), Boud.
Inver. On dead leaves of Pteris.
M. aspidiicola (B. et Br.), Boud.
Rev. of Scots. Disco. Tay.

URCEOLELLA, Boud.

U. deparcula (Karst.), Boud.
Balgarvie and Quarrymill. On dead stems of the meadow sweet.
U. effugiens (Desm.), Boud.
Kinfauns. On dead herbaceous stems in damp shady spots.
U. versicolor (Desm.), Boud.
Dunkeld. On dead stems of Pteris.
U. spirotricha (Oud.), Boud.
Balgarvie and banks of the Tay below Perth. On dead stems of Heracleum.
U. Berkeleyi (Blox.), Boud.
Not infrequent near Perth. On dead stems of Heracleum.
U. leuconica (Cook.), Boud.
About Perth and Dunkeld. On dead stems of Calluna.
U. stereicola (Cook.), Boud.
Kinnoull. On dead Stereum hirsutum.
U. melaxantha (Fr.), Boud.
Inver. On dead beech branches.

TRICHOPEZIZA.

T. Grevillei (Berk.), Sacc.
Cromwell Park. On dead Umbellifer stems. Rev. of Scots. Disco. Tay.
T. carinata, Cook et Mass.
Dunkeld. On dead stems of Felix mas.
T. flavo-fulginea (Alb. et Schwein.), Sacc.
Quarrymill. On stumps of Ulmus montana. First British specimens. Trans. Brit. Mycol. Soc., vol. 3, page 288.

Mollisiaceae.

PYRENOPEZIZA, Fuck.

P. Mercurialis (Fuck.), Boud.
Almond mouth. On dead stems of Mercury.
P. arundinacea (D.C.), Boud.
On dead culms of Arundo. Rev. of Scots. Disco. Tay.

P. digitalina (Phill.), Sacc.
Inver. On dead stems of the foxglove.

P. Carduorum, Rehm.
Quarrymill. On dead stems of Carduus palustris.

P. Rubi (Fr.), Rehm.
On dead raspberry canes. Common. Rev. of Scots. Disco. Tay.

P. urticticola (Phill.), Boud.
Dunkeld and near Perth. On dead nettle stems.

EPHELINA, Sacc.

E. Rhinanthi (Phill.), Sacc.
Rev. of Scots. Disco. Tay.

PIROTTÆA, Sacc.

P. veneta, Sacc. et Speg.
Cromwell Park, Almond mouth, and Balgarvie. On dead stems of Heracleum and Articium lappa.

MOLLISIA, Fr.

M. fallax (Desm.), Gill.
About Perth and Dunkeld. Not uncommon. On bark of Pinus sylvestris.

M. benesuada (Tul.), Phill.
Inver. Tay side below Perth on alder sticks and branches.

M. aquosa (B. et Br.), Phill.
Kinfauns and Muirhall. On dead willow branches.

M. cinerea (Batsh.), Karst. Common on dead wood. P.L.

M. caesia (Fuck), Sacc.
Inver and Kinnoull. Often growing in the shattered ends of fallen oak branches.

M. conigena (Pers.), Boud.
Dunkeld. On fir cones.

M. ventosa, Karst.
Lochearnhead, Glenfarg, Cromwell Park, and Quarrymill. On dead wood of oak and alder.

M. atrata (Pers.), Karst.
Very common on dead stems of the meadow sweet. Rev. of Scots. Disco. Tay.

TAPESIA, Fuck.

T. fusca (Pers.), Fuck.
Very common on dead wood. P.L.

T. Rosæ (Pers.), Fuck.
Very common on dead stems of wild roses. Rev. of Scots. Disco. Tay.

T. mutablis (B. et Br.), Phill.
Muirhall. On dead culms and leaves of Deschampsia cœspitose.

NIPTERA, Fr.

N. pulla (Phill. et Keith.), Boud.
Balgarvie and Kinfauns. On dead culms of Phalaris and Arundo.

MOLLISIELLA, Boud.

M. Teucrii (Fuck.), Boud.
Kinnoull. On dead stems of Teucrium scorodonia.

Potellariaceae.

HETEROSPHÆRIA, Grev.

H. patella (Tode.), Grev.
Not uncommon. On dead stems of the Angelica sylvestris. Rev. of Scots. Disco. Tay.

PSEUDOPHACIDIUM, Karst.

P. Callunæ, Karst.
Dunkeld. On dead stems of heather. Trans Brit. Mycol. Soc., vol. 3, page 40.

LAGERHEIMA, Sacc.

L. sphaerospora Berk. et Cook.), Sacc.
Dunkeld. On dead wood.

KARSCHIA, Körb.

K. lignyota (Fr.), Sacc.
Stormontfield, Quarrymill, and Dunkeld. On oak sticks blackened by other fungi.

DURELLA, Tul.

D. lecideola (Fr.), Rehm.
Kinfauns. On dead wood of birch and goat willow. P.L. Killicrankie.

D. livida (B. et Br.), Sacc.
Inver. On dead wood of Pinus slyvestris.

LECANIDION, Rabenh.

L. atratum (Hedw.), Rabenh.
P.L. Rannoch.

SCUTULARIA, Karst.

S. citrina (Chev.), Sacc.
Scone, Kinnoull, and Dunkeld. On cones and bark of Pinus slyvestris.

BIATORELLA, de Not.

TROMERA, Massal.

B. resinæ (Fr.), Mudd.
Inver. On fir wood.

Dermateaceae.

VELUTARIA, Fuck.

V. rufo-olivacea (Alb. et Schw.), Fuck.
Dunkeld, on dead branches of bird cherry. Glenfarg, on stems of wild rose.

PEZICULA, Tul.

P. amæna, Tul.
Inver. On scorched oak bark.

P. rhabarbina (Berk.), Tul.
Not uncommon about Dunkeld and Perth. On dead stems of wild roses and bramble. Rev. of Scots. Disco. Tay.

P. eucrita, Karst.
Kinfauns, Scone, and Inver. On chips of bark of the Scots fir lying on the ground as they had fallen from the axe in tree felling.

DERMATEA, Fr.

D. Cerasi (Pers.), de Not.
Rev. of Scots. Disco. Tay.

D. umbrina, Cook et Mass.
Muirhall and Glenfarg. On dead branches of Ulex.

D. Houghtoni, Phill.
The Hermitage, Dunkeld. On dead branches of Prunus laurocerasus.

CENANGUIM, Fr.

C. pulveraceum (Alb. et Schw.), Fr.
Dunkeld and Kinnoull. On sloe and birch.

C. Sarothamui, Fuck.
Inver. On cut branches of broom lying on the ground.

C. subnitidum, Cook et Phill.
Kinnoull and Inver. On dead wood of Pyrus aucuparia.

C. Abictis (Pers.), Duby.
Not uncommon near Perth. On cut or fallen branches of Pinus sylvestris.

ENCOELIA, Fr.

E. furfuracea (Roth), Karst.
Dunkeld. On dead alder. Rev. of Scots. Disco. Tay.

E. populnea (Pers.), Schroet.
Dunkeld. On dead ash sticks.

E. tiliacea (Fr.), Karst.
Dunkeld. On dead branches of lime. First British specimens. Trans. Brit. Mycol. Soc., Vol. 4, page 317.

TYMPANIS, Tode.

T. conspersa, Fr.
Dunkeld. On dead branches of Pyrus aucuparia. Rev. of Scots. Disco. Tay.

T. alnea (Pers.), Fr.
Dunkeld. On dead alder. Rev. of Scots. Disco. Tay.

CENANGELLA, Sacc.

C. Pinastri (Tul.), Sacc.
Dunkeld. On dead fir and spruce.

SCLERODERRIS, Fr.

S. ribesia (Pers.), Karst.
Dunkeld and Barnhill. On dead wood of Ribes rubrum.

S. bacillifera (Karst), Sacc.
Dunkeld. On dead wood of Abies excelsa. First British specimens. Trans. of Brit. Mycol. Soc., Vol. 2, page 169.

TROCHILA, Fr.

T. craterium (DC.), Fr.
Not uncommon on the underside of dead ivy leaves. P.L.

T. Laurocerasus (Desm), Fr.
Common on the underside of the dead leaves of Cherry laurel. P.L.

L. Buxi Capron.
P.L. Dupplin. On dead box leaves.

Stictidaceae.

PROPOLIS, Fr.

P. faginea (Schrad), Karst.
Dunkeld and near Perth. Not uncommon on dead wood.

P. rhodoleuca (Somm.), Fr.
Dunkeld. On dead cones of Pinus sylvestris.

STICTIS.

S. radiata (Linn.), Pers.
Rev. of Scots. Disco. Tay.

Phacidiaceae.

PHACIDIUM, Fr.

P. vaccinii, Fr.
P.L. Rannoch.

P. abietinum, Kunze et Schm.
Not uncommon about Perth and Dunkeld. On the leaves of fallen branches of Scots fir.

KEITHIA, Sacc.

K. tetraspora (Phill.), Sacc.
Dunkeld. On living leaves of juniper.

PSEUDOPEZIZA.

P. Trifolii (Bw-Bern.), Fuck.
P.L. Gannochy.
P. Ranunculi (Wallr.), Fuck.
P.L. Dupplin and Rannoch.
P. repanda (Fr.), Karst.
P.L. Kinfauns.
P. Sphaeroides (Pers.), Fuck.
Var. Lychnidis, Phill. Tay bank, near Almond mouth. On dead stems of Lychnis diurna.
P. petiolaris (Alb. et Schw.), Mass.
Dunkeld. On the petioles of dead Acer leaves.

STEGIA, Fr.

S. Ilicis, Fr.
Not uncommon on dead holly leaves. P.L.

SCHIZOTHYRIUM, Desm.

S. Ptarmica, Desm.
P.L. Rannoch.

COCCOMYCES, de Not.

C. coronatus (Schum), de Not.
P.L. Rannoch.
C. dentatus (Kunze et Schm.), Sacc.
P.L. Killiecrankie.
C. Pini (Alb. et Schw.), Karst.
Dunkeld. On twigs and branches of Scots fir.

COLPOMA, Wallr.

C. quercinum (Pers.), Wallr.
Dunkeld, Scone, and Stormontfield. P.L. Kenmore and Rannoch. On dead oak twigs.

RHYTISMA, Fr.

R. acerinum (Pers.), Fr.
Very common. P.L.
R. salicinum (Pers.), Fr.
P.L. Strathbraan.
R. Empetri, White.
P.L. Breadalbane, Rannoch, and Athol.

III.—*The Caledonian Camp, The Haer Cairns, and The Steed Stalls, in the Stormont.*

By Alex. M. Scott.

(Read 11th April, 1919.)

During an enforced holiday in the Stormont district in the summer of last year I had leisure, with favourable weather, to take rambles into certain unfrequented parts, and the following notes having reference to some of the objects visited I have gathered together in the hope they may prove, if not instructive, at least interesting, to those who are not already acquainted with that part of our county.

The little strath of the Stormont is situated between Blairgowrie and Dunkeld, and is about six miles in length. In appearance, it is exceedingly picturesque. The chain of lochs, connected by the Lunan Burn, running along its centre, beginning from the west with the Loch of the Lowes, Butterstone, Clunie, Marlee, and Ardblair, gives an entrancing diversity to the landscape; the arable land in most parts bears good crops; the stretches of woods and pasture here and there lend a pleasing variety to the eye, while from the rising hills which afford a protection from the north a wide prospect of the Valley of Strathmore is obtained.

Parts of the district have been familiar to me for some years, and certain objects of interest I have formerly noticed in my rambles, though only by a cursory glance. During my last visit, however, having more leisure, I devoted some time to make closer investigations, particularly of those pre-historic remains which are to be found in various parts of the locality. The principal objects I shall here mention, however, are the supposed Caledonian Camp, with the Haer Cairns, on the Lornty Burn, and the Steed Stalls, which are situated on the Hill of Gourdie about two and a half miles farther south. Many conjectures have arisen regarding these three objects, particularly the Steed Stalls, but nothing definite has been arrived at by those capable of deciding. It is evident, however, they are of great antiquity, and in all likelihood have had originally a connection each with the other.

In order, therefore, to trace out the connection we shall first of all make ourselves acquainted with the Caledonian Camp, as it is termed.

CALEDONIAN CAMP.

Taking the course of our journey from Blairgowrie in the direction of Dunkeld, on arriving at Marlee Hotel, about three miles distant, we leave the highway and follow a hilly road to the right, and after half an hour's walking we arrive at the Lornty Burn. Crossing the Burn at the Bridge of Drumaud, we here leave behind us the good macadamised road and enter upon an old hill road, which I understand eventually leads one to the Bridge of Cally. To the right, about half a mile distant, is discerned the ruins of the old Castle of Glasclune perched on the brink of a ravine. Up to this point the most of the land is in a good state of cultivation, but after crossing the bridge we come to the farm of Middleton, which is now entirely turned into pasturage, while the farm steading is completely ruinous. I might remark here in passing that the view from the road we have followed, looking westward, gives one a very fine prospect of these hilly ridges rising alternately which mark the peculiar configuration of the ground in this part of the district. These ridges, or *drums*, as they are termed, come stretching down from the high ground of the old Forest of Cluny, rising one above the other with striking uniformity. In the low ground between two of these ridges flows the Lornty Burn, which has its source from Loch Benachally and continues on its way twisting and turning till it enters the Ericht some distance above Blairgowrie. At the old farm of Middleton we leave the road behind and take our course westward, following a sheep track along one of these ridges for fully half-a-mile, having good walking ground over old pasture till we enter upon a part which apparently has never been cultivated and is sparsely covered with heather. The sheep track, however, can still be followed, and after another half mile's walk we come in sight of the old earthen dyke or vallum which marks the western extremity of the supposed Caledonian Camp. The eastern wall, which bordered on land once cultivated, has been levelled by time and the hand of man, and I had traversed nearly the whole breadth of the camp before I was aware. The extent of the camp is supposed to have been about a square mile. On the north side in the hollow to the right of the ridge I had traversed are here and there indications of an earthen wall, but it does not at any part give assurance to the observer as to its having been used as a means of defence. The earthen walls of the camp are termed the Buzzard Dykes, while the central parts or ridges are known locally as the Garry Drums. From the ridge I had followed is obtained a fair idea of the size and shape of the camp. It occupies two of those hilly ridges, the north side resting in a hollow, while it extends in the form of a square southwards to the Lornty Burn, on the southern bank of which is still to be traced distinctly its extreme fosse and breastwork. On the open part of the ground the western rampart still stands conspicuous at some parts about six or eight feet from the bottom of a ditch or trench which has been formed inside, and one can walk with perfect freedom along the summit of the wall. The breadth of the wall at its base will be fully six feet. I walked upon it from its northern limit till where, on the second ridge, it enters a fir wood. Time did not permit me to follow it to its southern extremity, but an open glade has been left in the wood running parellel with it till it ends at the brink of the Lornty Burn. In the wood the earthen wall is only about three feet in height; the ditch inside is still continued. This wall or rampart must have caused considerable labour to form; it is composed of earth and stones, and when entire must have afforded a strong protection. The ditch which runs inside is about two feet deep in parts. One is at a loss to account for the ditch being inside the wall, but probably, it might be presumed, the camp was formed not definitely for a place of defence, from a military point of view, but more as a protection to the families of the Caledonian army, the women and children, with their cattle and horses, and the ditch may have been intended to prevent the animals approaching the wall to destroy or attempt to cross over it.

Within the camp, particularly towards the west end on the second ridge, numerous cairns are to be found. They are dotted all over the slopes, and, on account of the heather having been burned in the preceding spring, at the time of my visit were plainly visible. On the outside of the ramparts also you find a number of them, but in this part the heather was rank in growth and no doubt hid many of them from sight. According to local writers similar cairns are met with even as far west as Benachally, a distance of two miles. There is little reason to doubt these cairns are sepulchral, although there is no evidence that any of them have been opened at any time.

About two hundred yards to the west of the vallum are to be found the remains of several hut circles, generally in pairs, while a little further to the north-west and occupying higher ground among the heather are other two, composed of larger stones and complete in formation. Another circle is also situated inside the camp ground within the wood. These circles vary in demensions, their exterior diameter being from thirty-four to over forty-two feet. The circle within the wood is the largest of the number, the outside diameter being sixty-seven feet.

This ancient camping ground is about seven miles from Dunkeld, which was one of the principal seats of the Caledonians, and its situation lends it favourably to the idea that it formed the centre of the army of Galgacus or Galdus, which occupied the heights, while watching and preparing for an onslaught on the Roman invaders who had advanced in this direction the length of Meikleour and Delvine. The position is assuredly a very strong one, and favourably situated for attack or defence. The right wing of the Caledonians is supposed to have rested on the more level ground between this and Benachally, while their left occupied an equally commanding position over above Marlee, and the front would be naturally defended by the Lochs of Clunie and Marlee, the ground between the lochs and eastward of Marlee, in particular, affording suitable advantage for the movements of their cavalry. How long this ground may have been occupied is open to conjecture, but a large army could have lain here with perfect freedom for a considerable time, if supplies of food were obtainable. Water would be plentiful, as there are traces of two watercourses within the camp, besides the Lornty Burn itself which at this part is about twelve feet wide.

Although I have no intention in the present instance to enter upon debatable ground regarding the site of the great battle of Mons Grampius, as it is termed, a subject which has occupied the attention of many learned men who have made the Roman occupation of Britain their peculiar study, one cannot refrain, when visiting this part of the country, of viewing with some favour that it was here the great conflict took place. The site of the battle has been claimed for Fifeshire by some, as being near to the sea-board, and evidences are not awanting that much fighting between the Romans and the ancient Britons had taken place in that county. Forfarshire also has put in a strong claim, with like evidences to bear out its assumptions. It has been generally accepted that the Muir of Ardoch or adjoining ground was the actual site of the battle, but according to what may be gathered from those who have studied the subject, in no other parts of the country are found so many of those cairns and tumuli as are met with in the Stormont district. Its distance from the seaboard may put a check on accepting a decision in its favour; but the adventurous Romans did not merely keep along the shores of the island; they penetrated deeply into the open country, while having at the same time their carefully placed lines of communication to their camps. They avoided the wild mountainous parts, however, and kept to the more favourable plains. General Roy in his valuable volume on the Roman occupation remarks on the great battle as follows: "Already 30,000 men in arms (Caledonians) encamped on the face of the Grampian Mountains under the command of Galgacus. . . . In this situation of affairs Agricola sent forward his fleet with orders to make descents in different places along the coast, and by devastation and ravage to harass and distract the enemy. In the meantime he put himself at the head of the army, which he had reinforced with some of the bravest Britons, and marching without his heavy baggage he arrived at the Grampian Mountains. The British host was drawn up on the hills in the most advantageous manner, so as to make at once a mighty great show, and a very terrible appearance. The first ranks stood upon the plain, the others rising successively behind them, one above another, as if linked together, till the brow of the hill was covered. Their cavalry and war chariots occupied the plain before the foot, with great tumult and many movements to and fro."

The formation of this district of the Stormont lends itself therefore most favourably as being the site of this momentous conflict, the high grounds providing a position for the Caledonians to compare with the words just quoted, the sloping ridges and the plains below affording suitable ground for the evolutions of the cavalry and war chariots. The vestiges that remain to-day scattered over a wide area testify most forcibly that at all events a conflict of great magnitude—call it Mons Grampius, if you may—here took place. According to Tacitus, the Roman historian, 30,000 Caledonians were engaged that day in battle; at the close 10,000 were numbered with the dead. The figures, of course, may be accepted with caution; likewise the eloquent speeches which he puts in the mouths of the opposing leaders in addressing their respective followers. The speech by Agricola might with fairness be assured as reliable; the patriotic and soul-stirring address which he ascribes to Galgacus is altogether composed of language which one would never dare expect from a rude and unlettered barbarian, and is one which entirely outclasses anything coming from a general of more modern times.

THE HAER CAIRNS.

Crossing the stream of the Lornty we come now to the Muir of Gormack, where a considerable number of these burial cairns are to be seen, similar in appearance to what we find within the camp itself. The name "Haer" or "Heer" Cairns, signifying "cairns of battle," is common in several parts of Scotland. These cairns are ascribed to be burial places of those fallen in conflict. On my first visit to the Muir of Gormack several years ago, it was much overgrown with broom, but on my visit last year the broom had disappeared, and a distinct view of the cairns could be obtained. They occupy an area of several acres in extent. At certain parts they are widely placed, but at other parts you find them in clusters, as it were, and being in some instances only about a yard apart. Truly, if these cairns mark the last resting place of the fallen in battle, the conflict at this point must have been very severe. In all probability, the camp being the centre of the Caledonian army, the defence here would be stoutest, and viewing these vestiges that still remain of the great battle for freedom which took place here over eighteen hundred years ago, no Scotsman could but feel moved with emotion and patriotic pride when he recalls to mind those stirring times:

"When the Romans endeavoured our country to gain,
But our ancestors fought, and they fought not in vain."

These cairns are comparatively all about the same size, measuring about eight or nine yards in circumference, and exposed about twelve or eighteen inches above the surface of the ground. They are composed of stones varying in size heaped together. The most of them during the past ages have lain undisturbed, with the exception of that part of the Muir on the south side where the ground has been broken up of late years during the course of the laying of the water supply from Loch Benachally to Blairgowrie. The first line of pipes was laid down in 1870, but in 1893, the supply of water being insufficient for the increasing population, a second installation was made. You can distinguish where the water track is laid by some of the cairns having been broken up. I have been unable to learn if any objects of burial were unearthed. Stones in the form of boulder slabs have apparently been turned up during the operation, as they appear to have previously lain in the earth.

At the western extremity of the Muir the Lornty Burn after winding its way from Loch Benachally here takes an abrupt bend, and descends into a gorge, which is continued for most of its course till it enters the Ericht. At the bend indicated the ground on the south side is precipitous, rising to about 40 feet in height. At the edge of this high bank you enter what appears at first sight to be a narrow footpath, but on taking a few steps further you enter a deep ditch or trench that runs in a line with the top of the bank, which here slopes down abruptly towards the stream. One might imagine it at first to be a sheep track worn down thus through the course of time, but in tracing it throughout you come to the conclusion that it is more than an ordinary track made by the feet of animals. That it is of artificial construction is quite obvious; and it resembles much the same formation of the bank and ditch you find within the wood in the camp ground. A slight ridge is observed along the top of the bank when you are standing on the level Muir, but the trench is not easily discerned on account of an overgrowth of high bracken which stretches along the slopes. It is only when you descend into the hollow, you discover its true depth and uniform formation. This trench is continued along the top of the bank broken at two parts by large gaps, probably obliterated by time. The western portion of the trench is the most perfect, being about 300 yards in length, with what appears to be, at short intervals, outlets to the Muir about two feet in breadth. Standing in this trench, the breastwork is about six feet in height, while the ridge behind is about two feet. From its construction and position it is quite apparent this trench must have formed the southern part of the old Caledonian Camp.

Along the Muir, a few yards in front of the entrenchment are to be found groups of hut circles similar to these met with to the west of the camp, and already referred to. At this point they appear to have been more numerous. At present these are ten in number, but more may have been displaced. Apparently they have been set down regularly along the Muir. They are all much about the same diameter, are formed of stones standing mostly a few inches above the level of the ground and about a foot apart. The ground within the circles is level, or, in instances, slightly hollow. You find in one place a solitary circle, and at other places there are two or more side by side about a foot apart. The circles are mostly complete, only I observed on the south side of each a gap about a yard wide, which might indicate that these hutments or tent dwellings had their openings all in that direction. I have inferred by my remarks these stone circles mark the sites of huts or dwelling-places. Similar circles are to be found in various parts of the country and are ascribed to such an origin. They display no sign of building, and are quite distinct from the burial cairns which are usually heaps of stones or mounds of earth. These ancient huts probably would be formed principally of timber, the most part branches and wattles, the circle of stones outside acting, it may be, as a protection or support to the rude timber foundations.

There are a number of large boulders to be seen on various parts of the Muir, and on my last visit to the place I examined several of them and discovered one lying near to the south side and a few yards distant from the track of the water supply, on which could be distinctly traced eight cup-marks. The boulder is about six feet in length, two in height, and two in breadth. One half of the surface is rough and broken, but the other half is smoother, showing the cups distinctly.

I have never seen mention made of any cup-marked stones on the Muir; if a careful investigation were made of the rest of the boulders other like pre-historic vestiges might be found.

Although it might be inferred from the presence of the hut circles and cup-marked stone this part of the country may have been a native settlement anterior to the Roman invasion, the position of the camping ground with its protecting vallum impresses the mind with the idea that the army of Galgacus could not have found in the county a more favourable position for defence, and the traditions that cling around it and the neighbourhood most pointedly assert that the Stormont was the scene of the momentous battle of long passed ages.

THE STEED STALLS.

The peculiar mounds of earth situated on one of the fields of the farm of the Hillocks of Gourdie, and known in the district by the name of the "Steed Sta's" have long occupied the attention of the archæologist, and various surmises have been the outcome as to their origin. Of their antiquity there is no doubt whatever, and that they are coeval and connected in a way with the Caledonian Camp we have been dealing with is very apparent. The "Stalls" are to be seen in a field which slopes slightly upwards and at its highest point overlooks the valley or the Haughs of Delvine. They are about two and a half miles due south from the Muir of Gormack, and about the same distance from the Roman Camp at Inchtuthil and Meikleour. The Rev. William M'Ritchie, writing in 1793 describes them as consisting of "eight mounds with eight corresponding trenches," "perhaps some more," he says, "have been obliterated with the plough. The mounds and trenches are of equal length, alternate and parallel. At the south end of each trench, or fosse, there is a circular concave, the centre of which lies in the line of the fosse, and to this circular cavity the fosse seems to have formed the entrance." Thus were they described in 1793, and at the present day the Stalls still present much the same appearance; the ridges are the same in number although they are unequal in some parts, having suffered much from the straying cattle and horses while pasturing in the field. The circular cavities referred to by Mr. M'Ritchie have lost much of their formation, and have become merely sloping banks. The ridges are still of equal length, measuring about twenty short paces, and the height of the highest one will be about eight feet, and at the base fully two yards in breadth. Originally these mounds would apparently be equal in height and breadth, while the fosse or trench which runs between each would be about two feet in breadth. Evidently these mounds were not hastily thrown up in the course of their construction, but have been formed according to a plan or design. They are composed mostly of earth, though there are stones mixed in the earth. Along the southern end of the trenches on the bank a slight ridge is perceptible, although such may have been formed through the process of agriculture. I asked the present tenant of the farm during the course of a conversation if any articles of antiquity had ever been discovered around the mounds or in the field itself, but he was not aware of anything having ever been found.

That these mounds are artificial is undoubted, but whether they be sepulchral or otherwise can only be conjectured. James Knox, in his "Topography of the Basin of the Tay" ascribes them with seeming confidence to be the burial mounds of the Tungrian and Batavian cohorts slain in the battle of Mons Grampius, and various writers follow him in his surmises. The peculiar construction of the mounds does not lend itself very favourably to my mind that they are burial places, nor do you usually find traces of Roman burial represented by mounds of earth or heaps of stones. The ancient Caledonians marked their burial-places by stone cairns or mounds of earth irregular and apart, but these mounds or stalls give one the idea they were formed for other purposes than burial mounds. What then was their purpose? The Rev. Mr. M'Ritchie writes thus: "It is said that an advance guard of the Caledonian army was placed here to watch the motions of the Romans when they lay encamped at Inchtuthil, about two miles to the southward on the plain below. The place of the Steed Stalls seems to be well calculated for such a purpose." One is inclined to believe this idea of Mr. M'Ritchie was quite consistent. From the Steed Stalls looking northward you command a view of the high ground, the Muir of Gormack being clearly recognised, and easy communication could be maintained by the light cavalry of the Caledonians conveying intelligence to the camp of the movements of the enemy below. By advancing about fifty yards southwards from the Stalls, you come to an elevation which affords you an unobstructed view of the plain of Delvine. This then would prove a strong vantage ground for the Caledonians.

After viewing the ground, and the situation of these Stalls, I am of the same opinion expressed by the Rev. Mr. M'Ritchie, that they formed an outpost of the ancient Caledonian, and may be termed according to modern warfare as "dug-outs" or shelters for scouting parties, and thus literally may have been stalls for the ponies as well as cover for the warriors themselves. Branches of trees could have been laid over the tops of the ridges, and covered with heath, and thus would be formed not only a shelter from the elements, but would supply as well a "camouflaged" place of concealment from the opposing Roman scouts.

It is not unlikely that the great conflict commenced near here, although the Romans, after securing the advantage, would probably advance over the more open ground to the west and east of Marlee. After suffering reverse on the plains below, the Caledonians fell back upon their main position on the heights, which were ultimately stormed by the enemy, who overran the camp, and as evidences at various points testify, carried the pursuit north-east for some miles distant. Various articles have been discovered which had belonged to the invader. The "Statistical Accounts" make mention of several Roman urns and Roman spurs having been dug up on a hill still named Craig Roman, above Marlee, while elsewhere in the supposed line of pursuit other articles have been discovered.

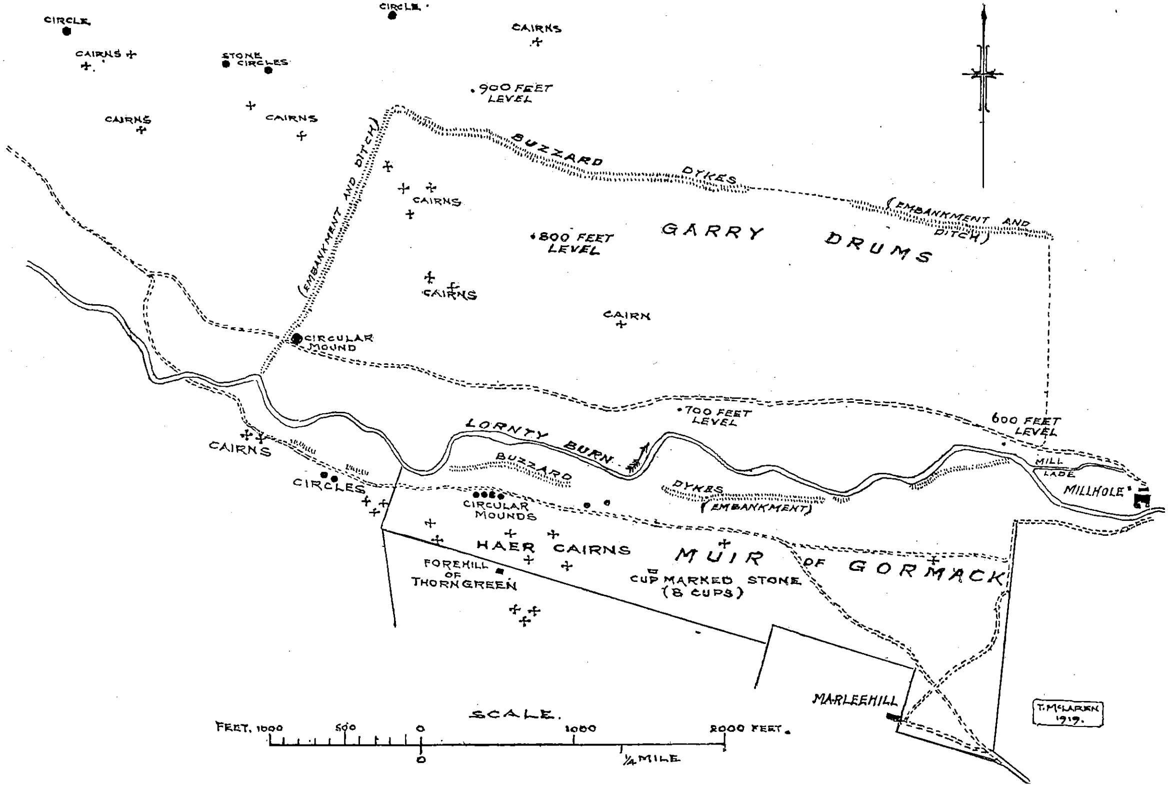


Plate 1.—Map shewing Haer Cairns, etc.

IV.—*Anomalies of Plant Structure.*

By George F. Bates, B.A., B.Sc.

(Read 14th November, 1919.)

Part I.

When we examine, by means of suitable sections, the internal structure of the vegetative organs of ordinary flowering plants, we find that although minor differences exist, yet on the whole the members of the two great groups—Monocotyledons and Dicotyledons—show a remarkable degree of similarity and conformity to type, so that the student of plant anatomy can obtain a very good idea of general structure by the detailed study of comparatively few forms. If, however, we pursue our investigations further, we find that there are large numbers of plants which show remarkable divergences from the normal type of structure.

These anomalies are in many cases closely connected with the habitat of the plants in which they occur, and may be regarded as adaptations to environment; for example, plants growing in dry situations require to economise water, plants growing in water have little need of water-conducting tissues, and in both cases the structure is modified accordingly, often to an extreme degree. In this connection it may be convenient to note the arrangement whereby plants may be placed in three great groups, quite distinct from the usual classification into Natural Orders, etc. These groups are (a) *Mesophytes*, plants growing in ordinary situations, neither excessively wet nor excessively dry; (b) *Hydrophytes*, plants growing in water or in excessively wet places; and (c) *Xerophytes*, the plants of dry situations. (It is not absolutely accurate, however, to say that all plants growing in wet situations are hydrophytes. A place may be physically wet but physiologically dry, that is, abundance of water may be present, but the plants growing there may not be able to use it. This is the case with plants growing in salt marshes, *e.g.*, on the marshy shores of estuaries affected by the tide. The salt in the water prevents it from being utilised by the plants, which often exhibit marked xerophytic characters, and are known as *halophytes*. Similarly, low temperature may cause physiological dryness, even in the presence of abundant fresh water, and this is one reason why Alpine plants are often xerophytic.)

In addition to the above we may recognise another great group of plants, based on habit of growth and not on habitat, the climbing plants.

For the purpose we have in view it is necessary to point out that the anomalies to be discussed consist largely of variations in the amount of the hard and soft tissues of which plant organs are built up, and in their relative arrangement. A brief explanation of the methods by which these tissues may be recognised in sections is consequently called for. The fundamental structural material of all the higher plants, and of which all young cell-walls are composed, is cellulose, a substance allied in composition to starch, but with somewhat different properties. In many cells this material remains essentially unaltered during the whole existence of the cell, and as a general rule in these cases, the cell-wall remains quite thin, and the tissue composed of these cells remains soft. On the other hand, if the cell is destined to form part of a hard tissue, the cell-wall is thickened and the cellulose modified into a kindred substance, lignin, which has somewhat different properties from the original cellulose. Such cells or tissues are said to be lignified. As examples of cellulose structures we may mention pith, cortex, and soft bast; while wood and hard bast are examples of lignified tissues. The difference in thickness of the walls of the various elements of the different tissues renders them easily recognisable under the microscope, but in addition we have valuable means of distinguishing between them by the action of suitable chemical reagents, or, for permanent preparations, in the process of double staining. Thus, by comparatively simple manipulations we can stain the lignified elements of a section with the bright red of safranin or eosin, and the non-lignified elements with the purple of haematoxylin; and in addition we have a wide choice of contrasting colours given by other pairs of stains; so that it becomes possible, in a properly stained section, to identify lignified and non-lignified tissues at a glance. Again, the external walls of the surface layer of herbaceous plants, where exposed to the air, are commonly modified into *cutin*, such external layer being then known as the cuticle, while the modified cell-walls are said to be cuticularised. In woody dicotyledons, which constitute the vast majority of our trees and shrubs, an external layer, often of considerable thickness, of a corky nature, is produced; the walls of the cells composing this layer become converted into *suberin*, and the cells are said to be suberised. Both cutin and suberin behave in some respects like lignin, but can be recognised by appropriate chemical tests.

Before proceeding to discuss any actual anomalies, it may be as well to get some idea of the structure of one or two typical stems. Take first, as an example of a herbaceous dicotyledon, the stem of a sunflower. Even without a microscope we can readily make out that it consists of a number of tough strands, arranged in a cylinder (appearing as a ring in transverse section) set in a mass of soft tissue, the whole being enclosed in a thin transparent skin. At the nodes of the stem, that is, at the points where the leaves spring, it will be found that there is some branching of the strands, and that they are connected with strands entering the stem from the leaf, but between the nodes they run parallel to one another. The outer skin is the epidermis, cuticularised on its external cell-walls, and the soft material is the ground tissue, in which three regions may be distingulshed—the central portion, or pith, the outer portion, or cortex, and the parts lying between each pair of strands, the medullary rays. In older stems it will be found that the strands tend to unite laterally, forming what looks like a continuous cylinder, the medullary rays being proportionally narrowed.

The strands are known as fibro-vascular bundles. By sectioning an uninjured strand, the detailed structure can readily be made out by means of the microscope. There are (1) an internal region, the wood, consisting of lignified tubular members or cells; (2) an extremely delicate layer of thin-walled cells, rectangular in cross section: this is the cambium or growing layer, and (3) externally, the bast, composed in our example of inner soft bast and outer hard bast. In a section stained with haematoxylin and safranin, the wood and the hard bast take the safranin (red) and the ground tissue, soft bast, and cambium the haematoxylin (purple).

The very young twigs of a woody dicotyledon resemble the sunflower quite closely. At an early stage, however, the wood appears as an almost continuous ring, with very narrow medullary rays, which also in many cases become more or less lignified. Commonly about the end of the first season of growth, the cork layer begins to develop, often just under the epidermis, but sometimes deeper, and ultimately everything outside the cork dies and is gradually shed off. Each year of growth sees the development of a new ring of wood, to the outside of that already formed. New bast is also formed on the inside of the older portions, these being crushed and disorganised by the pressure due to the increasing diameter of the stem. The new wood and bast are both produced from the cambium, which persist as long as the tree continues to grow. (The formation of the bark of trees is a complicated process, into which it is not necessary to enter).

For a typical monocotyledon we may glance briefly at the stem of the maize or Indian corn. Like a dicotyledon it shows in cross-section numerous fibro-vascular bundles embedded in ground tissue, but we note as peculiarities (1) that the bundles are not arranged in a ring, but are scattered irregularly throughout the ground-tissue, (2) that while each bundle resembles that of a dicotyledon in having bast externally and wood internally, it differs in the important fact that the cambium is absent; and (3) that a very considerable part of the ground-tissue, especially towards the exterior of the stem, is thick-walled and lignified. (Figures illustrating ordinary stem structure may be found in almost any botanical text-book).

It is perhaps among hydrophytes that we shall find the widest departures from the typical structures briefly described above. With so wide a choice it is difficult to fix upon an example, but let us take first the stem of *Potamogeton natans*, one of our commonest pond-weeds, growing in almost every loch and river where the current is not too strong. We shall first describe its structure, and then point out how this is related to its habitat. When taken from the water the stem is seen to be brownish in colour, very flexible, and of a very open texture, except for a distinct strand running along the centre, and having a diameter of about one eighth of that of the whole stem. It is not at all easy to make satisfactory sections of such a delicate structure, but, when made, a transverse section shows the following parts:—(1) A single-layered epidermis, with a feeble development of cuticle: (2) a broad cortex, forming by far the larger part of the section: and (3) the central cylinder. The cortex is very peculiar, and consists, as seen in transverse section, of a lace-like network composed of rows of cells, with large rounded or irregularly shaped spaces between them. The fact is that the cortex, instead of being a more or less compact tissue, as in a typical herbaceous stem, is of a spongy nature, containing large cavities which are separated by walls one cell thick, hence the lace-like appearance in transverse section. In the angles of the mesh a few thick-walled elements are occasionally seen. These cavities are of various lengths, and are separated at irregular intervals by approximately horizontal walls, fragments of which may often be seen in transverse sections. Towards the centre of the stem the cortex becomes more compact, and its innermost layer of cells, next to the central cyclinder, has the cell-walls distinctly thickened on the inner side. This layer is known as the endodermis, and is not often distinctly marked in stems, though it is usually quite conspicuous in roots.

As *Potamogeton* is a monocotyledon we might naturally expect the central cylinder to resemble the stem of the maize in structure, but at first sight the resemblance is not apparent. Careful examination, however, shows the presence of about eight fibro-vascular bundles, arranged in a somewhat irregular ring, but only cavities are found in place of the large wood elements. These bundles are set in a ground-tissue composed largely of thin-walled cells containing starch, with a few thick walled elements (fibres) in the neighbourhood of the bundles.

(For a figure of a transverse section of the stem of *Potamogeton natans* see De Bary, "Comparative Anatomy of Phanerogams and Ferns," p. 368).

These peculiarities in the stem of *P. natans* are distinctly related to its habitat. The following points are worthy of consideration :—

1. The cuticle of an ordinary plant is impervious to water, and its main function is to prevent the drying-up of the tissues beneath it. Living as it does, submerged in water, *P. natans* is not exposed to the risk of desiccation, and hence has little need of cuticle, which is in consequence feebly developed.
2. The larger intercellular spaces of the cortex contain air during the life of the plant. They thus act as floats and keep the stems and leaves supported in the water—the plant does not lie like an inert body on the bottom, but floats and waves to and fro in any current that may exist, and the leaves are thereby brought into contact with the largest possible volume of water—an important matter for a submerged plant which has to obtain its gaseous food from the air dissolved in water ; and, in addition, there can be little doubt that the air in the cavities serves as a source of such gaseous food.
3. The concentration of such hard material as exists into a central cylinder is a mechanical adaptation to the plant's habitat. The strains and stresses to which a plant growing in water is exposed are mostly longitudinal, and are thus different from those of a plant growing in air, which are largely transverse. To meet these latter strains, and to support the weight of the plant, a girder-like or cylindrical arrangement of hard tissues (wood, etc.), is best adapted, but for longitudinal strains an arrangement akin to a wire or string is more suitable.
4. The wood of a plant, or the young wood of trees, is the water conducting tissue, as can be readily shown by a few simple experiments. Clearly, a plant submerged in water has little need of water-conducting tissues, hence we can easily understand why wood is feebly developed in our type.

An interesting plant for comparison with *Potamogeton natans* is the Marestail (*Hippuris vulgaris*), an inhabitant of bogs and marshes in many parts of Perthshire, particularly in the higher regions. (This plant is not to be confused with the Horsetail (*Equisetum*), several species of which are very common, some growing in marshes and ponds). The chief differences of stem structure lie in the central cylinder, which consists of (*a*) an outer ring of bast ; (*b*) an interrupted ring of wood ; and (*c*) ground tissue forming a central pith. The more obvious arrangement of these tissues in rings is due to the fact that the Marestail is a dicotyledon, while the pondweed is a monocotyledon.

Another common hydrophyte showing special features is the Bog-bean (*Menyanthes trifoliata*), almost universally distributed throughout the marshes of Perthshire and many other districts. Its beautiful flowers make it conspicuous wherever it grows, and its former use as a medicinal herb has made it widely known. The plant consists of a stout rhizome or root-stock, really a modified stem, growing on or near the surface of the mud, and attached thereto by short thick roots. The leaves (and flowers) are not submerged but stand up above the surface of mud or water. The root-stocks usually form a dense tangle, as may be seen occasionally when the mud has been washed away by a flood or by the action of waves on the margin of a loch. They are half-an-inch or more in thickness, and somewhat swollen at the nodes like a miniature rattan cane. A transverse section shows a comparatively broad cortex, which, like that of the pondweed, is of a spongy texture, but the air spaces are smaller and much more numerous. The central cylinder is well-marked: there is a ring of fibro-vascular bundles with well-developed wood, and the pith closely resembles the cortex, but is of somewhat finer structure. Here and there a bundle may be seen breaking away externally from the ring—this is a bundle on its way to a leaf. A few thick-walled elements are found in some cases both internal and external to the bundles. There is no definite layer like the endodermis of Potamogeton, marking off the central cylinder from the cortex, but a layer of cells corresponding to the endodermis surrounds each individual bundle. (Plate 2, Fig. 1).

It is fairly obvious that the open texture found in the root-stock of the bog-bean can have no relation to floating, as the organ is attached to the substratum by roots; it is to the deficiency of the air supply, due to the plant's habitat, that we must look for an explanation of this structure.

Before leaving the subject of hydrophytes, I should like to refer for a minute or two to the water-lilies. These plants, as everybody knows, grow in still or slowly running water, the leaves floating on the surface and the flowers projecting above it. For our present purpose the chief interest lies in the leaf-stalks or petioles, which in the white water-lily are cylindrical, half an inch or so in thicknes, and in the yellow water-lily somewhat flattened, and considerably thinner. As the true stem, rhizome, or root-stock, of the plant grows attached to the mud at the bottom of the water, the leaf-stalks must be about as long as the water is deep. They are very flexible, so as to adapt themselves to minor alterations in the depth of the water, and so keep the leaves always on the surface; while at the same time they are very light, so that they are readily supported by the water, and do not tend to drag the leaves below the surface. The leaf-stalk of the white water-lily may be considered first. A transverse section shows the following structures:—

1. An epidermis with, as usual in water-plants, a very thin cuticle.
2. A layer of ground tissue, several cells thick, small celled externally, the cells gradually increasing in size towards the interior of the stalk.
3. Embedded in this layer, nearly but not quite touching the epidermis, are isolated lignified cells, forming a thin, scattered ring.
4. The general ground tissue, with relatively enormous air-spaces, separated by walls which are usually several cells thick. Projecting from the walls into the spaces are the so called "internal hairs"—branched lignified cells of a very curious and striking appearance. (It is difficult to imagine what part these hairs play in the economy of the plant, but as their walls are impregnated with calcium oxalate, a (probable) waste product which often appears in the tissues of plants in the form of crystals, one function would appear to be the storage of this material.)
5. Bundles of a somewhat peculiar type forming an interrupted ring in the region between the outer compact ground-tissue and the inner spongy region. Others are more irregulary distributed in the spongy tissue, lying in the masses of tissue formed by the junctions of the walls of the air-spaces. In all the bundles the woody portions are absent or feebly developed.

For comparison with this we may take a transverse section of the leaf-stalk of the yellow water-lily found in Methven Loch and elsewhere. It differs mainly in shape and size, but we may note the absence of the sub-epidermal layer of lignified cells, and the fact that the partitions between the air-spaces are only one cell thick. The internal hairs are very striking and numerous—they may be seen to originate from cells lying at the junction angles of the partitions, the same cell sending out projections into two or more adjacent air-spaces.

The point I desire to emphasise is that the structure of these leaf-stalks, as revealed by the microscope, is ideal for giving the combined lightness and flexibility required by the habitat and habit of growth of the plants in question. (Plate 2, Fig. 2).

Let us now pass on to consider a few structures typical of xerophytes. As might be expected, these are not so common among native plants as hydrophytes—the climate of Scotland does not tend towards xerophytic conditions!—nevertheless we can draw a few examples from native plants. Let us realise at the outset that the great object in life of a xerophyte is economy of water. This is effected by numerous devices, and by modifications of internal structure, some of which will be discussed later in the present paper. In an ordinary plant there is a steady flow of water through the organism, the water absorbed from the soil by the roots being evaporated from the leaves, chiefly through the stomata, in the process known as transpiration. This process is most active where growth is most active, and is reduced to a minimum when the plant is dormant, as, for instance, in deciduous trees in winter. The structure of a normal leaf is such as to enable the process (as well as other functions of the leaf) to be carried on efficiently. It consists of a system of more or less complete vascular bundles, which are in direct communication with those of the stem, embedded in cellular tissue, often composed of an upper compact layer and a lower spongy layer, with numerous air-spaces, the whole being enclosed in an epidermis, the external walls of the epidermal cells being more or less strongly cuticularised. Piercing the epidermis are numerous minute openings, the stomata or breathing-pores, which may be found on both, or either, of the surfaces of the leaf. These stomata are capable of opening or closing under varying conditions of light, temperature, etc., and it is through them that transpiration mainly takes place. An obvious method of reducing transpiration, then, would be a reduction in the number of the stomata by the reduction of leaf-surface. But leaves have other functions besides transpiration, and leaf-surface cannot be reduced indefinitely unless other arrangements are made for carrying on these functions. The common broom (*Cytisus scoparius*) will teach us something on these points. Growing as it often does, on sandy banks, heath etc., the water supply of this plant must often be precarious, and, except in its seedling stages, it is practically leafless. A transverse section of a young twig will show how the broom has solved its problem. The internal structure of pith, wood, and bast is quite normal, but towards the exterior we find a comparatively thick layer of soft tissue, running out into five points, which are the sections of five ridges which run along the stem. Each ridge is strengthened by a strand of lignified cells. In the fresh state this soft layer is found to be richly laden with chlorophyll, the green substance of leaves, and one without which the leaf cannot carry on its most important function. We guess then that the functions of the leaf have been taken over by this external layer of the stem, and our conjecture is confirmed by the presence of stomata on the epidermis. In this way the broom has secured for itself a considerable reduction of transpiring surface, without sacrificing the other benefits conferred by leaves.

It has already been mentioned that the cuticle of a plant is impervious to water—it is like a waterproof layer, checking evaporation from within as well as saturation from without. The thicker the cuticle the more effective it will be, and thus we find that one of the commonest plans adopted by xerophytes is a thickening of the cuticle. The "needles" of pine-trees are a case in point. They supply us with a very good example of a reduction of transpiring surface, for obviously the surface of a pine-needle is much less than that of a typical leaf, and in addition, illustrate what was said about thickening of the cuticle. A section of the leaf of *Pinus sylvestris*, the Scots pine, shows several points of interest, of which the following may be mentioned.

1. The cuticle is thick everywhere except over the stomata: these consequently lie in a depression, and their activity is doubtless modified by this fact.
2. Under the epidermis there is a layer of strongly lignified cells.
3. The cells composing the green tissue have their walls infolded into numerous depressions. This is possibly to give each cell a greater than normal surface, and thereby to make up for the reduction of leaf surface.

There is a well-marked central cylinder—unusual in leaves—but this does not concern us at present.

It is, however, to desert plants and to natives of regions with a long dry season that we must turn for the most extreme xerophytic characters. A visit to the appropriate house at Kew or other botanic gardens will show a perfect nightmare of xerophytes. Among other characters we may note plants without leaves, but with green succulent stems which carry out the leaf-functions, and in addition store up the precious water; plants of every degree of spikiness and thorniness; plants with sword-shaped leaves of surprising toughness, pointed like needles, and so on in endless variety; and not the least surprising fact is that plants of totally different natural orders have come to resemble each other closely in their external features, owing to their being developed in the same environment. Such a house is a perfect elysium to a microscopist, for he knows that almost every plant will furnish material of the highest interest. We have only time to refer, more or less briefly, to a few of the exotic plants which show more or less xerophytic characters. *Cycas revoluta* has its stomata not only at the bottom of comparatively deep pits, but each pit is roofed over, with the exception of a small aperture, by a projection of the cuticle all round it. In *Dasylirion acrostichon* the sides of the pit bear projections of cuticle, which almost block up the passage to and from the stoma. A more familiar plant is *Phormium tenax*, the New Zealand flax, which can be grown out-of-doors in the more temperate parts of Britain. A native of New Zealand, a country with a fairly equable climate, it is not so typically xerophytic as some plants we have mentioned, but a transverse section of one of its sword-shaped leaves shows the following points of interest:—

1. A (morphologically) upper epidermis.
2. Soft tissues (assimilatory), small celled and compact towards both surfaces, with slightly larger cells and air spaces towards the middle.
3. Fibro-vascular bundles, the larger ones with well-developed wood and bast; the smaller ones, which lie towards the lower surface, imperfect.
4. Surrounding each bundle is a sheath of fibrous tissue, the cell-walls being strongly lignified. Strands of fibrous tissue also occur near the lower epidermis. It is these fibres which give the plant its economic value.
5. A (morphologically) lower epidermis, with well-developed cuticle and sunk stomata lying in furrows.

This large development of fibrous tissue is another common xerophytic character.

With one other example I must conclude this part of my paper. It is taken from Australia, the land, *par excellence*, of xerophytes apart from tropical and sub-tropical deserts. The plant in question is *Hakea suavolens*, a member of the natural order, *Proteaceae*, a large order with about 50 genera, practically all of which are natives of regio s where there is a long dry season, and which have developed xerophytic characters in an extreme degree. In *H. suaveolens* the leaves are practically reduced to midribs, forming what is termed the centric type.

The epidermis in a section of such a leaf is seen to be well cuticularised, and the stomata are deeply sunk, the cavities being arched over, much as in *Cycas revoluta*. Under the epidermis we have a palisade layer, composed for the most part of two layers of relatively long narrow cells set at right angles to the epidermis; many of the cells, however, are so long that they abut on the epidermis at one end, and on the central cylinder at the other. The central cylinder is composed of three large complete bundles of wood and bast and several smaller ones, each with its sheath of hard tissue, embedded in a ground tissue of uniform cells. (Plate 3, Fig. 1).

In conclusion, I want to utter a word of warning which might perhaps have appropriately come earlier It is this: there are no hard and fast lines between mesophytes, hydrophytes, and xerophytes. We must not expect to find all hydrophytic characters in all water plants; every water-plant is not a typical hydrophyte; neither is every plant growing in a dry situation a typical xerophyte. All that we can say is that many plants growing in wet situations show remarkable adaptations to their habitat, and similarly for plants of dry situations. Some of these adaptations I have endeavoured to describe, largely from one point of view. The examples I have chosen might be varied almost indefinitely:

they have been chosen simply because of the material at my disposal; they best illustrate the points I wish to discuss. To deal fully with the characters of hydrophytes and xerophytes would require, not a paper, but a large volume, but I hope I have said enough to show you that the subject is full of interest.

In the second part of this paper I propose to deal with anomalies as illustrated by climbing plants, and with some peculiarities in the secondary thickening of stems.

Part II.

In the former part of this paper I dealt with a number of anomalies of plant structure which were intimately related to the habitats of the plants in question; in this second and concluding portion I propose to discuss a few peculiarities which arise from, or are correlated with, not the habitat, but the habit of growth of the plant. (By the term "habit of growth" we mean the general form taken by the plant, as, for example, when we speak of a plant as creeping, erect, a climber, etc.) The connection between peculiarities of structure and the habit of growth is not always obvious or easy of explanation, and indeed in many cases we are to a large extent in the dark as to the why and wherefore of certain phenomena. We also find ourselves face to face with problems analogous to those preferred to the former part of this paper. If certain structures are of obvious advantage to plants growing in water, why do not all water plants possess these structures, and why, again, if some peculiarity is of marked advantage to climbing plants, why is it not found in all climbers? Or, again, if certain members of a family exhibit structures advantageous to climbing plants, why do these structures appear in those members of the same family which do not possess the climbing habit? In cases of this kind we can only fall back upon general principles. Nature is not tied down to any one method of achieving her end, but may attain the same result by varied methods. Structures in a non-climbing plant which are apparently connected with the climbing habit, may be inherited from a climbing ancestor, and so on.

Climbers are pre-eminent as examples of anomalous stem structure, and these structures appear in many instances to have one object in view, that is, to prevent undue pressure upon, and crushing of, the soft tissues, and particularly of the soft bast—this tissue being of supreme importance to the plant, for by it the elaborated sap, the real plant food, travels to all growing and storing regions. Any serious interruption of the supply would be fatal to those parts which were cut off by the interruption, and there might be serious interference with the vital activities of the plant. Consideration will show that this is an accident to which climbing plants are particularly liable. They are, for the most part, plants of slender growth, the length of stem being often enormous in comparison with the diameter. Hence abrupt bendings of the stem may take place with comparative ease, through failure of the support, or for other reasons. Perennial twining plants may also be subject to enormous stresses by the increase in diameter, due to growth, of the tree or branch around which they twine. Hence we find not only that the stems of many climbing plants show peculiarities in their primary structure, but also that their increase in thickness is effected by abnormal methods. It will therefore be convenient to deal with our subject in two sections, giving first some examples of anomalous primary structure, and afterwards some of anomalous secondary thickening.

Let us commence with a very familiar plant, the vegetable marrow. A transverse section of the stem shows two rings of bundles, set in ground-tissue, and surrounding a central cavity formed by the disappearance of the pith, and hence known as the pith-cavity. This existence of two distinct rings is in itself a peculiarity of structure common in climbers, and more will be said about it later. The point to which I wish to draw your attention is that each bundle has got two well-developed bast strands, one in its normal position outside the wood, and the other in an abnormal position inside the wood. The vegetable marrow has, in this respect, two strings to its bow, and we can easily conceive circumstances in which the normal (outer) bast might be injured —crushed or ruptured—while the inner might remain to carry on its function Bundles of this kind are termed bicollateral, and they are found in practically all members of the cucumber family, to which the vegetable marrow belongs.

A section of the stem of the common field-convolvulus (convolvulus arvensis), shows a somewhat similar structure, but there is only one ring of bundles, which are not isolated as in the vegetable marrow, but are so closely connected that the internal bast forms an almost continuous ring, surrounding the somewhat scanty pith.

Another interesting plant is *Lycium barbarum*, or Kaffir thorn (also known as the Duke of Argyll's tea-tree) a somewhat thorny plant, a native of South Africa, but quite common in gardens in mild situations. I have found it growing freely as a garden escape near Dublin. It is a member of the *Solanaceae* (potato family), and its bright blue flowers are exactly like potato blooms in miniature, and when growing luxuriantly over an old garden wall it presents a very pretty sight. The stem differs from the two previously mentioned in being woody, and a transverse section shows a ring of close-grained, compact wood, with a complete ring of bast situated both internally and externally. It is interesting to note, in this connection, that the potato, though not a climber, has bicollateral bundles. It is a plant, however, which has climbing relations, *e.g.*, the common bitter-sweet, *Solanum dulcamara.* (Plate 3, Fig. 2).

An interesting natural order, from the point on view presently under consideration, is the *Apocynaceae*, of which the best-known, and perhaps the only genuine British member is the common periwinkle, *Vinca Minor*. The stem of this plant shows several pecularities worthy of notice. For our present purpose, however, it will be sufficient to note that inside the ring of wood, but quite separate from it, there is a ring of bast strands, so regular and delicate in appearance that when suitably stained the adjective "dainty" alone meets the case. An exotic member of this order, *Apocynum cannabinum*, resembles rather the type of *Lycium barbarum*, having a complete internal ring of bast closely connected with the wood.

In another set of stems the soft bast is quite normal, lying to the outside of the wood, but it is protected by an outer layer or set of strands of hard material. This arrangement is quite common even in the stems of non-climbing plants, *e.g*, in the sunflower, where a strand of hard bast lies to the outside of each bundle. There is frequently, however, a more complete developement in climbers, where the hard tissues tend to form a complete ring, as in some species of clematis. The classical example is the genus *Aristolochia*, one species of which, *A. clematitis*, is naturalised in England, though the same or a similar species is commonly grown in gardens, where its handsome leaves make it very conspicious. A transverse section of a young stem shows a very distinct ring of hard tissue, completely surrounding the vascular bundles (which have no hard bast) and separated from them by a layer of ground-tissue several cells thick. This ring of hard tissue is very distinctly marked off from the cortex proper, and lies in the region which is known as the pericycle.

It was mentioned above when dealing with the vegetable marrow that the occurrence of a second ring of bundles inside the normal one was a phenomenon characteristic of many climbers. Some of the best examples are drawn from exotic genera, and like many other pecularities, this one tends to run in families. The pepper family, *Piperaceae*, is a huge natural order of about 1050 species; the genus *Piper* alone has 600 species, mostly climbing shrubs. The familiar condiment is prepared from the fruit of *P. nigrum* All are natives of tropical countries. (It may be mentioned in passing that the British water-pepper does not belong to this order. Curiously enough, a South African friend brought me specimens of "wall-pepper," which proved to belong to a totally different order, and its stem though interesting, showed no structures bearing on the present subject). Of the two species of *Piper* which I have examined, *P. nigrum* and *P. geniculatum*, both show an inner ring of bundles embedded in the pith, and hence called "medullary bundles," in addition to an outer ring, which, in the young state is quite normal, and which alone undergoes secondary thickening. These medullary bundles originate in quite a simple way. In a typical dicotyledon, the bundles which enter the stem from the leaf, or leaf stalk, all penetrate to the same depth, and then, turning downwards, give rise to the familiar cylinder of bundles, which appears as a ring in transverse section. In plants with medullary bundles, however, the bundles from the leaf-stalk penetrate the stem to varying depths, and then, turning downwards, form two or more rings, which are often somewhat irregular. Thus the outer ring of bundles, especially after secondary thickening has begun, may act as a protection to the inner ring, especially as the outer ring is usually more complete and compact, at all events in the woody plants which possess medullary bundles. (Plate 4, Fig. 1).

The process of secondary thickening has been referred to more than once, and it may perhaps be well, before proceeding further, to describe this process briefly, in order that the anomalies about to be discussed may be the more readily understood. When describing a typical dicotyledonous stem it was pointed out that, between the wood and bast of the normal bundle, there lies a layer of exceedingly delicate thin-walled cells—the cambium layer. It is this layer which is responsible for secondary thickening, *i.e.*, the gradual increase in thickness of the stem. The first step is the formation of cambium across the medullary rays, in such a way as to join up the separate cambiums of the bundles into a complete ring. The cells of this ring then proceed to divide in two ways (1) at right-angles to the surface of the stem—by this means the ring maintains its own continuity, as its diameter increases with the growth of the stem (2) parallel to the surface—by this means new wood is continually, during the period of growth, formed internally, and new bast externally, the former much more abundantly and regularly. In this way a ring of wood is added to the stem for every period of growth. By the increase in the diameter of the stem the older bast, cortex, and epidermis become stretched and disorganised, and a new protective covering, the bark, is developed to prevent exposure of the internal tissues. In the trees and shrubs of temperate climates each year's wood forms a well-marked ring—the familiar annual rings seen when a tree is cut down. The primary medullary rays are maintained by the cambium, though usually much narrower than they are originally: new medullary rays are also started.

We find departures from this normal method of secondary thickening in a vast number of climbers. Again, our best examples are drawn from exotic orders. Let us consider one or two members of the natural order *Nyctaginaceae*, an order which has no British representatives, but which is not very distantly related to the pink family. The plants are natives of tropical regions, especially tropical America, but two general at least, are well-known in cultivation, *Mirabilis* and *Bougainvillaea*. *Mirabilis jalapa* is the well-known Marvel of Peru; *Bougainvillaea* is commonly grown in conservatories, its bright petaloid bracts rendering it very showy, although its real flowers are quite inconspicuous. In *Mirabilis* the vascular structure of the stem is somewhat complicated, owing to the varying depths to which the leaf traces penetrate the stem, and to the peculiar way in which the various parts of the leaf trace unite at the nodes. These primary bundles do not undergo secondary thickening, but at a comparatively early stage a ring of cambium* is formed in the ground tissue outside the bundles, and this proceeds to form new *bundles* (not simply *wood*) internally, the tissue between the bundles becoming lignified, and looking at first sight like a normal ring of wood.

This appearance is more striking in *Bougainvillaea*, the lignified ground tissue becoming intensely hard and difficult to cut, and resembling under the microscope a close-grained wood, from which it is distinguished chiefly, as seen in transverse section, by the embedded bundles. A more effective way of protecting the bast can scarcely be imagined; and strange to say a somewhat similar phenomenon occurs in the stems of Chenopodiaceae, an order which includes numerous common weeds, none of which are climbers, and the common garden beet—the familiar rings in the root of this plant being due to the activities of successive cambium rings. (Plate 4, Fig. 2).

Similar in principle, but differing in detail, is the mode of development which is found in the well-known Wistaria, and several other less familiar plants. In these cases the young stem is quite normal, but after secondary thickening has proceeded for some time the activity of the cambium ceases, and a new cambium is formed in the outer region of the bast. This new ring then proceeds to develop wood internally and bast externally, till in turn it is superseded by a third cambium ring, and so on.

But perhaps the most curious arrangement is that found in the genus *Strychnos*, one of whose members, *S. nux vomica*, is the source of strychnine. The plants of this genus show in the young state a ring of bicollateral bundles, secondary thickening produces a ring of wood with

* Strictly speaking this ring should not be called cambium, A normal cambium produces wood internally and bast externally, abnormal layers of this kind are more accurately termed merismatic or meristematic layers, but the term cambium may be used in a general sense.

narrow medullary rays. The peculiarity lies in the fact that the cambium produces somewhat irregularly, and externally to the wood so far formed, masses of secondary bast, in addition to the normal layer. At the points where these masses have been formed, the cambium then ceases to be active, but a new layer is formed from cells somewhat nearer to the surface of the stem, in such a manner that the continuity of the ring is restored. Growth then proceeds normally till a further interruption occurs, and the final result is that these large strands of bast become entirely surrounded by wood, and from their isolated appearance as seen in transverse section they are known as bast islands. These plants have therefore bast in three different situations: (1) internal to the wood (2) external to the wood, and (3) embedded in the substance of the wood.

In many tropical climbers, especially lianes of the order Sapindaceae, several cambium rings are developed side by side, each giving rise to its own set of tissues, so that the stem comes to consist of three or more rings of wood, etc., and presents the appearance of several stems fused together.

Less peculiar are the irregularities of development of wood found in several species of *Piper*. The stems of this genus of plants have already been referred to, and it will suffice to say here that secondary thickening is not absolutely normal, but unequal amounts of wood are developed at different parts of the circumference, so that in transverse section the wood has a lobed or undulated outline, the bast dipping into the depressions and following the outline of the wood. In other plants this irregularity of development is carried to an extreme degree, so that the wood comes to have a cruciform or even stellate outline.

In the general description of the structure of a stem in Part I, it was noted that the vascular bundles of monocotyledonous stems have no cambium layer. As a consequence of this the vast majority of monocotyledons undergo no secondary thickening—this is well illustrated in the stems of palm-trees, bamboos, etc., which when once fully formed retain the same thickness throughout their life. There are, however, a few monocotyledons, chiefly arboraceous *Liliaceae*, which do undergo secondary thickening, and in a certain sense such plants are doubly anomalous; first, in undergoing secondary thickening at all, and secondly, because, having no cambium in their bundles, they proceed on a plan totally distinct from that of dicotyledons. Perhaps the best known example is the dragon-tree, *Dracaena draco*, the source of the resin known as "dragon's blood." The central portion of the stem of this plant is almost typically monocotyledonous; it differs from the maize, however, in the fact that the bundles are concentric, the bast being entirely surrounded by the wood, and in the fact that there is little or no lignified ground-tissue in this region of the stem. Towards the outside of the stem, but still a considerable distance from the surface, a layer of meristem, or growing tissue, appears. As in the case of the Nyctaginaceae and other plants mentioned above, this growing layer should, strictly speaking, not be called cambium, because it does not produce wood internally and bast externally. It has, however, all the appearance of cambium, and this term may be applied to it in a general sense. From this layer are developed, on its inner side, numerous complete concentric fibro-vascular bundles, which, with the intermediate ground tissue, here strongly lignified, give rise to a compact ring of tissue. mainly of a woody nature, which gradually increases in thickness as the stem grows older. There used to be a famous dragon-tree at Teneriffe, but it was blown down about 50 years ago, being then nearly 15 feet in diameter, so that the above process of secondary thickening, if anomalous, is certainly effective.

This is the last of the examples which I propose to bring before you on the present occasion. I was encouraged in the selection of this subject by the fact that it is one which is ignored or slightly treated in the ordinary botanical text-book, and yet it is one which is full of interest and one which offers a wide field for further investigation.

DESCRIPTION OF PLATES.

Plate I., Fig. 1. Central portion of Rhizome of *Menyanthes trifoliata*, showing fibro-vascular ring, with lacunar cortex and pith, as seen in transverse section.

Plate I., Fig. 2. Portion of Transverse section of leaf-stalk of yellow water lily, showing air-spaces, fibro-vascular bundles and internal hairs or idioblasts.

Plate II., Fig. 1. Transverse section of leaf of *Hakea suaveolens.*

Plate II., Fig. 2. Portion of Transverse section of stem of *Lycium barbarum*, showing internal and external bast.

Plate III., Fig. 1. Portion of Transverse section of stem of *Piper geniculatum*, showing ring of medullary bundles and normal ring. At the bottom left hand corner is the commencement of an irregularity in the development of the wood.

Plate III., Fig. 2. Portion of Transverse section of stem of *Bougainvillaea glabra*, showing medullary bundles and broad band of hard tissue containing numerous bundles embedded therein.

The sections are uniformly magnified approximately 30 diameters.

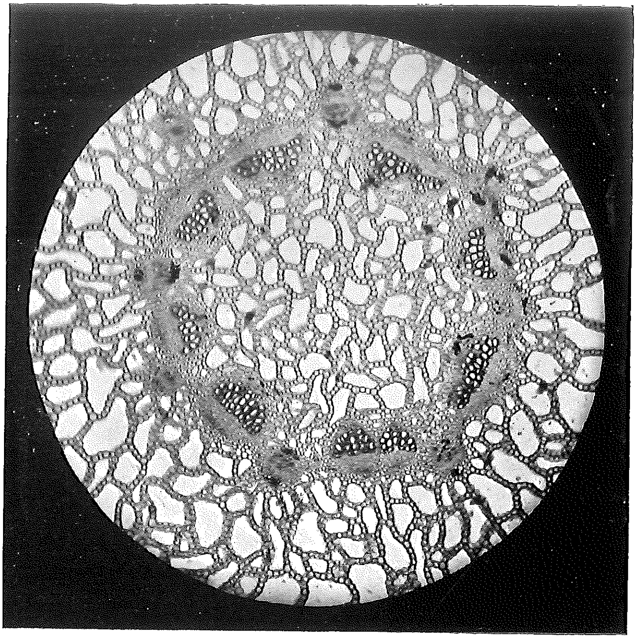


Plate 2, Fig. 1.

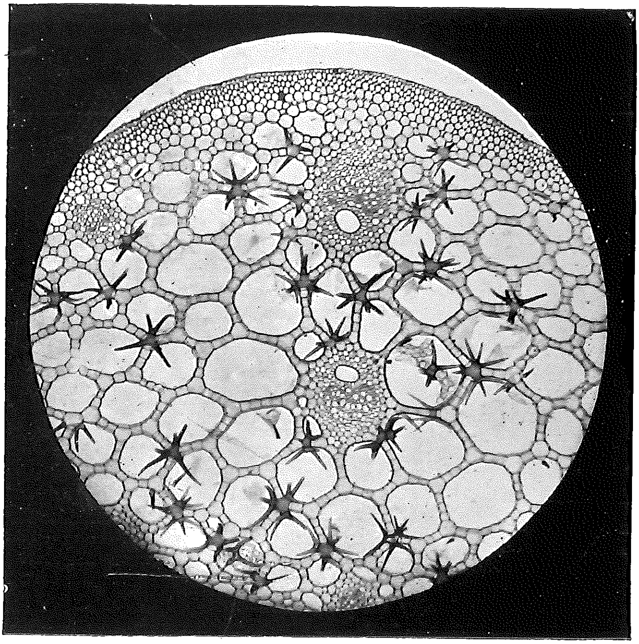


Plate 2, Fig. 2.

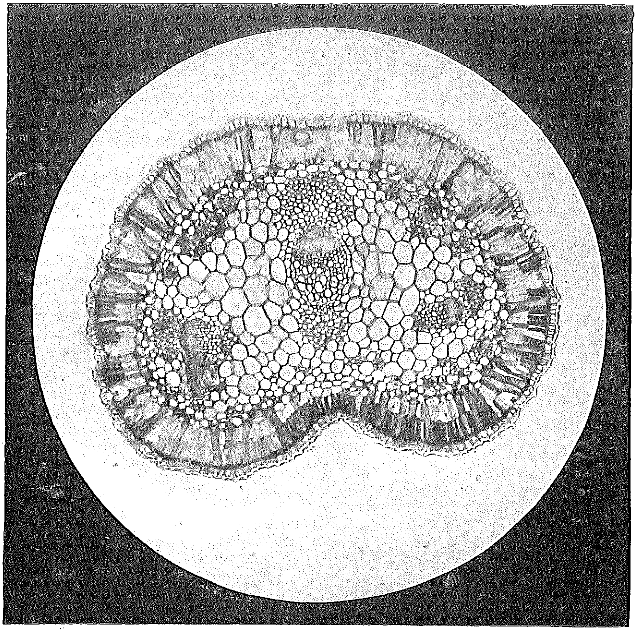


Plate 3, Fig. 1.

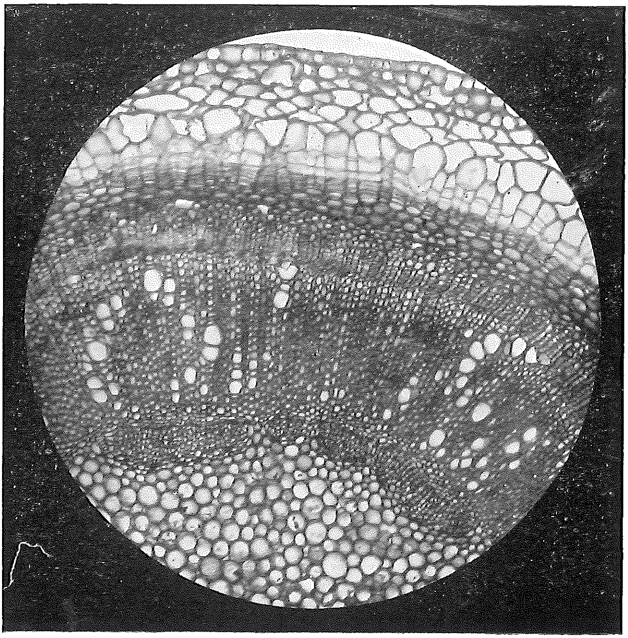


Plate 3, Fig. 2.

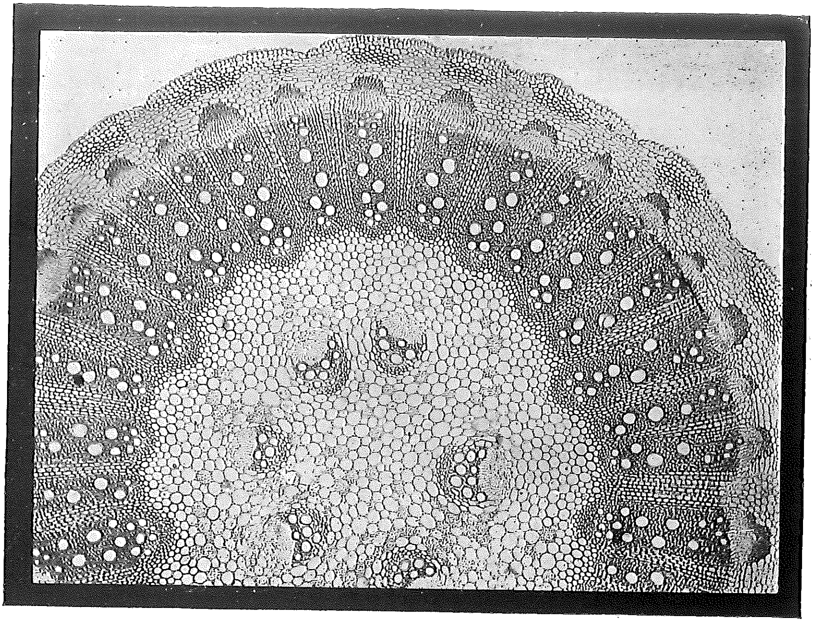


Plate 4, Fig. 1

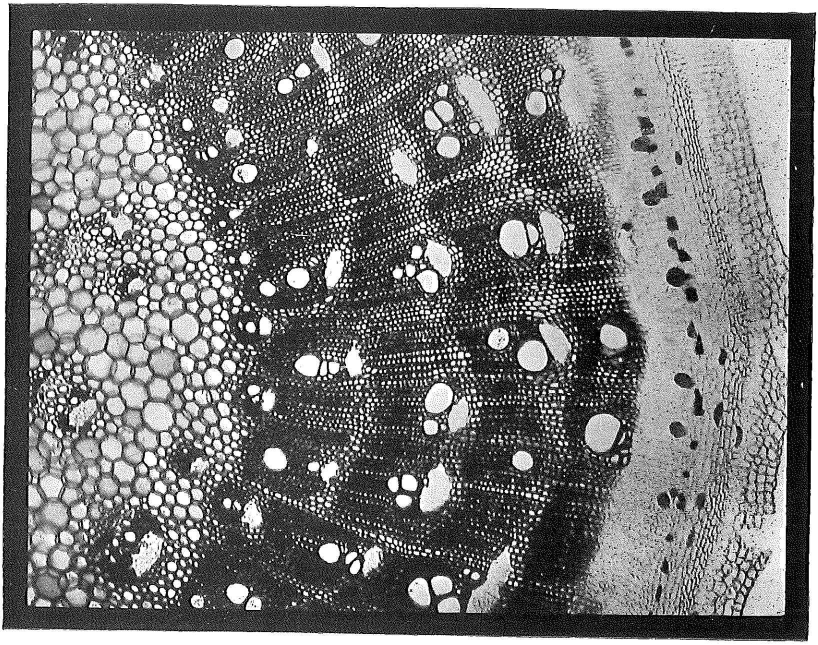


Plate 4, Fig 2

V.—*Facts and Fallacies about Foods.*

By Dr. C. PARKER STEWART, M.O.H.

(Read 12th December, 1919.)

There seems to be almost an innate feeling, widely prevalent particularly amongst the less well-to-do classes, that it is mean or wrong to think much about what one should eat, and yet, it is not overstating the case to say that national prosperity depends much more closely upon the kitchen than is at all appreciated. The health, vigour and working capacity of every member of the family are decided by it.

Now, without further preliminary remarks, I will proceed to the subject by asking the question, "What is Food"? To answer this question I take this illustration—a very old illustration, but nevertheless good, because it fairly represents to us a true basis on which the answer to the question can be given. My illustration is that of the steam engine, one constructed on the best and most scientific principles. We all know that the engine, however well constructed, will stand till the crack of doom, without turning a wheel, or moving a piston, with a heat corresponding to the air with which it is in contact, unless *something* is applied to it other than the mechanism of which it consists. We deal in fact with an Inanimate object—a thing of no Life—a thing without Power. That *something* we call Energy, or the power of doing work.

How do we supply that energy? We all know the answer. Fuel in the shape of coal or oil is put into the furnace—the fire burns, steam is raised, and it is soon at high pressure. The release of the steam into the cylinders sets the piston rod in motion, which in its turn moves the wheel. The engine now, as we may put it, is possessed of life—this power of doing work being derived from the combustion of the coal or oil. Now what does this burning of coal imply? Coal consists of $\frac{3}{4}$ of Carbon, or as more commonly known—charcoal. Now Carbon has a great attraction for Oxygen—a gas which is present in the atmosphere to the extent of 20%—and when Carbon is placed in such a situation that it can combine with the oxygen of the atmosphere the result of the chemical combination is the development of heat and the formation of Carbonic acid gas. The result of the fierceness, so to speak, of the force with which the particles of oxygen and carbon collide with one another, on entering into combination, is to produce heat. It is this combination then, of carbon in the coal and oxygen in the atmosphere, which produces in the steam engine the energy or the power of doing work.

Consider then the engine in working order. It expends its energy in a multitude of ways, and we know that the amount of work it will accomplish will depend upon the quantity of fuel consumed, or in other words, there is an absolute relationship between the amount of work the engine can do and the amount of chemical combination going on in the furnace. There is another thing it is well to note in regard to the engine. The mere shovelling of coal into the furnace will not keep your engine going indefinitely. The engine requires constant attention on the part of the engineer. Every rise of the piston, every turn of the wheel implies tear and wear. In short, the doing of work implies not only expenditure of fuel in the furnace, but the waste of the working parts of the engine, and in order that the engine may be kept in good working order, not only must the engineer supply fuel, but he must repair the waste.

Similarly with the human engine. The human body has the power of doing work. I do not necessarily imply manual labour only, though that, of course, is apparently the most pronounced way in which the human body can do work. For instance, take a person lying still—the heart beating regularly, the chest rising and falling sixteen times a minute. He may be lying awake, uttering no sound, but, through his eyes, taking note of the pictures on the wall; or he may be lying with his eyes closed, thinking of business or other problems. In all these ways the man is doing work—the muscles of his chest are doing work, the nerve cells of his brain are doing work, and work cannot be done unless by an expense of energy. It may interest you if I give you some idea of the large quantity of work a man may do while seeming to do no work at all. I need not take you through the calculation, but suppose the heart beats 75 times a minute, and that with every beat it expels 6 oz. of blood. As the arteries of the body are already filled, and room requires to be made for the additional 6 oz., considerable resistance has also to be overcome. It has been calculated that the heart alone, working quietly and steadily, in this way expends a quantity of energy in 24 hours sufficient to raise one ton to a height of 2400 feet, or one ton nearly half a mile into the air. If we add to this the work done by the muscles of respiration and the energy expended in the form of heat we find this amazing result—that there is daily expended in a human body at rest an amount of energy which, if applied to lifting, would lift a man of 150 lbs. to a height of nearly eight miles. That energy must be obtained from somewhere or other.

In the next place we note as in the case of the engine there is a "wear and tear." Even with the body at rest there is a constant waste going on. No living being can ever exist, or perform the simplest vital act, without entailing waste. You cannot lift an eyelid or move a finger without waste. Every beat of the heart means a waste of its muscular substance, every thought implies a waste of the nerve tissue of the brain, and none of these actions can take place without the organ which works in each case exhibiting waste proportionate to its work. If it works much it wastes much; if it works little it wastes little. I may mention here that the three organs in our body devoted to the getting rid of waste material are the lungs, the skin, and the kidneys. In addition to this internal work there is also external work in the form of manual labour, recreation, etc., implying a larger expenditure of energy and a corresponding degree of waste in the shape of "wear and tear." In these respects then we see that the steam engine and human engine are similar, and that if the human engine is to be kept in good working order material for the supply of energy must be given, and material for the repair of the waste must be provided.

It is interesting to note, however, that there are some very important differences between the steam and human engine. The efficiency of the human engine, that is the proportion of the latent power of the fuel or food which may re-appear as work, is as much as $\frac{1}{3}$ of the whole, while in the steam engine it is not more than $\frac{1}{8}$. The steam engine requires constant care and attention, whereas the human machine is self-repairing, its "wear and tear" being made good from some of the material supplied to it as fuel. The human engine is also more adaptable than the mechanical engine, as it can adjust itself to work economically or otherwise according to the task before it. Lastly, it has the means of storing up a reserve of food energy upon which it can draw for a time to do work when the ordinary supply of fuel or food is temporarily withheld.

These, then, are the functions which food performs:—

(1) To supply energy for performing work,
(2) To replace the losses continually taking place from the body —and I might mention
(3) To maintain the animal heat, or in other words to supply warmth—our clothes are only for the purpose of keeping that heat in—and it is from our food that the heat itself is derived.

And now we can give an answer to the question, "What is Food." Food, then, is a material which yields substances for providing energy for work in the body, or for the repair of the waste of the body, and if any substance does neither of these—if it neither yields energy or material for the repair of waste—it is not entitled to be called a food at all.

We next ask ourselves, "How does the human body obtain energy and from what kind of material"? We have seen that the steam engine was made to work from energy derived by the combustion of coal—a chemical combination of Carbon and Oxygen—causing formation of heat. In the same way energy is obtained for the body. It is perhaps not sufficiently realized that the energy or strength of the human machine is derived from the food consumed within it, in the same sense that the "power" of the steam engine is derived from the coal burnt within it. Operations go on within the human body essentially the same as in the steam engine. Material capable of combining with Oxygen is taken into the body, and the chemical combination produces heat which is the source of energy. This chemical combination is chiefly a combination of Carbon and Oxygen, carbon supplied in our food and oxygen from the air we breathe.

In the next place, what substances yield material for repair of waste in the body? We get our answer when we learn the composition of the body.

COMPOSITION OF THE BODY.

Water,	60	per cent.
Protein,	18	,,
Fats,	15	,,
Carbo-hydrates, Salts	7	,,

Let us consider some of the substances for a moment.

Fats and *Carbo-hydrates* are composed of three elements, Carbon, Hydrogen, and Oxygen, and it is in the way these elements are built together whether the product shall be a fat like butter, a sugar like syrup, or a starch like arrowroot. In the case of the substance Protein—typical examples of which are the white of egg and the curd of milk—we find it differs from the fats and carbo-hydrates in containing another element, viz. :—Nitrogen. Thus, excluding "salts," we come to the conclusion that the human body consists chiefly of four elements, C. H. O. and N.

Fats are one of the great sources of animal heat and energy for work. This quality is taken advantage of by people living in cold climates. When people have to eat a diet in which fat is deficient their health soon gets undermined. Fats are very important in assisting the assimilation and digestion of the other substances of a diet, and in fact protein substances are not properly digested unless in the presence of fat. This may be shown by the administration of small doses of Cod Liver Oil or Olive Oil. It is then given, not so much for the sake of the small quantity of fat in a teaspoonful of oil, but to promote the digestion and absorption of other substances. It thus becomes a remedy in some forms of indigestion. Fats do not directly tend to the upbuilding of the body. Fat is contained in a large number of articles of food—both animal and vegetable.

PERCENTAGE OF FAT IN SOME ARTICLES OF FOOD.

Animal.		Vegetable.	
Lean Beef,	4.5	Bread,	1.
Bacon,	65.	Indian Meal,	5.
Ham,	52.2	Rice,	.3
Cheese,	33.	Oatmeal,	7.
Milk,	4.	Flour,	1.9
Eggs,	10.4	Barley,	2.
Butter,	86.	Dried Peas,	1.5
Margarine,	82.6	Lentils,	2.
Dripping,	96.4	Haricot Beans,	2.2
Mackerel, Herring	7.	Potatoes,	.2
		Turnip,	.15
Salmon,	12.5	Cabbage,	.37
Cod, Whiting, Haddock	.5	Carrot,	.3
		Onions,	.28
		Cocoa,	1.5
		Apples,	.4
		Banana,	.56
		Beer,	Nil.

Carbo-hydrates are largely contained in vegetable sources of food. They have no nitrogen in them, and are therefore not capable of nourishing the tissues of the body by themselves. Within the body they are changed into fat, and largely assist in the supply of heat and energy. The quantity of Carbo-hydrates in animal food is negligible.

PERCENTAGE OF CARBO-HYDRATES IN SOME ARTICLES OF FOOD.

Animal.		Cereal.	
Milk,	5.	Rice,	77.
Cheese,	2.4	Flour,	71.
		Barley,	69.6
Vegetable.		Indian Meal,	69.4
Potato,	19.	Oatmeal,	66.
Onion,	9.8	Bread,	47.
Carrot,	10.		
Turnip,	5.	**Pulse.**	
Cabbage,	5.8	Lentils,	58.3

Proteins. In most animal foods these are present in large amount, but scanty in the vegetable foods. There are exceptions to this rule in the case of many cereal foods such as oats, wheat, and maize, and also in the pulse foods. The latter are very rich in protein but deficient in fat, while the three first-named contain the necessary food-stuffs in good proportion.

Generally speaking the proteins of the vegetable world are not so accessible to us—that is to say, not so capable of assimilation and not so digestible. Without further change we can eat the flesh of an animal and be nourished thereby, but it is difficult for us to get albumenoids from vegetables without cooking, while from many it is impossible even with the aid of cooking to get them. Animals can, however, extract these albumenoids for us. The ox, for instance, is furnished with a stomach which enables it to digest woody fibre and cellulose—substances which defy our stomachs—and convert them into a form easily digestible by us, and with the aid of cooking we have a very cheap and accessible store of albumenoids in the vegetable world.

As I have already remarked, proteins are remarkable on account of containing a large proportion of nitrogen in their structure. The others—fats and carbo-hydrates—contain no nitrogen, and any substance which does not contain nitrogen will not build up the tissues of the body. The special function of protein substances is to build up the body, to repair its tissues, and subserve the purpose in some cases of furnishing warmth and energy, though for the latter purposes they are wasteful food. When animals are fed on food from which protein substances are totally wanting they rapidly lose substance, and die from what is called nitrogen starvation. On the other hand protein substances are not sufficient for carrying on the functions of the body for any time. Gelatine will not keep a dog alive for any length of time. In fact it dies rather sooner than if starved out and out.

We have then seen that the chief elements in the composition of our body are C. H. O. and N., and as proteins are the main source of nitrogen, while the fats and carbo-hydrates are the chief sources of carbon required by the body, it is convenient to estimate diet according to the nitrogen and carbon contained in it. By numerous experiments it has been determined that a healthy man doing an ordinary amount of work needs per day 300 grains of nitrogen and 4800 grains of carbon. If he gets these two quantities supplied to him, he will be able to expend energy in the doing of a good day's work and be able to make good his tissue loss; and at the close of the day he will be in the condition he was in the morning, having neither gained nor lost. In the two bottles before me I have these elements—carbon, a solid; nitrogen, a gas. This bottle contains the daily quantity necessary for a man doing a moderate amount of work, viz. 10 oz., the other contains a sample of nitrogen. But the human body is not designed to take these elements in this form, and this is where vegetable and animal life come to our aid. Vegetation takes up the elements—ammoniacal salts containing nitrogen from the soil and carbon from the air—and works these beggarly elements into the substance of its own body, forming proteins, fats, and starch. In turn cattle introduce this material into their bodies and work it into higher forms. Then man takes the barley and oats and potato, and he makes use of the ox and the sheep, and he builds up this material into the higher structure of his own frame. It is possible that in the future our chemists may have the power of building up these elements, and by synthesis give us foods prepared without the intervention of plant or animal. Personally, I am content to rely on Nature.

In what forms then do we find carbon and nitrogen worked up for our use? The following tables will show you the chief forms of foods that contain these elements:—

CARBONACEOUS FOODS.

STARCHES.	SUGARS.	FATS.
Sago.	Cane Sugar.	Butter.
Cornflour.	Grape Sugar.	Margarine.
Arrowroot.	Beet Sugar.	Dripping.
Tapioca.	Treacle.	Lard.
	Golden Syrup.	Oils (Almond)
	Honey.	,, (Olive, etc.).

These food stuffs contain no nitrogen, and while yielding energy for doing work yield nothing which will repair the tissues.

NITROGENOUS FOODS.

FROM ANIMAL KINGDOM.	FROM VEGETABLE KINGDOM.
Butcher Meat of all kinds.	Beans, Peas, Lentils.
Poultry.	Oatmeal, Flour.
Wild Fowl and Game.	Rye, Barley, Indian Corn.
Fish and Shell Fish.	Rice, Potatoes.
Eggs.	Vegetables and Fruits of all kinds.
Milk.	

There is here a large assortment of substances which contain carbon and nitrogen worked up into a form in which they are fit for use. Now the problem is to take such a quantity of the carbonaceous and nitrogenous foods as will yield us the 300 grains N. and 4800 grains C. It is plain that the carbonaceous foods, having no nitrogen, are unable to supply what is necessary. But meat, eggs, milk, peas, oatmeal, etc., contain both nitrogen and carbon. Would anyone of these foods alone suffice? This resolves itself into the question: Does any of the food stuffs contain the C. and the N. in the proportion of 4800 grains of the former to 300 grains of the latter?

The following table shows whether it is easy to get a single food in the proportion named:—

	300 Grains of Nitrogen in	4800 Grains of Carbon in
Cheese, - - -	$12\frac{1}{2}$ oz.	$64\frac{1}{2}$ oz.
Lentils, - - -	$15\frac{3}{4}$,,	26 ,,
Peas, - - - -	$18\frac{1}{2}$,,	$26\frac{1}{5}$,,
Beef, - - - -	$19\frac{1}{2}$,,	72 ,,
Eggs, - - - -	31 ,,	29 ,,
Bread, - - - -	$46\frac{1}{3}$,,	20 ,,
Rice, - - - -	82 ,,	$18\frac{1}{3}$,,
Potato, - - -	320 ,,	$65\frac{1}{2}$,,

Four and a half pounds of Beef will yield the 4800 grains of Carbon we require, but at the same time it contains 1200 grains of Nitrogen, or four times too much. On the other hand, if we eat 5 lbs. of rice we will get the requisite amount of nitrogen but an unnecessary quantity of carbon. This is not an economical thing to do from the point of view, either of our pocket or our health. Since you cannot get the carbon and nitrogen in due proportion in almost any food stuff, it becomes necessary to combine two or more food stuffs to secure the proper quantity of each element.

Now, putting carbon and nitrogen aside for a moment let us consider the proportion of Proteids, Fats, Carbo-hydrates and Salts required in an average daily diet. A person doing a day's moderate work requires :—

Protein, - - -	$3\frac{1}{2}$-4 oz.	All in the dry state
Fats, - - - - -	$3\frac{1}{2}$ oz.	
Carbo-hydrates, - -	$17\frac{1}{2}$ oz.	
Salts, - - - - -	1 oz.	

or a proportion of 1 of Protein to $5\frac{1}{2}$ of other food-stuffs. But of these food-stuffs some are more essential than others. Thus, starch and fats are to a large extent interchangeable, a deficiency of one can be made up by an extra allowance of the other. This applies also to some extent to the proteins, but only to a limited degree.

A suitable diet must contain a certain minimum quantity of proteins generally placed at 2 oz. of the dry material for the 24 hours.

As I have stated, the quantity for moderate work is about double, $3\frac{1}{2}$ to 4 oz. Broadly speaking, $\frac{3}{4}$ of the day's food consists of starch. For hard work the amount of protein would be 6 to 7 oz., fats 4 to 5 oz., carbo-hydrates about 20 oz., and salts $1\frac{1}{4}$ to $1\frac{1}{2}$ oz.

It is thus seen that there should be a certain balance between these substances, otherwise disaster in the shape of various ailments is sooner or later likely to result, and it is perfectly wonderful how correct popular instinct is in the combinations which it has affected. For instance, animal and vegetable food are taken together. Bread, which is deficient in fat, is taken with butter, bacon with greens, pork with peas pudding. Peas contain 22 per cent. of nitrogenous material, while bacon has only 8. On the other hand, peas are poor in fat, having only 2 per cent., while bacon has 65 to 70, so that, by combining the two, the excess of the one balances the deficiency of the other. Many other combinations will occur to your mind.

In the next table is set forth the proportion of nitrogenous to non-nitrogenous constitutents in different foods according to Liebig, and it will be seen that there is no single article of diet which is perfectly balanced. (Milk is the one exception, and this only for young children.)

	Nitrogenous.	Non-Nitrogenous.
Veal, - - - - -	1	.1
Beef, - - - - -	1	1.7
Peas, - - - - -	1	2.3
Fat Mutton, - - - -	1	2.7
Cow's milk, - - - -	1	3.0
Human Milk, - - - -	1	3.7
Wheaten Flour, - - -	1	4.6
Oatmeal, - - - -	1	5.0
Potatoes, - - - -	1	8.6
Rice, - - - - -	1	12.3

Of these foods only three have the necessary elements in anything like the proportion required, viz.:—milk, flour, and oatmeal. Milk contains too much nitrogen for old people, but that makes it all the more suitable for growing young people. Oatmeal and wheat flour have the advantage of being nearly balanced, and with the addition of milk, it would be possible to live on either of them for long periods of hard work. The excellent and time honoured porridge of Scotland does not agree with some (young and old). When this is the case it may be corrected by longer cooking or by mixing wheat or barley meal with the oatmeal. If it cannot be taken in any form, bread and milk is the best substitute.

I would now direct your attention to the economic value of food.

The economic value of food is decided in the main by three considerations, viz.:—

(1) The amount of digestible nourishment it contains.
(2) The amount of energy it contributes to the human body.
(3) Its actual cost in money.

First, then, with regard to the amount of nourishment in a food. This depends upon two factors—(a) the proportion of water it contains and (b) the composition of the remainder. All natural foods, however dry they appear, contain more or less water. But though water is of vital necessity it is not generally classed as a food; it yields no energy to the body. The nourishing value is decided solely by the amount and composition of the dry food material which the article of diet contains.

Foods differ greatly in their content of water, but it may be taken as a general rule that animal foods, root crops and green vegetables contain the most water, while cereal and pulse foods in the ripe and dry condition contain the least. It follows, therefore, that weight for weight food of the latter classes contains more nourishment than the former. The large quantity of water and the relatively small amount of actual food contained in the first three classes is surprising. This is shown in the following diagram, which gives the water and dry food material in a pound weight of each food.

	WATER.	DRY FOOD.
Beef, - - -	11.35 oz.	4.65 oz.
Mutton, - - -	12	4
Ham, - - -	9.6	6.4
Herrings, - - -	11.6	4.4
Milk, - - -	13.9	2.1
Potatoes, - - -	12.6	3.4
Turnips, - - -	14.43	1.57
Peas (fresh), - -	12.5	3.5
Cabbage, - - -	14.7	1.3

On the other hand, the contrast in the case of cereal and other dry foods is very marked as shown by the following:—

	WATER.	DRY FOOD.
Bread, - - -	4.5 oz.	11.5 oz.
Oatmeal, - - -	1.17	14.83
Maize, - - -	2	14
Peas (dried), - -	1.9	14.10
Butter Beans, - -	1.65	14.35

In so far, therefore, as one can substitute foods of the latter group for the more costly animal foods it is economical in every sense to do so.

Having ascertained the amount of dry material in a food it is then necessary to consider its composition. To be nourishing a diet must provide certain well recognised classes of substances or "Food-stuffs," which fulfil different purposes in the human body. These I have already enumerated as Porteins, Carbo-hydrates, Fats, Salts (and Water). Of these food-stuffs some are more essential than others, and I have already stated that, while fats and starch are to a large extent interchangeable, this is not so in the case of porteins. The variety and proportion of the food-stuffs in different food materials vary widely. In some, such as flesh meat, fish, and most animal foods, only three classes are present, viz., proteins, fats, and mineral salts, the carbo-hydrates (sugar and starch) being absent or negligible (see diagram of Composition of Foods). On the other hand, in most vegetable foods all four classes are represented, though as a rule the protein or flesh-forming class is scanty, while the starch and sugar class is very abundant. As I have already said there are exceptions to this rule; wheat, oats, maize, and the pulse foods being well proportioned, except the last which is somewhat poor in fat.

Second. The amount of energy it contributes to the human body.. The energy value, or "power," of nearly all foods has been carefully ascertained, both by feeding experiments and by scientific determinations of a simple kind which do not involve feeding. Of the essential food-stuffs previously mentioned, fats yield weight for weight, the most energy to the body. Thus the energy value of 1 oz. of fat is 263.6 units or calories, of 1 oz. dry protein food, 111.2 units, and of 1 oz. of carbo-hydrate food, the same. It is, therefore, economical to introduce fats into the dietary as far as they can be utilized. The mineral salts add no energy to the body. Knowing the composition of food materials, it is possible at any time to calculate the quantities of each which will yield the same energy when consumed in the body. The following table shows the energy equivalents of 1 lb. of various articles.

ENERGY VALUE FROM 1 LB. OF

Beef (lean),	615 units.
Bacon,	2900 ,,
Butter (Dripping, 4607),	3604 ,,
Cheese,	1950 ,,
Eggs,	720 ,,
Milk,	325 ,,
Herring,	660 ,,
Cod,	325 ,,
Oatmeal,	1860 ,,
Bread,	1150 ,,
Rice,	1630 ,,
Lentils,	1600 ,,
Potato,	310 ,,
Turnip,	137 ,,

In the next table is a list of the energy equivalents of 1 lb. of Beef.

	LB.	OZ.		LB.	OZ.
Butter, - - - - -	0	$2\frac{3}{4}$	Bread, - - - - -	0	7
Bacon (Mixed), - - -	0	$3\frac{2}{5}$	Ham (lean), - - - -	0	$9\frac{1}{8}$
Oatmeal, - - - -	0	$5\frac{1}{4}$	Eggs, - - -	0	$13\frac{2}{5}$
Cheese, - - - - -	0	$5\frac{2}{5}$	Herring, - - - - -	0	15
Lentils, - - - - -	0	6	Peas (fresh), - - - -	1	$5\frac{1}{8}$
Butter Beans, - - - -	0	6	Potatoes, - - - - -	1	$9\frac{1}{2}$
Rice, - - - - -	0	6	Milk, - - - - -	1	$14\frac{1}{4}$
Peas (dried), - - -	0	$6\frac{3}{4}$	Cod, - - - - -	1	$14\frac{1}{4}$

Now while $2\frac{3}{4}$ oz. of Butter, or $3\frac{2}{5}$ oz. of Bacon, or $5\frac{1}{4}$ oz. of Oatmeal, or 1lb. 9 oz. of Potatoes, etc., have the energy equivalent of 1 lb. of Beef, it is not to be supposed that these quantities of the different foods are equivalent to each other in all respects. They are only so when, and in so far as, they can be included in the daily diet without disturbing the proper proportion of protein, fat, and carbo-hydrate food. Energy equivalents of different foods are under these circumstances of equal nourishing value as well.

The *third* consideration which determines the value of a food—assuming it to be digestible and nourishing—is its relative cost in money. By that is meant the amount of energy and nourishing material obtainable for a given sum of money when used to purchase different foods. I may say here that the Atwater standard of food energy required for moderate work for one day is 3500 units or calories.

The following table shows the relative value of foods by calculating the cost of a single diet to meet this standard.

	LBS.	COST IN 1919. S.	D.
Oatmeal, - - -	2	0	$8\frac{1}{2}$
Potatoes, - - -	11	0	11
Peas, - - - -	$2\frac{3}{8}$	1	$2\frac{1}{4}$
Cheese, - - -	$1\frac{4}{5}$	2	$8\frac{1}{4}$
Bacon, - - -	$1\frac{1}{5}$	3	0
Herring, - - -	$5\frac{1}{3}$	3	$2\frac{1}{2}$
Separated Milk, - -	$2\frac{1}{5}$ gallons	3	8
Milk, - - -	$9\frac{1}{3}$ pints	3	$11\frac{1}{2}$
Beef, - - -	5	9	2
Cod, - - -	11	12	10
Eggs (40—2oz.) - -	5	18	4

The relative food values may also be illustrated by the weight and cost of various articles required to do a specified amount of work, in this case the raising of a man (140 lbs.) to a height of 10,000 feet.

	Ozs.	Cost.		Ozs.	Cost.	
		D.			S.	D.
Flour,	21	$3\frac{1}{4}$	Dripping,	8.9	0	$10\frac{1}{2}$
Rice,	21.5	$5\frac{1}{4}$	Cheese,	18.5	1	$8\frac{1}{4}$
Oatmeal,	20.5	$5\frac{1}{2}$	Butter,	11.1	1	$8\frac{3}{4}$
Bread,	37.5	$5\frac{3}{4}$	Cabbage,	192.3	2	0
Potato,	81.1	$6\frac{1}{2}$	Milk,	128.3	2	8
Peasmeal,	21.4	$7\frac{1}{2}$	Beef,	56.5	8	3
Margarine,	11.9	$8\frac{1}{4}$	Eggs,	46	10	$6\frac{1}{2}$

It will be noticed that the smallest quantity is in dripping, consisting as it does almost entirely of fat at a cost of $10\frac{1}{2}$d., followed by margarine and butter at a higher cost. Oatmeal, which requires $20\frac{1}{2}$ oz. as compared with 21 oz. of flour and $21\frac{1}{2}$ oz. of rice, has, owing to the increase of price, to drop from the position of being the cheapest of the cereal foods—a position it had always previously held. The quantity of cabbage required is absolutely ridiculous. A man, to do the work, would require to eat about a stone of cabbage, and who is sufficient for that? Of course it must be understood that this table merely gives the theoretical quantities that would produce the force. It is obviously impossible to digest a stone of cabbage or 5 lbs. of potatoes in addition to subsistence diet; nor would it be healthy to take large amounts of unbalanced food. I have already remarked that oatmeal and flour have the advantage of being nearly balanced, and with milk added make a diet with which it is possible to do hard work.

Another illustration of the relative food values is shown by comparing the energy equivalents of a glass of milk and their cost.

	Oz.	Cost.		Oz.	Cost.
		D.			D.
Bacon,	1	$1\frac{1}{2}$	Bread,	$2\frac{1}{2}$	$\frac{1}{3}$
Cheese,	$1\frac{1}{2}$	$1\frac{3}{4}$	Oatmeal,	$1\frac{2}{5}$	$\frac{2}{5}$
Herring,	$4\frac{2}{5}$	2	Potato,	9	$\frac{3}{5}$
Beef,	$4\frac{1}{2}$	$6\frac{1}{3}$	Peas,	2	$\frac{3}{4}$
Cod,	$8\frac{4}{5}$	$7\frac{3}{4}$	Beans,	$1\frac{7}{10}$	$\frac{3}{4}$
Eggs,	4	11	Stout,	20	8

Stout is here represented in its most favourable light. Of the 180 units of energy which two glasses yield, 165 come from alcohol. But alcohol although it has some of the properties of a food is not harmless; the protein in two glasses of stout is less than $\frac{1}{10}$oz., while in a glass of milk it is $\frac{1}{4}$ oz.

Looked at in whatever way we like, the same conclusion is reached, that the cereal and pulse foods are the cheapest, those of animal origin the dearest.

Supposing that we have in these various foods got the requisite quantity of C. and N., is anything else needed to keep the human machine in a healthy state? There are salts needed—common salt and other salts. These are contained in all food-stuffs. Thus, beef contains 5 per cent. of saline material; peas, 2.5 per cent.; rice, $\frac{1}{2}$ per cent.; and so on. We may dismiss this part of the subject with the remark that we get these salts readily in the food itself or by the universal practice of adding salt to please the palate. Then we need water. The daily quantity we require is about 3 pints, and as all the foods we take contain water we simply require that quantity which will make up the deficiency in the food.

These, then, are some physiological facts concerning foods. We are, however, face to face with this fact—that human beings not only require what is necessary, but crave for what is pleasant, for what supplies a change, for what gives variety. There is a universal demand for some liquid substance, which not only meets the requirement of the body by introducing water, but which will also meet the demand for variety. This brings us to the question of drinks. Leaving out milk, which is essentially a food-stuff, the drinks in common use are tea, coffee, and cocoa on the one hand, and alcoholic beverages on the other. Lemonade, soda water, etc., are only to be considered as varieties of water. Do they supply any nourishing material and, if so, does it supply anything else which acts beneficially or harmfully?

A cup of tea (apart from added sugar and cream) contains 21 grains of material—$4\frac{3}{4}$ grains mineral matter and $16\frac{1}{4}$ grains organic matter. This quantity of organic material is not worth considering as a food stuff at all. But it is important because the chief ingredient of this organic material is a substance called Thein, the amount of which in the cup is equivalent to 1 grain of nitrogen. It cannot, therefore, be considered as a food-stuff. What then is its use? It stimulates, it relieves or removes feelings of fatigue, and as a stimulant has this great advantage that under ordinary circumstances, it leaves no feeling of depression. It is not food, however. If we take tea in order to fill out an otherwise deficient diet we delude ourselves—we are simply by a false stimulation endeavouring to mask the fact we are not supplying to our bodies what they need for their work or for their waste of tissue. Tea, then, is useful to us as a stimulant provided always we supply with it the energy yielding and tissue repairing substance. Coffee is exactly on the same basis—it also contains thein, but its nutritive power is practically nil. Cocoa occupies an entirely different position. It consists of about one half of fat, and as such yields material for the liberation of energy. A cup of the beverage cocoa shows it to contain —Water, 87.5 per cent.; Protein, nearly 1 per cent.; Fat, 1.5 per cent; and Carbo-hydrates, 10 per cent.—scarcely half the amount of protein and fat there is in milk, but double the quantity of carbo-hydrate matter.

Now the one fallacy, which you will have noted in the course of the lecture, is that "meat is an essential." I am no advocate of vegetarianism but, nevertheless, we eat more flesh than is necessary or desirable. In this respect we are not so great beef eaters as our neighbours the English, but we tend in that direction. Oatmeal particularly among our town inhabitants is more and more being cast into the background, and this is unfortunate, for if there is one kind of food—cheap and nutritious—which satisfies the needs of our climate it is oatmeal. I do not refer to that concoction which you get served up in London hotels, but to the "halesome parritch, chief of Scotia's food."

Flesh is more nutritious if eaten raw than when cooked, but not so digestible. Some people imagine that the white of an egg is more easily digested in its raw state, but that is not so; if it is swallowed in its ordinary state it is much longer in being digested than when cooked, though, if whipped, it is so divided that it affords a large surface for contact with the gastric juice and it is therefore quickly attacked. Cooking further entails a loss of "vitamines." Vitamines are present in minute quantities in nearly all foods in their natural condition, but may be removed or destroyed in the process of manufacture. If removed, the diet will cause disease. Thus Beri-beri is caused by eating white rice from which the vitamine layer has been rubbed off. Scurvy and rickets are likewise partly the result of lack of vitamines. Peas, lentils, potatoes, greens, meal, milk, fresh meat, lime juice, etc., all contain vitamines, and by a varied diet, therefore, we can secure enough even when they are absent or removed from some of the food materials which compose the diet.

It is popularly supposed that fish, of all the foods, is the most essential for brain work. Now fish cannot be said to contain a high percentage of phosphorus and are not, as so commonly believed, especially good as a brain food.

Another fallacy with regard to food concerns milk, and in this connection I feel I cannot do better than repeat what I said two years ago when giving a lecture on Infant Mortality. "Milk is a fluid and, being a fluid, they cannot conceive how milk can be a 'food,' and a nutritious food, nor can they be made to believe that milk which contains all the elements of an infant's dietary is a complete food. They are obsessed with the thought that what baby requires in order to thrive is something solid. Something 'solid' appeals to them, and milk, which contains all the essentials, is supplemented by something 'solid,' which varies according to the number of visits and gratuitous advices from neighbours. These neighbours have themselves had many children and therefore feel well qualified to give advice, though they fail to see the difference between having had, and having brought up, children."

While on the subject of milk I would like to draw your attention to the value of skimmed milk. There can be no doubt that we under-estimate the value of this food. It contains a high proportion of excellent food-stuff in the form of casein, and protein foods, as a class, are the most costly of all. Casein, taking it all round, is probably the most useful of all proteins.

For a long time people looked askance at Margarine. I admit that in former years margarine was not very palatable, but the same can be hardly held to-day. Its value as an energy food is undoubted, those brands containing the higher percentage of animal fat having the higher nutritive value. As with porridge, so with margarine. Some people say they cannot look at it. It upsets their stomach. This may be so, but barring invalids, and even in their case it is the exception, the cases are rare.. I have known ladies, who said they could not tolerate margarine in any shape or form, partake of it and enjoy it under the impression that they were eating the best fresh butter.

Of all the alcoholic liquors, beer and stout, from the nutritive point of view, are the most economical. Stout was, or is, a favourite beverage for mothers on the mistaken idea that nothing was better for improving the condition, or increasing the quantity of milk for the feeding of their baby. When we consider the cost, and the fact that the nourishing material is very small—1 lb. weight of stout contains about 35 grains of protein and 60 grains of carbo-hydrate food—it is quickly gathered how fallacious is this idea. A tablespoonful of oatmeal in the shape of gruel would not only prove less costly but be more beneficial. Any energy value of stout or beer is to be attributed to the alcohol.

In conclusion I would summarize.

The chief feature in animal foods are :—

(1) The large proportion of water.
(2) The negligible quantity of carbo-hydrates.
(3) The high percentage of proteins.
(4) The relatively low energy value.

Animal foods are, however, well digested; animal protein to the extent of 97 per cent. is absorbed and utilized; of animal fat, 95 per cent.

Cereal foods contain :—

(1) Very little water,
(2) As a rule have proteins, fats, carbo-hydrates, and salts well represented,
(3) And a high energy value as well as being economical.

Their proteins are less completely digested, viz., 85 per cent., as also are their fats, but the carbo-hydrates are utilised to the extent of 98 per cent. Cereal foods should be thoroughly cooked.

Pulse foods in the fresh green state contain a high percentage of water, but in the dried condition this is much reduced :—

(1) They are almost as dry as cereals.
(2) They are very rich in protein, 82.5 per cent. of which is utilized. Can therefore be profitably used as substitutes for animal food.
(3) The proportion of carbo-hydrates is good, but that of fat is low. This latter has to be borne in mind in serving and cooking.
(4) The energy value is high.

With reference to fish—of course, an animal food—the edible portion contains a large proportion of water, and more gelatine than in flesh meat. Owing to the latter fact there is a considerable loss in the boiling of fish, unless the water be made use of for soup or in some other way. The energy value varies with the proportion of fat being low in the cod and whiting and high in the herring, mackerel, and salmon. A pound weight of the edible portion of herring is more than equivalent to 1 lb. of beef.

Roots and Green Vegetables all contain :—

(1) A great deal of water.
(2) Root Crops, next to the cereals, possess the largest proportion of Carbo-hydrates of human food.
(3) The quantity of fats and proteins is small.
(4) Mineral matter, as a rule, is high.
(5) They are a valuable source of "vitamines" which are essential for healthy nutrition.

Vegetable foods, as a class, are less completely digested and absorbed into the system than animal foods.

In conclusion, let me say that it is not, however, to be understood, that the mere supply of enough protein and energy is all that is required. The food must not only be sufficient and wholesome; it must also be well prepared and attractive. The value of attractiveness in food is not sufficiently appreciated. It has, however, been proved by experiment, that a food which is relished promotes a better flow of gastric juice and is better digested than one for which there is little appetite. The same applies to the serving of food; neatness, tidiness, comfort, and absence of worry at meal times all assist in stimulating the digestive organs to get the greatest amount of nourishment out of the food provided. Food which is enjoyed does more good than food which is not appetising.

Variety in meals not only assists towards the same end but does more. It ensures a supply of all the chemical substances which are essential for nourishment.

VI.—*A Forgotten Perthshire Botanist—Robert Macnab.*

By Mr. W. BARCLAY.

(Read 9th April, 1920.)

The facts which I have been able to gather concerning Robert Macnab are very meagre indeed, and relate only to a very short period of his life, that extending from March, 1836, to October, 1842.

Of his previous and of his subsequent career I have not been able to learn anything. What leads me to rescue his name from the darkness into which it had fallen and to shed some little light upon it, is the fact that during the period I have mentioned he contributed to the *Perthshire Courier* a series of notes on the Botany of Perthshire, which seem to me to be of value and to be worth re-printing in our *Transactions.* From these notes we learn that he had projected a Flora of Perthshire and was investigating and recording the flora of different localities in preparation for the work. When we first meet with him in the columns of the *Courier* in 1836 he occupied the post of gardener at Kinfauns Castle. From June, 1837, to April, 1839, no note from his pen appears, and at some time during these two years he must have left Kinfauns. There is but the one contribution in 1839, but on 1st October, 1840, the notes again become more or less regular. On 19th August, 1841, he first signs his name, R. M'Nab, and dates his note from Ruthven House. Where he was employed from the time he left Kinfauns till entering at Ruthven House we do not know, but probably the latter portion of that interval was spent at or near Bridge of Earn. He must have left Ruthven House at Martinmas, 1841, as the remainder of his notes, up to the last one which appeared in January, 1842, are dated from Perth. Up to his entering at Ruthven House the notes are purely botanical, but from that time onwards they quite change their character and became in the main, first horticultural and subsequently agricultural. He had evidently given up, or at least postponed, the plan of publishing a Flora of Perthshire, and instead, we have the following advertisement which appeared in the *Courier* on the 13th, and again on the 20th October, 1842:

"Just Published

By Robert M'Nab

THE NORTH BRITISH CULTIVATOR—comprising the Vegetable, Fruit and Forcing Gardens; Agriculture, Botany, Basket-making, &c. Dissertations on the Choicest Vegetables, Fruits, Flowers, Grains, Grasses, &c., that have been most successfully cultivated and adapted to the different soils in Britain; the diseases that have affected Wheat, Potato, Onion, &c., and the cures that have proved most successful in counteracting them explained, their respective nutritive and medicinal qualities. Completed in one Vol., 12mo, of 400 pages. Price reduced at the suggestion of friends to 5/-, with a view to bring it within the reach of all classes. This work is allowed by competent judges to be the best of the kind hitherto published in point of utility, cheapness, brevity, and plainness of diction.

Sold by Messrs. Dewar & Richardson, Perth; Urquhart & Middleton, Dundee; Wood, Newburgh; and Robertson, Blairgowrie. October, 1842."

I have never seen a copy of this work, nor have I been able to learn any further particulars regarding the author.

The following are M'Nab's Notes as they appeared in the *Courier*, the lists of native plants in full, but the other matter sometimes considerably abridged where it appeared of no value.

31st March, 1836.—Linnæa borealis. This interesting plant was first detected in Perthshire by Messrs. Brown & Campbell on the estate of Kinfauns in the year 1816. Since that period a considerable portion of the plantation, wherein the plant was situated, having been cut down, the plant was lost sight of until, after many an anxious search, it was re-discovered in the summer of 1835.

Botrychium lunaria (Moonwort). This singular fugitive is to be found plentifully on the much trodden North Inch of Perth.

14th April, 1836.—Vicia sylvatica. Allowed to be the most beautiful climber of the pea tribe. This plant may be found in the woods of Invermay in great perfection, flowering in July and August.

Betonica officinalis (Wood Betony) has medicinal qualities of great repute. To be found with the preceding.

5th May, 1836.—Hill of Kinnoull. Along the middle of the Hill the following reputed medicinal plants may be found:—Conium maculatum (Hemlock), Hyocyamus niger (Henbane), Cynoglossum (Hound's tongue), Verbascum (Mullein), Solanum (Bittersweet), Daucus (Wild Carrot), Origanum (Marjoram), Scrophularia (Figwort), Digitalis (Foxglove), and Mercurialis (Dog's Mercury).

In the crevices of the rocks Cheiranthus (Wallflower), abundant; Grammitis (Spleenwort), sparingly.

On the summit, Astragalus hypoglottis (Mountain Milkwort), and Cistus Helianthemum (Rock Rose).

7th July, 1836.—Geranium sylvaticum, var. compactum. We lately had the pleasure of gathering this beautiful and striking variety in the Den of Gray, Forfarshire. Sambucus ebulus (Dwarf Elder or Danewort). With the exception of this plant no genus of trees belonging to the Flora of Britain embraces herbaceous species. Found along with the preceding. In the Park of Gray are some admirable examples of exotic trees.

25th August, 1836.—Pyrola uniflora. We were most agreeably surprised to find this exceedingly rare plant in the neighbourhood of Perth so abundant that there is little fear of it ever being extirpated.

NOTE.—In our Flora Perthensis which we have in contemplation to publish soon, the particular station of this most rare plant will, of course, be given.

Oxycoccos palustris. It grows in a marsh near the Earn on the estate of Moncreiffe.

Eriophorum angustifolium and E. polystachion are common in bogs.

29th September, 1836.—Flora of Glenfarg—Ferns. Polypodium vulgare; P. Phegopteris; P. Dryopteris; Blechnum boreale; Asplenium Filix-femina; Asplenium Ruta-Muraria; A. Adiantum-nigrum; A. Trichomanes; Pteris aquilina; Aspidium Thelypteris; A. aculeatum; A. dilatatum; A. Filix-mas; and A. fragile:

15th June, 1837.—From the severity of the weather during last winter and spring, several exotic plants, that were considered acclimatised, perished. We may remark that at Kinfauns Castle Acacia dealbata and Ribes speciosa have stood "the pelting of the pitiless storm," and have flowered profusely.

The broad-leaved ivy, commonly called Irish Ivy, is a native of Madeira, and from thence was accidentally introduced to this country along with an importation of orange trees; thus it was first detected in a very young state by the acute Mr. Brown, late of the Perth Nursery.

4th April, 1839.—In botanical pursuits we have had the pleasure of travelling with Cunningham and Douglas, names, alas! no more,—save from the important discoveries of these enterprising travellers, enriching this country with valuable exotics, which, with botany will immortalise their names.

From the number of rare plants inhabiting the Lochs of Cluny, Marlee, and their boundaries, an excursion to them will be found peculiarly interesting.

The following plants may be found in and by these Lochs:—*Hippurus vulgaris; Veronica montana; Utricularia vulgare;* Asperula odorata; Plantago maritima; Potamogeton, all the British species except Potamogeton lanceolata; *Radiola millegrana;* Myosotis repens; Menyanthes trifoliata, Lysimachia nemorum; *Lobelia Dortmana;. Viola palustris;* Gentiana campestris; Œnanthe fistulosa; Parnassia palustris; *Drosera longifolia*; Convallaria verticillata (Den of Rechip); *Triglochin palustre; Trientalis europaea; Vaccinium Oxycoccos;* Butomus umbellatus; *Pyrola secunda;* Saxifraga aizoides; *Stellaria scapigera;* Sedum album, Lythrum salicaria; *Rosa Doniana;* Comarum palustre, Nymphaea alba; Nuphar lutea; *Stratiotes aloides;* Ranunculus hederaceus; Ranunculus lingua; *Caltha montana;*

Melampyrum sylvaticum; *Subularia aquatica*; *Lotus tenuissimus* Inula Helenium; Orchis latifolia; Gymnadenia conopsea; Habenaria viridis; Habenaria alba; Habenaria bifolia; *Carex remota; C. limosa;* Litorella lacustris; Ceratophyllum demersum; Myriophyllum spicatum; Myrica gale; *Hydrocaris Morsus-ranae; Pteris crispa; Ophioglossum vulgatum; Isoetes lacustris;* Pilularia globulifera. Those marked *Italics* are the rarer.

17th September, 1840.—(We are happy to be able to conclude from the following notices with which we have been favoured that our intelligent Botanical friend has not lost sight of his intended work on the indigenous plants of Perthshire, and that he is receiving very distinguished assistance in the materials for his collections.—Ed. "Perth Courier.")

Rubus arcticus—On the north side of a little hill near the source of the Tilt, Perthshire. Pyrola secunda.—By the falls of Fooltarf, Glentilt, Perthshire. R.

1st October, 1840.—Scolopendrium officinarum (Hart's tongue). This beautiful fern, which more resembles a tropical production than one of our indigenous plants, and may well be regarded as a triumph of botanical research, has lately been discovered by Col. M. Belshes. Invermay, in a rocky dell not many miles from Perth, where situated inaccessible, it inhales the refreshing spray of a beautiful cataract, its graceful appearance forming a striking object to the eye of the beholder. The station will be given in the Flora Perthensis. R.

29th October, 1840.—The Hill of Birnam.—Col. Belshes has discovered the following ferns, Allosurus crispus; Asplenium septentrionale; A. Viride; Cystopteris dentata; and one from the Den of Rechip, seemingly a non-descript.

The Hill of Moncrieffe has frequently been traversed by botanists, but with the exception of Campanula uniflora (a very doubtful species), nothing uncommon has been found, until lately Sir Thomas Moncreiffe discovered Ceterach officinarum, perhaps the most northern station in Scotland for this rare plant, which has hitherto been known to exist only in the Carse of Gowrie range in a truly wild state. R.

VII.—*Zannichellia palustris* (*Linn.*) in *Perthshire.*

By J. R. Matthews, M.A., F.L.S.

(Read 9th April, 1920.)

The following notes are suggested by the discovery of *Zannichellia palustris*—the Horned Pondweed—in a small loch situated about a mile west of Dunning and known locally as Keltie Loch.

The plant, though common in England and widely distributed in Scotland, is exceedingly rare in Perthshire. The only known station within the county, apart from the present record, is the White Moss, which is situated about two miles west of Dunning, where it was found by Dr. Buchanan White and Mr. A. Sturrock in the year 1883. Specimens by these collectors are preserved in the Herbarium of the Perth Museum. There are no further examples of the plant from Perthshire and, so far as my knowledge goes, it has not been found anywhere in the county since the date of the original discovery in 1883 until last year (1919) when its occurrence in Keltie Loch came under my observation.

During many successive summers I have explored the White Moss Loch in search of Zannichellia and other aquatic plants and, although usually limited to hand-dredging, I was able on one occasion to secure a boat and I then made as careful a survey of the lake flora as I could. But I did not succeed in re-discovering Zannichellia, although, of course, it by no means follows that the plant is now extinct at the White Moss. It is necessary to be extremely cautious in coming to any decision regarding the question as to whether a particular species has become extinct in a certain locality. There is no doubt that plants do become exterminated owing to competition of other, perhaps more potent, species or to changes in the general conditions of the habitat in which they occur. But in the case of an undisturbed lake like the White Moss, it seems unlikely that the true aquatics should die out so long as there is a fairly large expanse of open water. It is true that topographical changes are slowly taking place at the White Moss owing to silting and to various biotic influences, and it is conceivable that conditions might arise under which a delicate aquatic plant like Zannichellia might succumb. I have not given up hope of finding it, however, as it only three years ago since I re-discovered *Utricularia vulgaris* at the White Moss (also first found here in 1883) after repeated failures to find it during the past eleven or twelve years.

The appearance of *Zannichellia palustris* in Keltie Loch, although not adding much to the range of the plant's distribution in Perthshire, raises one of those little problems in plant dispersal where one can do little more than suggest a possible solution. Interest in the present case centres round the history of Keltie Loch. There is no doubt that at one time the nature of the area justified its name, but ultimately the "loch" became nothing more than a quaking bog supporting a dense carpet of vegetation composed largely of *Potentilla palustris* L., *Menyanthes trifoliata* L., *Carex ampullacea* Good. and *Equisetum limosum* L., with an admixture of a good many other common marsh plants. The area extended to about three acres, and in dry weather one could walk over this bog in comparative safety. There were no pools of open water in which true aquatics could exist. A certain amount of water found its way under the carpet of vegetation, entering the area at its western end and finding an outlet at the east side by way of a deep ditch which had been constructed long ago for the purpose of draining the area. Early in the spring of 1913 the outlet was barricaded and the marshy area was allowed to become flooded. During the summer the marsh plants grew luxuriantly, in no way retarded by the waters that had collected over the original surface of the bog. The plants were cut down as far as possible by means of a long-handled, double-bladed scythe worked from a flat-bottomed boat. But the underground portions of the plants were not removed by this process, and during the month of September huge cushions of vegetable fibre commenced to rise here and there to the surface of the water. These were cut up into manageable blocks and floated to the side. The same thing happened during the three succeeding summers, and each season the operation of removing the floating mass had to be repeated. In this way the great accumulation of roots and rhizomes of the former bog plants was ultimately removed. The area now presented itself as a sheet of water some four acres in extent, ten or twelve feet in depth near the east side and gradually shallowing towards the west and south sides.

Aquatic plants almost immediately made their appearance in the open water, while marsh plants soon regained a foothold around the margins. Water Milfoil and various pondweeds were the first to appear, but as I cannot state the exact order of arrival, I shall give the list as I compiled it last summer. The aquatics are confined mainly to the shallower water at the west end of the loch and though some of the species extend into deeper water they are at present less common in the latter. *Myriophyllum spicatum* L. is dominant, and associated with it, forming an abundant undergrowth, is *Callitriche autumnalis* L. *Potamogeton pusillus* L. occurs in large quantity at the south-west side where the water is about one foot deep, and it was here also that *Zannichellia palustris* was first noticed. Later, it was found in greater abundance on open mud under nine or ten inches of water. *Potamogeton heterophyllus* Schreb. is frequent while *P. obtusifolius* M. et K. is occasional. *Polygonum amphibium* L. forms here and there a characteristic floating-leaf association. *Nitella opaca* Ag. is rare and occurs only in deeper water.

So far as I have observed, these are all the aquatic plants that have as yet established themselves in the recently-constructed Keltie Loch. The actual number of species is not large, but time and further search will doubtless add to the number. Most of those that have made their appearance have spread with remarkable rapidity, and in places it is impossible to row a boat owing to the dense growth especially of Myriophyllum.

It is probable that water-fowl are mainly responsible for the introduction of the aquatics into Keltie Loch. There is a considerable body of evidence to show that birds on migration do not carry seeds, or other objects adhering to their feathers, legs or feet, and it has been shown also that birds migrate on empty stomachs; but on short flights—e.g. between the White Moss and Keltie Loch—they are probably not so particular in their habits, and since six of the eight plants mentioned above are known to occur at the White Moss, it is perhaps not unreasonable to suppose that this loch may have provided the source of the aquatic flora now appearing in Keltie Loch. As already stated, Zannichellia has not been re-discovered at the White Moss, but if the theory that the plant has been recently introduced into Keltie Loch from the White Moss be correct, it follows that this species still exists in the latter.

As is well known, many aquatic plants reproduce themselves readily by vegetative means. They often develop roots freely at the nodes, so that a small portion of a plant may be sufficient to start a new colony if introduced into a fresh area. Perhaps the most notable example of the rapid spread of an aquatic is the now familiar American water-weed—*Elodea canadensis*—which, since its first appearance in Britain in Leicestershire about seventy years ago, has spread to nearly all the lakes and waterways of the country. That this has taken place entirely by vegetative propagation is practically certain since the female plant only is common in this country, the male plant being known from one or two localities only. One must not, of course, entirely exclude the possibility of bird-carried seeds reaching Keltie Loch, and it may be that some of the aquatics which have appeared there have been introduced in this way. Those interested in the means of plant dispersal will find a series of interesting papers on the subject by the Rev. E. A. Woodruffe-Peacock in the *Selborne Magazine*, 1918, and a contribution by the same author to the *Journal of Ecology*, 1918, deals largely with the same topic.

Some observations of my own may be worth recording. I had been following the slow conversion of a small open loch, situated on the Ochils, into a bog by the gradual encroachment of the marginal vegetation proceeding from the west side. The plants chiefly concerned in this centripetal invasion were *Equisetum limosum*, *Menyanthes trifoliata* and *Carex ampullacea*. They advanced in the order named, the first to take possession of the water being the Equisetum. This was followed by the bogbean whose long, floating, intertwining stems formed a fairly close covering of vegetation over the water. The sedge, giving rise to its characteristic tussock formation, followed, ultimately replacing the bogbean. The area provided a very clear example of the successional development of vegetation in an aquatic habitat. The loch is frequented by large numbers of water-birds which nest amongst the tussocks of the sedge. In one place, the Carex has been practically exterminated owing to the constant trampling to which it has been subjected by the birds. On this comparatively bare area of organic débris, situated about 50 yards from the lake margin and reached only by running some risk of sinking into a saturated mass of vegetable remains, the following unexpected plants were observed :—*Poa annua* L. in considerable quantity, Oat (several plants), *Polygonum Persicaria* L. (several), *P. aviculare* (several), *P. lapathifolium* L. (one plant), *Plantago major* L. (one plant), *Crepis virens* L. (one plant), *Holcus lanatus* L. (one plant), *Cynosurus cristatus* L. (one plant), and *Lolium perenne* L. (one plant). Growing over an old nest of a water-hen were *Cerastium vulgatum* L. and *Galium saxatile* L. It seems not improbable that the majority of these plants had come from seed introduced to this unusual habitat from neighbouring cultivated ground by birds, possibly ducks. The two plants mentioned last had almost certainly been introduced with pieces of dead twigs of gorse gathered from the hill-side by water-hens for nest-building purposes.

These remarks are rather a digression, but they are offered in order to draw attention to an interesting aspect of Field Botany too often forgotten or ignored by many plant collectors.

To return to *Zannichellia palustris*. This interesting water-plant should be looked for in Perthshire, since it seems unlikely that it should be confined to so limited a range within the county such as the known records suggest. In Scotland the plant is reported in *Top. Bot.* and *Supp.* from vice-counties :—72 Dumfries, 74 Wigton, 75 Ayr, 76 Renfrew, 77 Lanark, 79 Selkirk, 80 Roxburgh, 81 Berwick, 82 Haddington, 83 Edinburgh, 86 Stirling, 87 W. Perth, 88 M. Perth, 90 Forfar, 92 S. Aberdeen, 97 Westerness, 101 Cantire, 103 M. Ebudes, 106 E. Ross, 111 Orkney. Mr. Bennett informs me that the following have to be added :—93 N. Aberdeen, 110 Hebrides and 112 Shetland. The record for 87 West Perth is based on specimens found in Clackmannan which by Watson is included in W. Perth.

Zannichellia palustris Linn. is considered an aggregate species by many authors and, like many other "Linnean species" that have been critically examined, numerous varieties and forms have been described some of which have been accorded specific rank. The plant was described by Linnaeus in *Sp. Pl.* ed. I., 1753, and is retained as a single species by Graebner in his account in *Pflanzenreich*, iv., II., 1907, including, however, a number of varieties and sub-varieties of which the following have been reported as occurring in Britain :—var. *repens* (Boenn.), var. *major* (Boenn.), var. *polycarpa* (Nolte), var. *pedicellata* Wahl, var. *radicans* (Wall.), subvar. *gracilis* Hagstrom and subvar. *gibberosa* (Reichb.). There is considerable difference of opinion as to the value of many of these forms as well as considerable confusion with regard to synonymy. In trying to arrive at a decision on these matters I am greatly indebted to Mr. A. Bennett for much kind assistance.

Z. repens was described by Boenninghausen in *Prodr. Fl. Monast.*, 1824, as a species, reduced to a variety by Koch in *Synops.* ed. I., 1837. Similarly, *Z. major* Boenn. ex Reichb in *Moessl. Handb.* ed. II., 1829, was reduced to varietal rank by Koch, *Synops.* ed. I., 1837, *Z. polycarpa* (Nolte) dates from 1826 in *Novit. Fl. Holst.*, but the name only is given without description. The first descriptive account appears in *Moessl. Handb.* 1829. It was reduced to a variety of *Z. palustris* L. by Prahl in *Krit. Fl. von Schlesw.-Holst.* II., 1890, and Graebner retains it as such, but other authors, e.g. Babington, keep is as a species. The plant from Kirbister Loch, Orkney, first noticed by Boswell-Syme in 1849 has been referred to var. *tenuissima* Fries. The name *pedicellata* was first used by Wahlenberg in 1821 as a variety of *Z. palustris* L. In 1826 Nolte used *Z. maritima* for a similar plant, but gave no description. The same plant was described with full specific rank under the name *Z. pedunculata* Reichb. in *Moessl. Handb.* 1829, and *Z. pedicellata* Fries. *Novit. Mant.* I., 1832, as a species is the same plant. The really essential feature of this plant which has given rise to so much confusion is the development of a *common peduncle* which bears the cluster of pedicelled fruits. *Z. radicans* Wallman dates from 1840 *Bot. Notiser*, but has since been reduced to a variety. Var. *gracilis* Hagstrom in *Baagoe in Vidensk. medd. Nat. Foren. Kjoebenk*, 1903, is presumably the plant appearing in *Hayward's Bot. Pocket Bk.* as var. *gracilis* Druce. Var. *gibberosa* (Reichb.) is a slight variety, crenate on both dorsal and ventral sutures of the fruit.

The British List, therefore, may be drawn up as follows :—

1. *Z. palustris* Linn.
   - (b) *repens* (Boenn.) Koch.
   - (c) *major* (Boenn.) Koch.
   - (d) *gibberosa* (Reichb.) Asch. et Graeb.
   - (e) *gracilis* Hagstrom.
2. *Z. pedunculata* Reichb.
   - (*Z. maritima* (Nolte), *Z. pedicellata* Fries. *Z. palustris* var. *pedicellata* Wahl.)
   - (b) *radicans* (Wall.) Asch. et Graeb.
3. *Z. polycarpa* (Nolte) in MSS.
   - (b) *tenuissima* Fries.

VIII.—*History of the Strathmore Meteoric Fall of 3rd December, 1917.*

By HENRY COATES, F.S.A.Scot.

(Read 14th December, 1917, and 8th February, 1918.)

On Monday, the 3rd of December, 1917, at a quarter past one in the afternoon, there occurred in the Strathmore district of Perthshire and Forfarshire one of the most remarkable meteoric falls that has ever been recorded in the British Isles, and certainly the most remarkable that has been recorded in Scotland.* The day was a particularly bright one for the time of the year, with clear frosty air, brilliant sunshine, and only a few cirrus and cumulus clouds covering one-tenth of the sky. The thermometer, at nine in the morning, had been standing at 20 deg. Fahr., and the barometer at 30.240 inches, while the hydroscope showed 100 per cent. of humidity in the atmosphere. The wind was from the S.W., with force one, equal to two miles per hour. I mention these meteorological details, not that they have any connection with the phenomenon itself, but on account of their bearing on visibility, and the transmission of sound—important factors in weighing the evidence received from various quarters.

Under these conditions, then, and about the time specified, a visitor from space was seen to enter our atmosphere. I say "seen," because, as will soon be evident, it is necessary to draw a sharp distinction between what was seen and what was heard. The appearance which presented itself in the heavens was that of a ball of fire swiftly moving across the sky, leaving behind it a brilliantly luminous trail, gradually becoming more attenuated, until it seemed to end in a shower of sparks. (Plate 5). This description I take from the combined reports of several witnesses. One witness, viewing it from a geographical distance of over 40 miles, describes it as a truly magnificent spectacle, even as seen in the brilliant noonday sunshine of a particularly bright day. The same phenomenon seen on a dark night would have been awe-inspiring indeed. The head of the comet-like body is described by some as being of a fiery red colour, but with a yellowish tinge in it, while the trail was of a pale blue-green colour, shading off into what looked like red-hot sparks. This body was seen from Aboyne, Aberdeenshire, in the north; from Hexham, Northumberlandshire, in England; from St. Boswells, Roxburghshire, in the south of Scotland; from Edinburgh, Leith and Musselburgh; from St. Andrews and Crossgates in Fife; and from Perth and Burrelton in the immediate neighbourhood. So far as my information goes, only one person both saw

* See Appendix A.

the meteor and heard the subsequent detonation. I am not now, of course, referring to the fall of the actual meteoric fragment, which was witnessed by Mrs. Welsh as it reached the earth at Carsie. What I am referring to is the incandescent mass as seen in the high heavens before its disruption. The person who witnessed this and also heard it explode was Mrs. Alex. McLaren, living at 40 Queen Street, Craigie, Perth. She says that while gazing up into the sky, as she frequently does, she saw a ball of fire, followed by a trail of light, rush across the sky, and disappear behind a small grey cloud. Before it had time to emerge on the other side of the cloud, she heard the sound as of a terrific explosion, and saw nothing more. It is true it was both seen and heard from Aboyne, but not by the same people.

It is a remarkable fact that while the meteor was seen by a large number of people at distances of forty miles from Strathmore, we have only two records of its being seen from points at distances less than forty miles, namely, the Perth record, already referred to, and one at Burrelton, only about two miles from Coupar Angus, where Mr. George Miller, Innkeeper, saw what he describes as "two swirls in the sky." The explanation of this, no doubt, is that at a distance of forty miles or more the angle of vision would be a comparatively low one, so that a person who happened to be walking in the proper direction, and whose gaze was elevated even to a moderate extent, could hardly fail to see it; whereas, nearer to the centre of disturbance, an observer would require to have been gazing nearly vertically upwards, as Mrs. McLaren said she frequently did.

When we come to analyse the records of what was heard, we find that they are in exactly the inverse ratio from the records of what was seen. The former diminish with the increase of the distance from Strathmore and practically cease beyond thirty miles, while the latter diminish as we approach Strathmore, and practically cease within the thirty mile radius, with one or two notable exceptions in both series. This will be strikingly apparent on comparing the tables of distances and directions which are appended to this paper. †

Practically all these witnesses agree that the meteor, when they saw it, was travelling in a direction approximately from South East to North West, the angle of elevation, of course, varying with the point from which it was seen. It seems to have entered the earth's atmosphere and become luminous somewhere off the south-east coast of Scotland, and to have travelled in an oblique and gradually descending course until after it had crossed the Carse of Gowrie and the Sidlaws. Up to that point, the friction exercised by the atmosphere, acting against a body travelling at a stellar velocity of some

† See Appendix B.

twenty miles per second, would be a constantly increasing quantity, as the body gradually descended into the regions of increasing atmospheric density. At length a point would be reached when the surface tension of the glowing mass would not be able to resist the enormous force generated by the difference in temperature and pressure between the interior and exterior of the body, with the result that the whole mass disrupted into fragments, producing in doing so a detonation which was heard over an area of hundreds of square miles. Judging by the curvature of the outer surfaces seen in the fragments which have been recovered, I have estimated that the original body, before its disruption, must have been at least four feet in diameter, although this calculation is subject to certain doubtful factors. If it approached anything like that size, however, it is evident that only an infinitesimal proportion of the whole has been recovered. No doubt many fragments may have fallen in the water or waste land or among vegetation, but probably the largest proportion was dissipated into dust and gases, as it the case with the vast majority of the meteorites or "shooting stars" which enter our atmosphere every night.

If we next examine the evidence as to the nature, intensity, and direction of the sounds which were heard, we find that there is pretty general agreement amongst the various witnesses, the testimony varying chiefly according to the distance and angle from which the sound was heard. Thus in the immediate neighbourhood over which the explosion took place, it is described not only as a very loud but as a very sharp explosion. Many of the witnesses speak of the first explosion being followed by several reports of less intensity. These were probably produced by reverberations from clouds, or perhaps from inequalities of land surface. Others again speak of a loud humming sound, as of a projectile or an aeroplane rushing through the air. This may have been the sound of the original great mass being hurled through the atmosphere before its disruption. The observer at Aboyne estimated the time which elapsed between the meteor being seen and the detonation heard, and, allowing for the rate at which sound travels, he calculated the distance, at the time of the explosion, to be 70 miles. As Aboyne is at a horizontal distance of 40 miles from Strathmore, this would imply that the body was about 50 miles vertically above the earth's surface when it exploded. Mr. W. F. Denning of Bristol, however, one of our leading authorities on meteoric falls, to whom I sent all the evidence I had collected, gives it as his opinion that it had reached an elevation of only 14 miles from the earth's surface when it became non-luminous and exploded.‡

We have now reached the stage in the history of our celestial visitor when it ceases to be a meteor, and

‡ See Appendix C.

becomes a congeries of meteorites, that is, a number of fragments of inert matter, still warm, but not glowing with incandescence of white heat; and falling towards the earth by the attraction of the force of gravity, but not with the velocity of a stellar body. When at length they reached the solid surface of the earth, all the available evidence seems to prove that both their great initial velocity and their great acquired heat were almost or altogether exhausted. These conclusions we arrive at because, as regards (1) the velocity, we find that the Keithick fragment, while it pierced the slates and roofing boards of the Lodge, had not sufficient impetus left to penetrate the lath and plaster ceiling of the room; while the Carsie fragment, weighing $2\frac{1}{4}$ lbs., was only able to sink to a depth of some six inches into the soil of a ploughed field, while the Essendy fragment, weighing nearly ten times as much, penetrated only eleven inches through the turf of a grass field. As regards (2) the heat, again, we find that the Keithick fragment produced no appearance or smell of burning in the roof or ceiling of the Lodge, while the Carsie fragment, which was extracted from the ground by Mrs. Welsh's son ten minutes after it fell, produced no noticeable effect of heat or cold in his hand, and the Essendy fragment caused no appearance of scorching in the grass surrounding the hole, or even in the clods which were thrown out by the impact. The conclusion is, therefore, that the energy which the body possessed before its disruption must have been dissipated, partly by the opposition it encountered through the friction of the atmosphere, and partly by the expenditure of energy in the actual disruption itself, and its accompanying detonation.

We have now brought our fragments to earth, and to rest, and their interest changes from the astronomical to the mineralogical sphere. To us, inhabitants of the earth, they have become meteorites pure and simple, inert bodies of a definite mineralogical character and chemical composition, susceptible of microscopical examination, chemical analysis, and tests for specific gravity, besides the more obvious investigations of weight and measurement. For the result of some of these methods of investigation, we shall have to wait for a considerable time, as the processes involved are of extreme delicacy and complexity, and can only be carried out by the aid of the highest skill available in the country.

In the meantime, however, it is possible to give a general description of the external characters of the various fragments which were recovered.

Before describing them *seriatim*, it may be well to enquire as to which of the three recognised types of meteorite they should be referred. These three types, which merge gradually into each other, are represented by meteorites which consist (a) mainly of iron, (b) mainly of iron and stone, both in large proportions, and (c) almost wholly of stone (Fletcher), and are known respectively as Siderites, Siderolites, and Aerolites. On a first cursory examination, I was inclined to classify the Strathmore Meteorites as belonging to the second group (Siderolites), as they manifestly contain a very appreciable proportion of iron, but Dr. McLintock has no hesitation in referring them to the third group, and pronouncing them to be Aerolites. Certainly the non-metallic stony material largely predominates in their composition, although the metallic particles glisten throughout the mass. Where an edge has been chipped, so as to reveal a fresh fracture of the interior mass, the latter is seen to present the appearance of a fine-grained crystalline rock, of a light grey colour, resembling perhaps a very fine granite more than any other known terrestrial rock, and yet differing from it in some particulars. Through this grey magma are scattered the metallic particles already referred to, consisting, most probably, of an alloy of iron and nickel. For particulars regarding the remaining constituents we must await the results of the detailed analysis.

These characters being common to all the fragments recovered, we may now take up the examination of the fragments individually. Four in all were found, three in Perthshire, and one in Forfarshire. Taking them in the order in which they were got, they are as follows :—

1. The Keithick Fragment, weighing 2 lbs. 8 oz. (Plate 6). This was the fragment which crashed through the roof of the South Lodge, Keithick (Plate 7), $1\frac{1}{4}$ miles south-west from Coupar Angus, occupied by Mr. and Mrs. Thomas Hill, and their daughter, Miss Mary Hill. It was first discovered by the latter, who climbed on to the low roof by means of a ladder immediately after the fall, and saw it resting on the upper surface of the ceiling below. It was not removed until the following day, however, when Mr. George S. Mann, slater, Coupar Angus, took it out, and repaired the hole in the roof. This fragment is roughly cuboidal in shape, two of the axes being about three inches, and the third axis about five inches. Two of the surfaces are slightly spherical, and represent the outer surface of the original mass. The other four are fractured surfaces. All six surfaces exhibit the characteristic black coating of thin fused skin, except where they have been chipped in striking the roof of the Lodge. One end is rather smaller than the other, and is evidently the one which was in front in travelling through the air, as it is more damaged than the other end. The great interest of this fragment lies in the fact that it seems to be the only one which has been recorded in this country as having struck and penetrated a building, although one similar incident has been recorded from India.

2. The Carsie Fragment, weighing 2 lbs. 6 oz. (Plate 8). This fragment is in some respects the most remarkable of the four. It is conical in shape, coming to a sharp point at one end, and exhibits in a very perfect degree the stream-lines which are sometimes produced in meteorites by a creeping or flowing motion set up in the fused and semi-fluid outer layer during its rapid passage through the atmosphere. These striæ, or stream-lines, all run from the pointed end backwards, indicating that the fragment travelled through the air in the same position as does a pointed shell from a gun. An interesting feature of this fragment is that its fractured surfaces show only a rudimentary crust, which must have been caused by rapid partial fusion, after the disruption of the original mass.

This fragment fell close to the farm steading of Carsie, 2½ miles south from Blairgowrie, occupied by Mr. and Mrs. James Welsh and their son, James Douglas Welsh. Mrs. Welsh was standing at the door of her house, within twenty yards of the spot where it fell, and actually saw it enter the ground. (Plate 9). So far as I am aware, there is only one other record of a meteorite having been seen to fall to the ground in this country, and only one or two in other lands.

3. The Essendy Fragment, weighing 22 lbs. 4 oz. (Plate 10). This is a truly magnificent specimen of a meteorite, which has few rivals among British examples. It forms nearly a perfect cube, each face being some seven or eight inchs square. It is coated on all sides with the usual black varnish, or fusion crust, and exhibits besides very characteristic pittings, or "thumb-marks," on three of the sides, produced by the great heat to which it had been subjected. The remaining sides are comparatively smooth, and represent the original curved outer surface.

This fragment fell to earth in a grass park on the farm of Easter Essendy, in the Parish of Kinloch, two miles south-west from Blairgowrie, belonging to Mr. Charles Howard Scott. (Plate 11). In this park a flock of sheep were feeding, which scattered in all directions when the meteorite fell among them. Charles Smart, the foreman on the farm, and two of the ploughmen, were standing at the steading, about 500 yards distant, and saw the commotion, but it was not until the following day that they went into the park, and discovered the cause. The hole in the ground was about 18 or 20 inches deep, and about as wide. It had a slight dip towards the north-west, and on that side some clods had been thrown out, showing that the meteorite had fallen in a slightly oblique direction, from the south-east. The ground, both here and at Carsie, was frozen at least as far down as the fragments had penetrated, otherwise the holes would doubtless have been deeper than they were.

4. The Corston Fragment. (Plate 12). This fragment, which weighs 2 lbs. 5 oz., fell on the lawn adjoining the farm house of South Corston, tenanted by Mr. Thomas A. Buttar, two miles south-east of Coupar Angus, and on the Hallyburton Estate, in Forfarshire. (Plate 13). At the time of the fall, on 3rd December, some of the farm workers, who were in an adjoining field, about 200 yards distant, were under the impression that something had fallen near the house, but it was not until four days later, on the morning of Friday, 7th December, that the fragment was found by William Duff, gardener at Corston. It had made an oblique hole in the ground, about five inches wide and six inches deep, dipping towards the north-west at an angle of about 20 degrees. The spot was only a few inches from a flower bed, where it might easily have been overlooked, and not fifty yards from a pond, where it would certainly have been lost. This fragment shows the same tabular form as the Essendy and Keithick fragments, showing very evidently that it has come from the same original mass. It exhibits two faces of disruption fracture, which are practically at right angles to each other. The surface is entirely covered with the usual black fusion skin, except at one point, where it seems to have struck a stone on entering the ground, and got chipped. It shows several well-defined "thumb-marks," and numerous stream lines, or striæ, running from the point backwards. It is $5\frac{5}{8}$ ins. long, the other two dimensions being $2\frac{3}{4}$ ins. and $2\frac{3}{8}$ ins. (= 143 × 70 × 60 millimetres).

It is interesting to note the geographical relation of the spots where these four fragments fell. They are all practically in one straight line, extending a distance of about six miles, from South Corston on the south-east to Easter Essendy on the north-west, and passing through Keithick Lodge and Carsie at intervals of about two miles, more or less. (Plate 14). This corroborates the view that the path of the meteor, before its disruption, was from S.E. to N.W.

It now only remains to mention the destination of these four fragments, at the date of reading this paper. All four were claimed by the Crown Authorities, and were sent to the King's Remembrancer for Scotland in Edinburgh, for disposal. The Director of the Royal Scottish Museum was instructed to select two of the fragments for that Institution, and he chose the Essendy and Carsie Fragments, as exhibiting the most interesting and characteristic features. The remaining two fragments were directed to be returned to the finders, those being Miss Mary Hill in the case of the Keithick Fragment, and Mr. Thomas Buttar in the case of the Corston Fragment. The Keithick Fragment is now in the possession of Miss Brodie-Wood, the owner of the Keithick property. The final destination of the Corston Fragment is uncertain. In the meantime, Mr. Buttar has very kindly placed it on temporary loan in our Museum, and has indicated that in all probability the Perthshire Natural History Museum will form its ultimate resting place.

I am indebted to my friend, Mr. Thomas M'Laren, Burgh Surveyor, for preparing the three diagrammatic sketches which accompany this paper.

APPENDIX A.

The Perth Meteorite of 1830.

Only two meteorites are recorded as having fallen in Scotland since the beginning of last century, and one of these, strangely enough, also descended in Perthshire, its landing place being none other than the North Inch of Perth. A portion of this meteorite is preserved in the British Museum, and is recorded in Mr. Fletcher's "Introduction to the Study of Meteorites," published by the Trustees. Like the Strathmore fragments, it is classified as an Aerolite, or Meteoric Stone. The fragment weighs only 1.5 gram, and is registered as having fallen on the North Inch of Perth on May 17, 1830. At my request, Mr. Barclay kindly looked up the file of the *Perth Courier* for that year, and found the following paragraph under date Tuesday, April 22, 1830:—" On the evening of Friday last (April 18), about half-past nine, a meteor of uncommon size and brilliance was seen in the north-east. So slow was its apparent motion that for the space of 20 seconds its course was traced from the horizon to the zenith, near which it exploded. It must have been at a great height, as the meteor was seen in almost the same circumstances at different and distant places in this county. The atmosphere had been, during the day, unnaturally close and sultry for the season, and changed in the course of the evening to cold and wet."

After getting this reference, I wrote to the British Museum, and asked the authorities to send me all the information they possessed regarding this meteorite, including a transcription of the original label, etc. In reply, Mr. George T. Prior, Director of the Mineralogical Department, wrote to me as follows:— "Of the previous fall in Perthshire, in 1830, very few particulars are to be obtained. The time of fall is given as half-past 12 o'clock noon on May 17, and to this your extract from the *Courier* would not seem to refer. Of the original stone, measuring 7 inches in diameter, only two small specimens appear to be extant. These originally formed part of the collection of Dr. Thomson, of Glasgow, but passed into the possession of Mr. William Neville, of Godalming, by whom one, weighing 23 grains (1½ grams), together with a microscope section, was presented, in 1862, to this Museum, and the other, weighing only 6½ grains, to the Museum of the Geological Survey of India, Calcutta, in 1868. The label which accompanied our specimen was in Dr. Thomson's handwriting, and read as follows:—'Part of a Meteorite that fell on the North Inch of Perth during a thunderstorm on the 17th May, 1830, at half-past 12 o'clock noon. The whole mass of which this is a portion, was about 7 inches in diameter.' Maskelyne described the B.M. specimen in the Philosophical Magazine, 1863, Vol. 25, p. 437, and the Indian specimen is referred to in Records, Geol. Surv. India, 1868-70, Vol. 1, p. 72."

Notwithstanding Mr. Prior's expression of opinion to the contrary, I cannot help thinking that there is a close connection between the phenomenon described in the *Courier*, and the specimen referred to in Dr. Thomson's label, and now in the British Museum. Every museum curator knows how easy it is for slight discrepancies as to date, etc., to creep into the description of specimens, unless the label is written on the very day a specimen is found. We do not know how long it was after this meteorite was recovered before it came into the possession of Dr. Thomson, of Glasgow. In the meantime the description, if given to him from memory, might easily have become erroneous as to date and hour. The description in the *Courier*, on the other hand, must have been written not more than four days after the event. The references to the weather are in both cases, of course, purely gratuitous, as there is no connection between meteorites and meteorological conditions. It is interesting to note, however, that in Dr. Thomson's label, the "sultry" weather of the *Courier* has become magnified into a "thunderstorn"! In any case, the weather is a coincidence, not a consequence.

APPENDIX B.

RECORDS OF DISTANCES AND DIRECTIONS FROM WHICH THE METEOR WAS SEEN, AND THE DETONATION HEARD.

PLACE.	DISTANCE.	DIRECTION.	SEEN BY.	HEARD BY.
	Miles.			
In the District,	0	—	—	10
Burrelton,	2	S.W.	1	—
Dundee,	12	S.E.	—	Several.
Glencarse,	13	S.5°W.	—	Several.
Perth,	14	S.W.	1	9
Cotton,	16	S.W.	—	1
Forfar,	16	E.N.E.	—	Several.
St. Andrews,	22	S.E.	—	1
Crossgates,	32	S.	1	—
Bridge of Allan,	37	S.W.	2	—
Leith,	39	S.	1	—
Aboyne,	40	N.N.E.	1	1
Edinburgh,	41	S.	7	—
Callander,	42	W.S.W.	3	—
Musselburgh,	44	S.10°E.	1	—
Port of Monteith,	46	S.W.	2	—
St. Boswells,	71	S. by E.	Several.	—
Hexham,	126	S.S.E.	1	—

N.B.—The distances and directions are reckoned from Coupar Angus.

APPENDIX C.

REPORT ON THE PATH OF THE METEOR, BY MR. W. F. DENNING, F.R.A.S., BRISTOL; DEDUCED FROM EVIDENCE SUPPLIED.

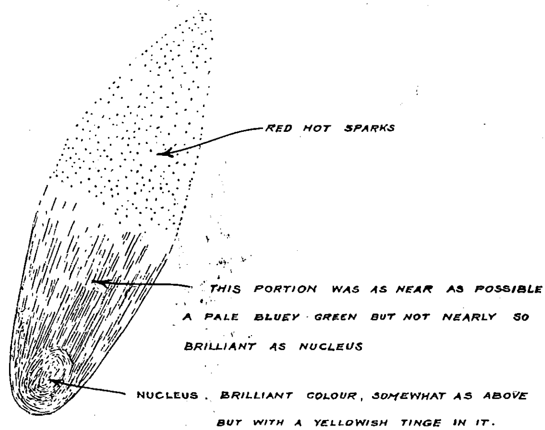
I have gone thoroughly into the various observations, but they are of such a character that to obtain exact or certain results from them as to the meteor's flight in the atmosphere is not possible. The most that can be done is to derive the best result possible from the data. From the distribution of the fragments, the line of flight must have been about azimuth 309° counted W. from S. Some of the descriptions of the path also clearly indicate this direction, and I believe the apparent astronomical radiant point is very likely to have been at R.A. 302°, declination 24° N., which had an altitude of 49° at the time of the meteor's apparition. If this is correct, probably the place of the meteor's first appearance was over a point about 8 miles E.N.E. of Dunbar, at a height of 64 miles. Directed nearly to N.W., it passed over Anstruther at a height of 41 miles, and over the Firth of Tay (S.W. of Dundee) at a height of 18 miles. It seems to have detonated when over the region of Rossie Priory, and N.W. of that place, and to have become non-luminous at a height of about 14 miles. The whole path was 87 miles, during which it descended at an angle of 49°, so that the geographical distance traversed was about 57 miles. The velocity is uncertain, for the observers give no estimate of the duration of flight. It was presumably about 15 or 20 miles per second at first, but the motion of the fragments on reaching the ground was probably not more than 500 feet per second. (Plate 15).

Quite a number (8 or more) of bright, slow moving meteors were seen between Dec. 1 and Dec. 12, 1917, directed from the same radiant in the small constellation Sagitta, at 302° + 24°, from whence the Strathmore meteorites appear to have been also directed. It would seem therefor that the original mass formed an exceptional member of a regular shower.

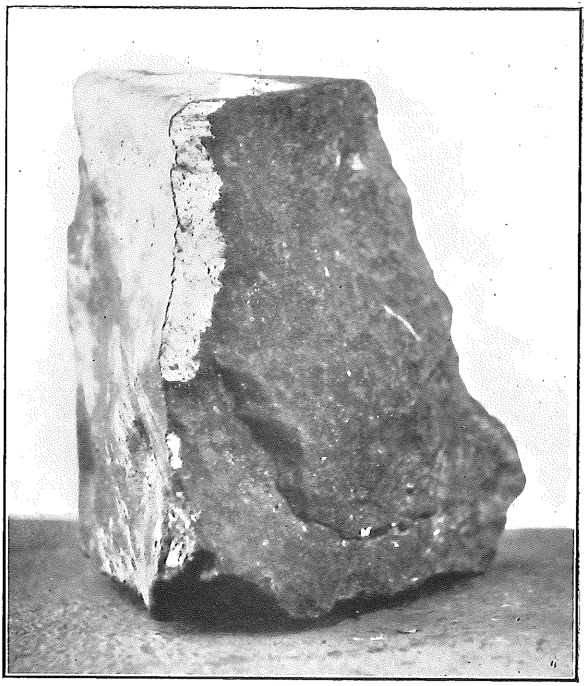
The meteorite which fell in Lancashire on Oct. 13, 1914, became non-luminous at an elevation of about 15 miles. I think it is proved that these bodies lose their luminosity sometime before they actually fall, and that they reach the ground in a semi-cool condition.

From a mean of about 40 estimates of the time of the Dec. 3 meteor, I make it 1.18 p.m.

METEORITE AS SEEN BY Mr J.F. DUNCAN IN EDINBURGH.

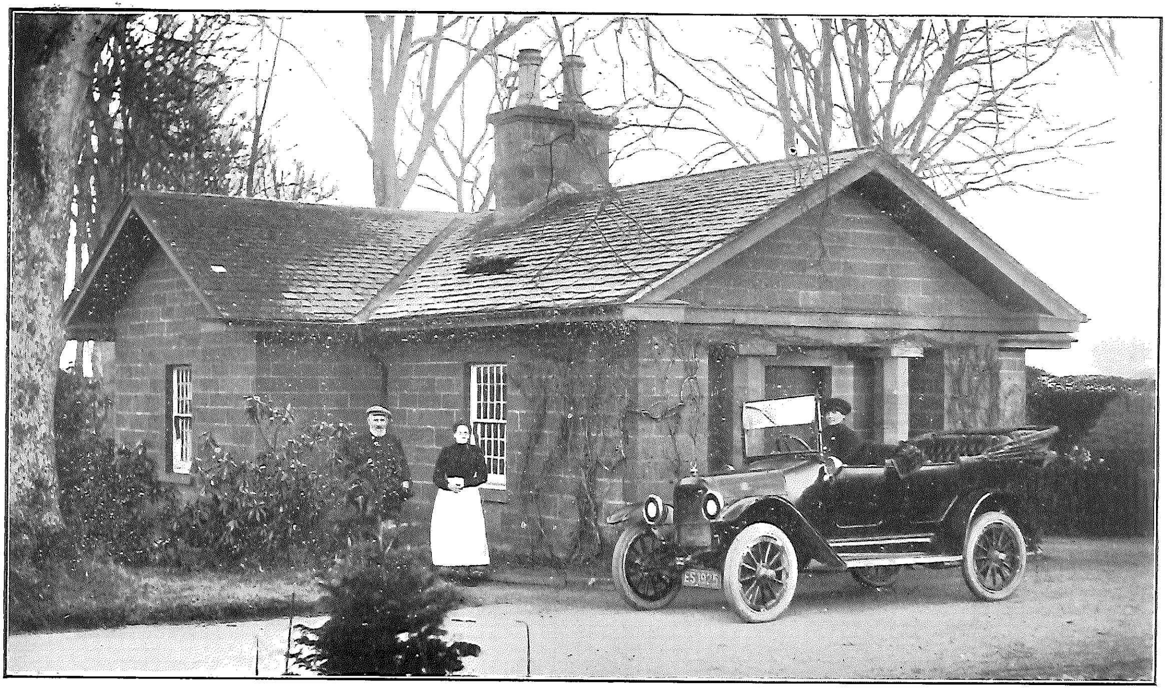


5.—The appearance of the Meteorite as seen from Edinburgh.



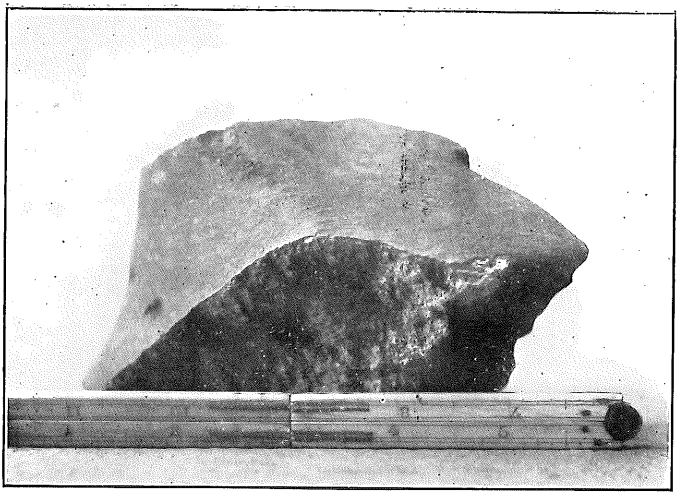
H. Coates, Photo.

6.—The Keithick Fragment.



H. Coates, Photo.

7.—The South Lodge, Keithick, with Mr. and Mrs. Hill.

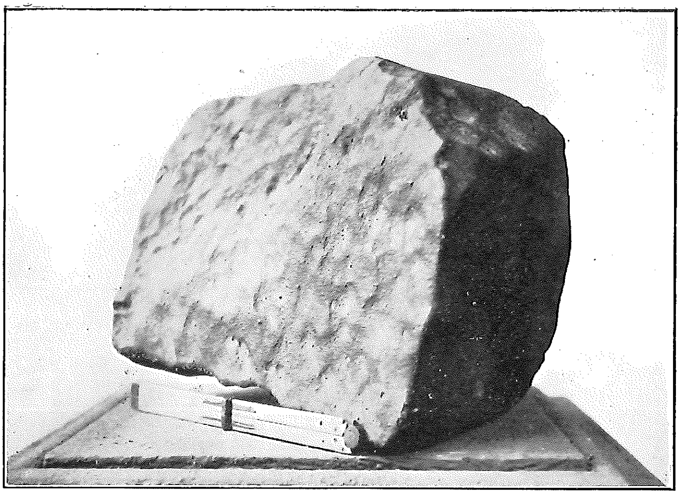


H. Coates, Photo.

8.—The Carsie Fragment.

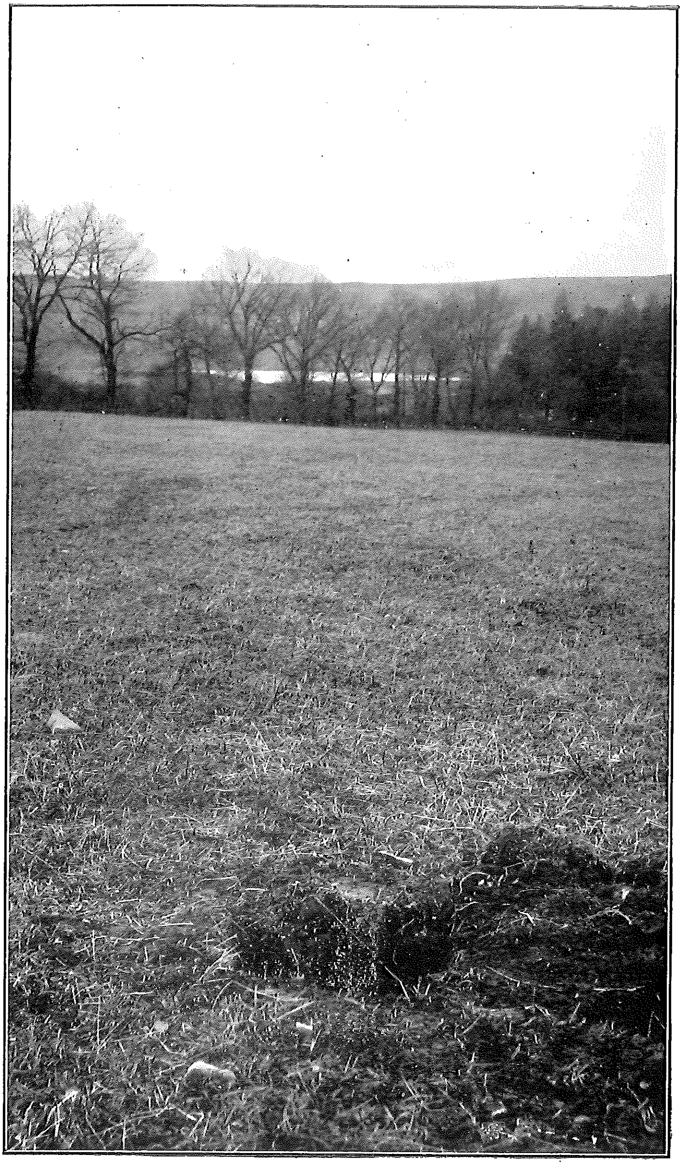
H. Coates, Photo.

9.—The Hole at Carsie, with Mrs. Welsh.



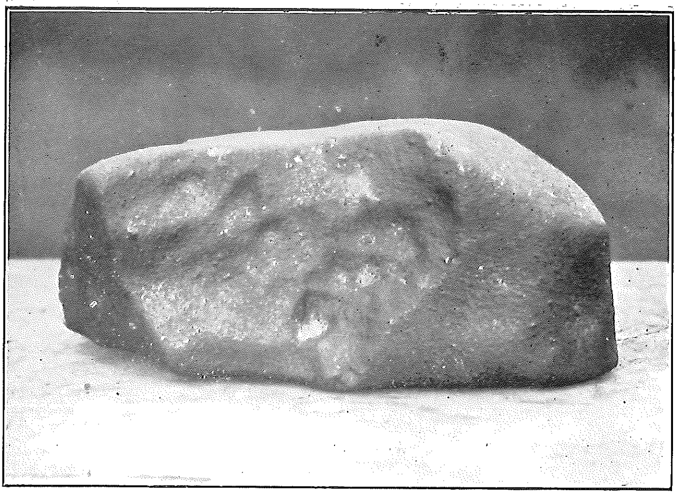
H. Coates, Photo.

10.—The Essendy Fragment.



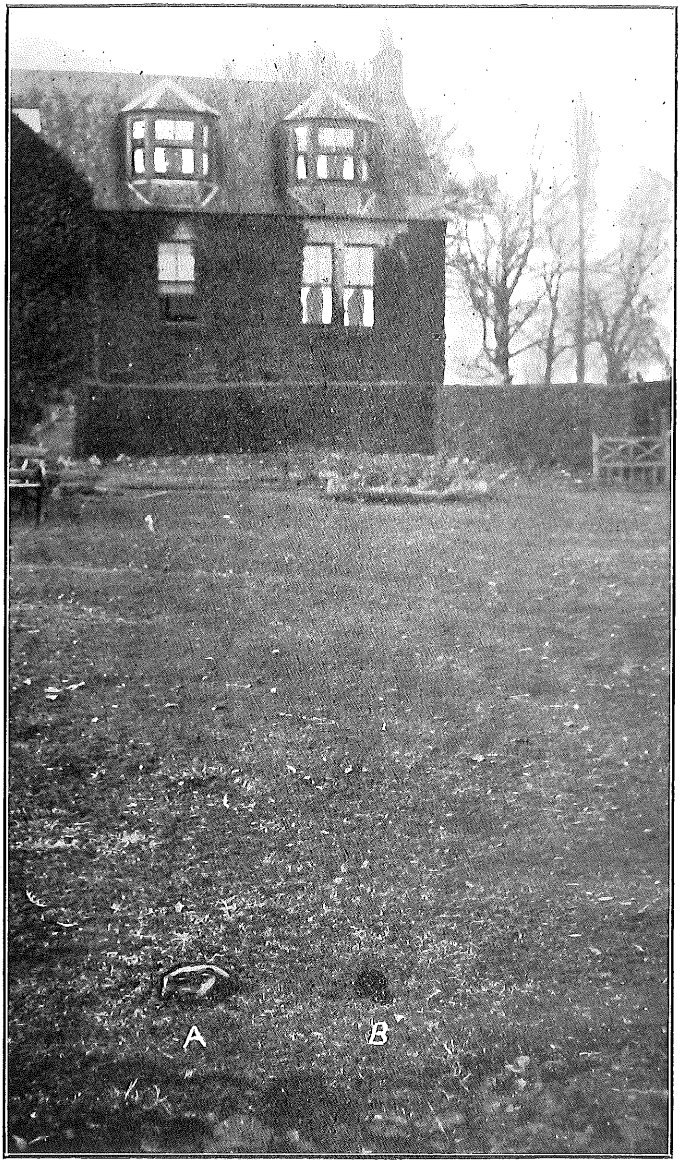
H. Coates, Photo.

11.—The Hole in the Field at Essendy, showing Loch Marlee in the Distance.



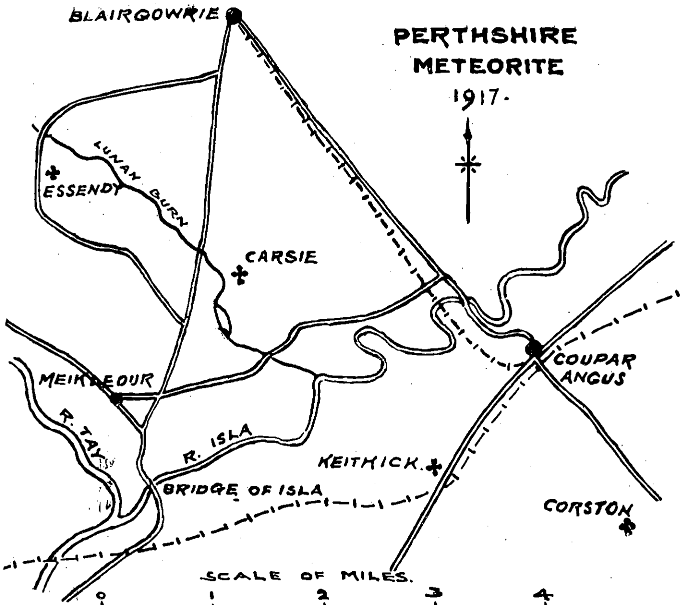
H. Coates, Photo.

12.—The Corston Fragment.

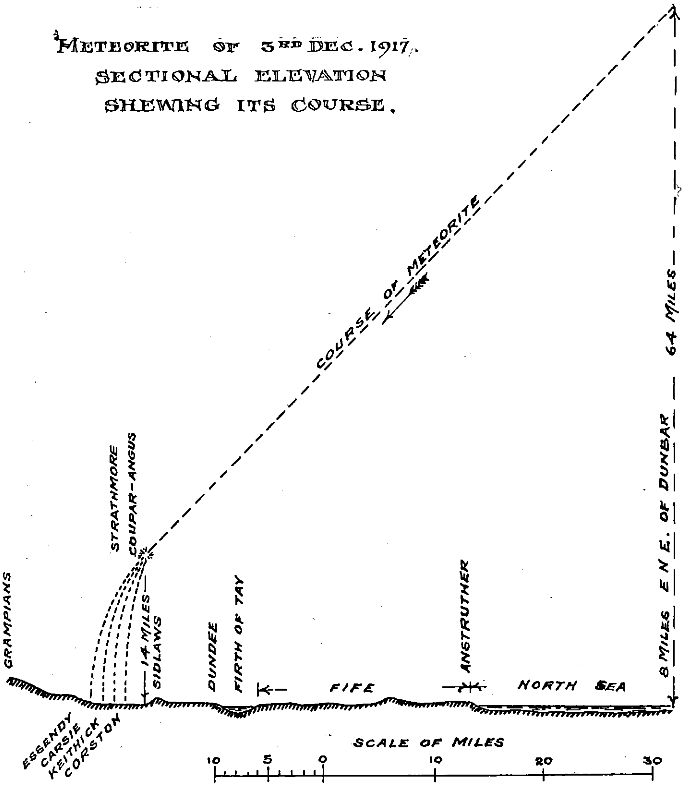


H. Coates, Photo.

13.—The Hole in the Lawn at Corston.
A. The Meteorite. B. The Hole.



14.—Sketch Plan of the District, showing where the Four Fragments fell.



15.—Diagrammatic Elevation, showing the Course of the Falling Meteor.

VIII.—*Rhizopods of Perthshire.*

By FRANK M'LAGAN.

(Read 9th January, 1920.)

The Protozoa are an exceedingly small although intensely interesting phylum of animals. The distinguishing feature between these members of the zoological kingdom and all the others is, that they are unicellular, while the metazoa, as their name indicates, consist of many cells, different groups of cells composing the different organs. The various organs in the metazoan are composed of cells which are physiologically entirely different and also anatomically different in many cases, while the protozoan, on the other hand, is composed of one cell which apparently performs the multitude of actions and duties imposed upon the innumerable cells of the body of the higher type of animal. Like them it is irritable, although no nervous system or even tissue has been demonstrated. It engulfs and digests food without the aid of an alimentary canal and has no organs to pour their secretions upon the food. The single cell, therefore, of a protozoon must possess the characteristics of all the cells which go to compose the body of a metazoan.

The term Protozoa includes both animals and plants. This may appear a strange statement to those who have never studied this very primitive phylum, but the difficulty in stating whether an organism of this class is an animal or a plant can be appreciated when at one period of its life it may feed and carry on its functions the same as a very lowly plant, such as the members of the vegetable world known as the algæ, while during another phase of its life the same organism will physiologically function the same as an animal. The zoologist then places the organism in his scheme of classification and the botanist also places it in his; each claiming his functions are the more predominant. These are the more primitive types, however, for even in these most simple of organisms there are simple and more complex species. The higher types, such as the Ciliates, Sporozoa, and even the Rhizopoda, can be definitely and accurately placed in the list of members of the animal kingdom.

Protozoa, being unicellular protoplasmic beings, can only live in fluid media. They are cosmopolitan in nature and are found everywhere, amid the most varied and different environments. Many species are parasitic in habit, while the greater number are free living. The non-parasitic members of this family are found all over the world. Some, such as the Radiolaria, Foraminifera, and Ciliates, are found in salt water, the Foraminifera being that very important group which bear the minute shells which through aeons have accumulated in such numbers as to compose the chalk cliffs and strata which bear such an important part in the landscape and fertility of southern England. The dead Radiolarian plays a no less important role in the foundation of the world, as it is their shells which compose the greater part of those flinty rocks which have originally been submerged in the depths of the ocean. These two great classes, the Foraminifera and the Radiolaria, are only to be found in the sea, not being obtained in fresh water at all. The Ciliates, however, may be called cosmopolitans of a race of cosmopolitans, as they are found over all, living under the most various conditions. Many of them live in salt water and are never found in fresh water at all, others live in fresh water and never change their abode, while many are parasitic. The above illustrations show what a widely spread race of animals this is. They are found not only in equatorial regions, but even in the Arctic and Antarctic seas, not confined to the clean waters of river, sea, and loch, but found even in the city sewage pipes. Some more adventurous than others have become parasitic, many of these forms causing severe pathological conditions in man, such as the malaria parasite, *Plasmodium malariæ,* and the cause of one type of dysentery is due to a Rhizopod, *Entamœba hystolitica.*

The present classification of the Protozoa is very artificial and extremely unsatisfactory. The organisms are classified according to their mode of locomotion, but, as can be seen, when an animal moves according to one group at one part of its life, and according to another group at a different phase, it is rather difficult to say to which group it belongs, since many of the organisms pass through various stages in their life history before they attain an adult form, and many of these immature stages are totally different from the adult, and have been classed as distinct species. These few instances will serve to show how poor the present method of classification is, and the difficulty one has in announcing definitely to which class an organism belongs.

This phylum is primarily divided into four main classes:—
(1) The Sarcodina, which are Protozoa which grow to a relatively large size and have no permanent organs of locomotion during the "adult phase." The animal moves and captures its food by means of pseudopodia, the formation and function of

which will be discussed later. The young forms of this group may be either amœboid or flagellate. (2) The Mastigophora, or Flagellata, are Protozoa of a minute size which seldom have a large adult phase. In the adult phase the organism moves and captures food by means of a flagellum, a very long, slender thread of protoplasm, which is lashed to and fro and so causing the animal to move. These two groups are the more primitive of the four groups, and it is from these that the more highly specialised Sporozoa and Ciliata have been evolved. (3) The Sporozoa have no visible means of locomotion and are entirely parasitic. They propagate their species from one host to another by means of resistant seed-like bodies which contain the immature parasite. These resistant cases are known as spores, hence the general class name Sporozoa. (4) The Infusoria, or Ciliata, are very highly developed, and evolutionary far superior to any of the other groups of this large phylum. In this group the cell structure attains a high degree of complexity and differentiation of parts. They move by means of a great number of small cilia or tags of protoplasm which, by means of a combined wave motion in one particular direction, propel the animal through the water. The Sarcodina, the class under discussion, is again divided into several sub-classes, of which the Rhizopoda forms a very important member. As the name indicates, these animals are the possessors of branched, root-like pseudopodia, which are variable in shape and in number, as they can be protruded and retracted into the general protoplasm of the cell. This sub-class is found in many different situations. Some are parasitic in many animals, including man; others are found in fresh and salt water, living on the debris which they find while creeping slug-like over the aquatic vegetation. A few members of this class are semi-terrestrial in habit. An example of this can be well seen in *Amœba terricola,* which inhabits moist ground. Many others are to be found dwelling on moss, the small film of water covering this plant being sufficient to allow them to carry on their metabolic functions.

Many members of the sub-class Rhizopoda, instead of being naked masses of protoplasm have shells or tests in which they dwell and which protects them from their many enemies. Others, however, like *Amœba proteus,* the common laboratory example, appear to be naked masses of protoplasm without even the limitations of a cell membrane.

Although found in nearly every sample of water taken from river, stream, and loch, these animals are usually overlooked by zoologists on account of their minute size and their sluggishness. Many of them are quite large, relatively speaking, such as many of the amœbæ, but on account of their slow motion and appearance they are very difficult to see, while the Euglyphas and Nebelas, which anyone could tell at a glance were animals, are so minute that the higher powers of the microscope are required before they can be found, and, even then, a twelfth-inch oil immersion objective is required before the details can be seen which determine the species.

The Rhizopods are the naked or testaceous Sarcodina with pseudopodia of the lobose, digitate, acicular, or reticulate types. The adult forms are amœboid in structure, while the young individuals are amœboid of flagellate and are produced by cell division during life or following encystment. In some species, *e.g.*, *Vampyrella vorax,* a number of individuals fuse together to form a plasmodium. This sub-class is divided into two main orders :—(1) Amœbina, which have a naked body, being simply masses of nucleated protoplasm; and (2) the Conchulina, which bear tests of the most varied shapes and of different construction. Each of these orders is again divided up into families and genera, but of these nothing need be said in a short survey of the class such as this.

The cell, like all others, is composed of that basis of life, protoplasm, which is apparently a very complex chemical compound of the nature of a protein. Unlike most other types of cell, however, the naked or Amœbinoid type of Rhizopod has no cell membrane to preserve the individuality of the animal, *i.e.*, there is nothing between the protoplasm and the external world. The protoplasm in contact with the external medium appears to form a covering for the animal which effectively keeps the water which is generally the surrounding medium from entering and permeating the cell. There are many views on the subject of this differentiation of protoplasm at the surface of contact, Auerbach stating that a cell membrane does exist, while Dr. Wallich refuted this statement and announced that there was no cell membrane, a view which is held by most of the students of the subject at the present day. The protoplasm in contact with the water is supposed, by some, to " stiffen " or coagulate immediately it comes in contact with the surrounding liquid; others, however, think the effect is due to surface tension. This point is not settled at the present moment, but undoubtedly both the biological and the physical factors are at work in this phenomenon.

This external layer of protoplasm, or ectoplasm as it is called, is more hyaline and clearer than the granular and more fluid endoplasm. Although visually it is entirely different from the more easily seen endoplasm, it is anatomatically the same. At one moment endoplasm forms ectoplasm and vice-versa. Many students of the subject have brought forward statements saying that there are intermediate layers between the ectoplasm and the endoplasm. They even stated that these layers were definite and fixed, and went so far as to assign functions to them. This effect may have been artificially produced by the action of the fixing and staining methods on the proteins of the cell, and in this way producing an artifact.

The endoplasm is that portion of protoplasm of the cell which is internal to the ectoplasm. It is more fluid in nature and is densely granular, containing the small particles of digested and partly digested foodstuffs each within a small vescicle of protoplasm containing liquid. The endoplasm is in constant motion, the particles in many cases making definite periodic journeys to the different parts of the cell. It is in the endoplasm that the processes of digestion of food takes place. Each food vacuole, as a pellet of food and its surrounding envelope is called, appears to contain digestive ferments which act on the food alone and in some peculiar manner leave the neighbouring protoplasm of the vescicle untouched. The undigestable remains of the food is got rid of at any point on the surface of the body in the naked forms, and at the aperture of the test in the shelled forms. This defecation consists simply of the movement of the vacuole towards the surface and finally the extrusion of the contained particles. Many of the vacuoles contain, instead of food, stored up nutrient substances such as fat and "paraglycogen." These are stored up in great quantities before the animal undergoes developmental changes. Many substances, however, contained in the endoplasm are excretory in nature and apparently are of no use for future metabolism; examples of these are the pigment granules seen in many Rhizopods and also the crystals which in many cases are said to consist of uric acid. Finally, the bubbles of gas seen in the various Arcellae, although probably not metaplastic in nature, can be classed as parts of the endoplasm, as they are formed there and can apparently be reformed and absorbed at the pleasure of the animal. These seem to serve hydrostatic functions, the animal apparently depending on the number and size of these bubbles for its position in the water.

As can be seen from the foregoing instances the endoplasm serves a very important function in the metabolism of the cell, as it carries the various nutrient juices which are the results of digestion to all parts of the cell; carrying on, in fact, the functions of the blood in the higher animals.

Since the structure of the ectoplasm and the endoplasm and also their functions have now been discussed, the formation and uses of pseudopodia can now be studied. In the class Rhizopoda, there are a few different types of pseudopodia :—(1) The Amœbina and the Arcellida possess lobose forms which are usually few in number; (2) The Acicular type of pseudopodia seen in the genus Euglypha. These form stiff, branching nets in some cases which serve to capture food; (3) There is the reticulate form, which spreads out widely, branching and anastomosing many times, forming a very efficient net which serves to capture prey. In all cases the pseudopodia are variable in shape, size, and number.

The cause of the production of pseudopodia has been the subject of a few theories and a large number of lively controversies. Some thought that contractile fibres, which were never demonstrated, acted like small muscles and pulled the protoplasm into the form of a pseudopodium. This is just one of the many fantastic and erring theories which were advanced in order to explain the peculiar motion of these animals. At present the formation of these processes are being explained satisfactorily by means of the physical laws governing the behaviour of liquids, particularly the laws of surface tension. By means of these physical laws, however, everything cannot be explained, and as Dr. Calkin remarks, "The theories advanced still remain working hypothesis."

The laws governing the formation of pseudopodia may not be known, but the different appearances which they undergo are well understood, and may be briefly described as follows :—The ectoplasm flows out, forming a slight protuberance which continues to grow, being at first perfectly hyaline and clear, as it consists entirely of ectoplasm. In some forms the pseudopodium is mainly formed before the second stage occurs. This consists of an axial stream of granular endoplasm which flows to near the tip of the structure, where it diverges and flows backwards into the mass of the cell *via* the edges of the pseudopodium. This fountain-like process can be easily studied in *Amœba proteus*, which protrudes ideal lobose pseudopodia on the slightest provocation.

By means of these digitate processes the animal moves in a peculiar flowing manner, in fact it is nothing more nor less than an actual flowing forward of the mass of protoplasm which constitutes the animal. The shelled forms, on the other hand, pull themselves along by means of pseudopodia which grasp the substrata. *Amœba terricola,* however, which possesses a pellicle, or cell membrane, puts forth a number of pseudopodia on one side, which overbalances it, and in this manner the animal literally rolls along. These examples show how the different species use the same organs in different manners to achieve the same end, and that even in this very primitive group of organisms evolution, or specialisation of parts as it may be called, has taken place.

Although locomotion is accomplished by means of the pseudopodia, they also serve the animal as instruments for the capture and inception of food. When some nutritious substance is in the vicinity of a Rhizopod which possesses pseudopodia, the animal can be seen to flow round its prey and enclosing it within a chamber of living protoplasm together with a small amount of water, this forming what is termed a food vacuole in which the processes of digestion are carried on. This process of food inception is also assisted by a slimy adhesive secretion which forms a thin layer on the surface of the ectoplasm of the pseudopodia, as the object which has been encountered is in this way more firmly held while the animal surrounds it. The various other types of Rhizopoda, other than the family Lobosa, capture their food by similar methods which vary very little from the example which has been cited.

The food of the Rhizopoda may be generally stated to be of vegetable origin, from which they extract the chlorophyll and get rid of the indigestible remains. It consists most frequently of these microscopic members of the vegetable kingdom such as diatoms, desmids, and the spores of algæ. Some species, however, prey upon other minute animals, as commonly Radiolaria and even other Protozoa may be seen in the gastric vacuole, making very violent attempts to escape. They seem also to have a slight power of selection, but this is not found in every case. In *Vampyrella lateritia,* for example, this power is relatively abnormally developed, as the animal apparently searches for its food, which consists of the protoplasmic contents of the cells of filamentous algae allied to Spirogyra. The chlorophyll obtained from these various sources is then distributed through the endoplasm, there to undergo further digestion and be changed into soluble compounds which can nourish the various parts of the organism.

Since food is ingested, the results of metabolism—that is, the results of katabolism—have to be removed from the protoplasm. Partly, this is accomplished, as has been previously stated, by the expulsion of the solid end-products at any portion of the surface in the members of the Amœbina, and at the aperture or mouth of the test in the members of the Conchulina. The finer waste products of metabolism are got rid of, however, by definite organs of excretion, which are called contractile or pulsating vescicles or vacuoles. Each species of the sub-class under discussion usually has a definite number of these organs, but the number may vary, as in *Arcella vulgaris,* that beautifully symmetrical shelled form which is common in all the ponds and ditches about Perth, which commonly has four of these organs, but has been seen with far more.

In all forms the vescicle pulsates rhythmically, gradually filling up with fluid and suddenly bursting at the surface of the body, where its contents are expelled. The time of a pulsation can be varied by the temperature, pressure, and also by varying the medium in which the animal is situated. This vacuole has been definitely ascertained to be for the purpose of nitrogenous excretion, and therefore analogous to the urinary organs of the metozoa. There is a relation between the contractile vacuole and the nucleus which is at present not understood. It is seen that as the vacuole grows, it lags on account of the increase of its weight compared with that of the surrounding protoplasm and so finally reaches the ectoplasm of the posterior region, where it discharges its contents. Its reappearance is always somewhere at its point of disappearance, and while still a very minute globule it is carried by the currents of the protoplasm back to a position in close proximity to the nucleus. The contractile vacuole is also supposed to aid the elimination of carbon dioxide, formed as a result of respiration. This has never been actually proved, but beyond doubt is one of the chief functions of this organ about which so little is known and upon which experiments are so difficult to perform.

The nucleus in all its various forms is distinguished from the other elements of the cell by containing a large quantity of that substance known as chromatin, which is now mentioned in every volume of evolution and heredity, and which plays such an important part in many of the theories which have been invented to explain some of the multitude of mysteries which surround these very interesting subjects. Another complex constituent of the nucleus is a substance termed achromatin, which is distinguished from chromatin by not possessing the property of staining with basic aniline dyes, and in fact is very difficult to demonstrate by any means whatsoever. These substances are, relative to the cytoplasm, very much richer in phosphorus containing proteins.

A very common occurrence in the Rhizopoda, however, is that a certain amount of extra nuclear chromatin is sometimes present. This is well seen in that example, *Arcella vulgaris*. This chromatin is known as chromidia, and may take up different forms outside the nucleus, either in the form of scattered granules or as masses of chromatin. A great deal has been written about this chromidia and the important part it plays in cell life, but it would be a deviation from the subject if dwelt more fully upon in this article.

The nuclei of the different species of Rhizopoda vary greatly from one another in their shape and according to the manner in which the chromatin is distributed within it. In many cases secondary nuclei are formed from the extra nuclear chromatin, therefore proving that the statement "Omnis nucleus e nucleo" is false in the case of Rhizopods. The chromatin in a cell, however, can never form *de novo;* at least it has never been observed in this group, and the only way in which it increases in quantity is from pre-existing chromatin which grows as a result of assimilation.

The nonchromatinic portion of the nucleus consists of various structures. There is a fine network which is composed of a substance termed linin, which ramifies through the whole structure, optically giving an effect of alveolar nature. The interstices of this supporting skeleton are filled by a fluid probably identical with the hyaloplasm of the cell and named enchylema. Another component of the nucleus named plastin occurs in masses or knots throughout the structure, and forms the ground substance of the nucleoli or karyosomes. In addition to these substances named above the nucleus often contains a body named the centrosome, which appears to act as controlling centre for the many peculiar operations which the various parts of the nucleus perform during reproduction.

The number of nuclei in a species is usually fairly definite, although there are members of this class in which the number varies within limits. Some, such as *Amœba proteus,* possess only one, while that giant among the Amœbina, *Pelomyxa palustris,* is the proud possessor of many thousands scattered throughout the protoplasm. The variation in the different species, however, does not occur in numbers alone, but in the structure of the nucleus as well. A good example of this can be seen in that very small animal called *Amœba limax,* the nucleus of which, if it may with exactitude be called a nucleus, has no protecting membrane surrounding it like most of the other Rhizopods. The reasons will now be evident why this structure has been so long dwelt upon. Firstly, because there is no specific characteristic by which the nuclei of this group might be distinguished at present. A law could certainly be formed which would define the ideal Rhizopodan nucleus, but, unfortunately, every animal would prove an exception. Secondly, this structure appears to function greatly during the time of reproduction or cell division.

The Rhizopoda reproduce mainly by simple cell division or spore formation, either in the active state or during encystment. In the former there is an equal bi-partition of the protoplasm and the other constituents of the cell after the nucleus has undergone that complicated form of division known as karyokinesis. In the testaceous forms this simple method of division becomes more complicated, especially in those forms whose shells are secreted. Taking as an example of this kind that beautiful member of the Conchulina, namely, Euglypha, the nucleus before division is seen to be nearly surrounded by quartz plates of a similar shape to those of the parent shell. The cell then undergoes nuclear division and one of the nuclei travels towards the aperture of the cell. The next step in this act is the growing out of the protoplasm in the form of a bud, which gradually enlarges until it is about the same size as the parent, when the plates around the nucleus then symmetrically cover the animal. Separation now occurs, and the two animals go their own ways to carry on the same functions. Reproduction under the protection of a cyst, on the other hand, usually takes place in the manner known as spore formation. The animal becomes more spherical in its shape and secretes a protective covering for its body or aperture of its shell, and fragmentation of both the protoplasm and nucleus takes place. Each portion of nucleus surrounded by its " ration " of protoplasm may then do two things according to its species. It may develop flagella and break through the cyst, and after a time lose its flagella, develop pseudopodia, and become amœboid; or it may never pass through the flagellate period, but develop straight away into the amoeboid phase. In some cases, however, there is a slight deviation from this method of a sexual reproduction, as the swarm spores may take the place of gametes and conjugate, and in this way produce the adult individual.

After this short description of the main points of this class of animals, a few remarks of their distribution in the vicinity of Perth will not be out of place. As will be seen from the table, many of the most beautifully shelled forms of the genus Euglypha are to be obtained amongst the moss growing in the quarry at

Corsie Hill, and also from the Muir of Durdie. The more common members of the Difflugia genus are fairly evenly distributed throughout the pools in the vicinity, living on the debris at the bottom of the pools, but the place *par excellence* for this type is in the backwaters of the Earn, where many rare forms are to be obtained. The naked Amœbæ are found in great abundance in that small ditch running along the side of the Dunkeld Road, where certain species appear to grow to a relatively large size. The commonest species is *Arcella vulgaris,* which has been found in great numbers in every gathering which has been made, and can be obtained at nearly any period of the year in the pond at north end of the North Inch. Several rare forms, which have never been found in Scotland and which have not been recorded for Perthshire before, are contained in the list, and I am certain if any of the members of the outlying district took up the study of this interesting sub-class, or sent gatherings to the Museum, many species would be obtained which have never been seen before. In addition to the increasing the members of their native fauna, they could, I am sure, by the careful studies of the life histories of the different species, overthrow the present artificial and complicated classification for a more natural and simpler one.

This work was mostly done, during my vacation, in the laboratory of the Perth Museum, for the use of which I am indebted to the Perth Town Council; also the curator, Mr. Ritchie, for his encouragement and the help which he has given me from time to time.

PHYLUM PROTOZOA—

Class, SARCODINA; Sub-class, RHIZOPODA; Order, AMŒBINA.

Family, LOBOSA.

Genus Amœba—		
	A. proteus	B.B., I., C.C.
	A. villosa	B.B., M.D.
	A. fluida	P.Q.
	A. vespertilio	M.D.
	A. verrucosa	M.D.
	A. verrucosa var papyraceæ	M.D.
Genus Dactylosphærium—		
	D. radiosum.	I.
Genus Pelomyxa—		
	P. palustris	B.B., C.C., M.D.
	P. villosa	M.D.

Family, VAMPYRELLIDÆ.

Genus	Vampyrella—	
	V. lateritia	P.Q.

Order, CONCHULINA; Family, ARCELLIDA.

Genus	Arcella—	
	A. vulgaris	B.B., E., I., M.D., M.L., P.Q., My.L.
	A. vulgaris var angulosa	A.
	A. discoides	I., M.D., My.L.
	A. mitrata	M.D.
Genus	Pseudochlamys—	
	P. patella	C.Q., M.D.
Genus	Centropyxis—	
	C. aculeata	I., E.
	C. aculeata var discoides	A.L.
Genus	Difflugia—	
	D. oblonga	C.C., C.Q., I., E., My.L., B.B.
	D. oblonga var lacustris	C.C., E.
	D. oblonga var venusta	E.
	D. constricta	E., M.D., I., A.L., M.L., My.L.
	D. constricta var spin ifera	E., M.D., M.L., B.B., A.L., My.L.
	D. accuminata	E., M.D., I.
	D. accuminata var inflata	E., M.D., I.
	D. brevicola	C.C.
	D. globulus	C.Q., I., M.D.
	D. oviformis	A.L.
	D. lanceolata	E.
	D. lobostoma	E.
	D. pristis	I.
	D. urceolata	M.L.
Genus	Quadrula—	
	Q. symmetrica	C.Q., M.D.
Genus	Lesquerusia—	
	L. modesta	C.C., E.
	L. spiralis	C.C.
	L. inæqualis	C.C.
Genus	Nebula—	
	N. collaris	C.C., M.D.
	N. tincta	C.C.
	N. galeata	C.C.
	N. vitræa	C.C.
	N. Americana	C.C.

Genus Hyalosphenia—	
H. inconspicua	E.
H. sinuosa	C.C.
Genus Pontigulasia—	
P. compressa	C.C.

Family, EUGLYPHIDA.

Genus Euglypha—	
E. ciliata	C.C., C.Q., M.D.
E. ciliata forma glabra	C.Q., C.C., M.D.
E. compressa	C.Q.
E. tuberculata	C.Q., M.D.
E. scutigera	M.D.
E. acanthophora	E.
Genus Trinema—	
T. enchelys	C.Q., My.L., P.Q., M.D.
T. lineare	C.Q., M.D.
Genus Cyphoderia—	
C. ampulla	C.Q., M.D., I.
C. ampulla var major	P.Q.
Genus Assulina—	
A. seminulum	M.D.
Genus Corythion—	
C. dubium	M.D.
Genus Sphenoderia—	
S. lenta	C.C.

Family, GROMINIA; Sub-family, PSEUDOGROMINIA.

Genus Lecythium—	
L. hyalinum	M.D.
Genus Pseudodifflugia—	
P. gracilis	M.D.

LIST OF ABBREVIATIONS.

A.	Mouth of the Almond.
A.L.	Abercairney Loch.
B.B.	Bogle Bridge, Dunkeld Road.
C.C.	Caledonian Camp.
C.Q.	Corsiehill Quarry.
E.	Backwaters of the Earn.
I.	Pond, top of North Inch.
M.D.	Muir of Durdie.
M.L.	Methven Loch.
My.L.	Marley Loch.
P.Q.	Perch Quarry, Muirhall.

IX.—*Cairngorm Mountains seen from Perth.*

By JOHN RITCHIE, M.A., LL.B.

(Read 10th December, 1920.)

In 1903 I submitted to the Society notes on the horizon seen from Corsiehill and some other points of view near Perth. In the interval since then little or nothing has been discovered which calls for remark so far as the view from Corsiehill is concerned, though my attention has been drawn to the fact that, in favourable weather, the summit of Schiehallion is seen (and no more) from the place at which the Chart stands.

A friend has, however, been able to identify for me some important mountains seen from Murrayshall Hill, and I wish to have the result of his observations placed on permanent record in the Society's *Transactions* for future reference.

On examining the Chart it will be observed that there is a part of the horizon between Beinn Bhuirich and Carn an Righ, *i.e.*, almost due north of Perth, in which no distant mountains are shown. I expressed my opinion in 1903 that from Murrayshall Hill some of the summits of the Cairngorm range could be seen in this direction, including Cairntoul. The indentification of these, however, was a matter of great difficulty, but all doubt has now been removed by the investigations of the gentleman referred to (Mr. William Barclay, Sunnyside, Scone). One very clear morning, near the end of May, 1919, he went up Murrayshall Hill and by the aid of a telescope made a sketch of the distant tops seen in the space referred to, noting the shapes and positions of the snow patches, then three or four days later he made his way to some of the hills near the Spital of Glenshee—Glas Thulachan and Carn an Righ—and from the summits of these mountains compared his sketch with the hills and snow patches seen still further to the north. "I had no hesitation at all," he writes, "in coming to the conclusion that the tops visible belong to the Cairngorm giants—Cairntoul, Angel's Peak, and Braeriach. There were no snow patches in that direction to be mistaken for those on Braeriach descending in parallel lines from the skyline." He also identified a mountain seen to the west of those already named as Sgoran Dubh, which lies to the east of Kingussie and on the east side of Glenfeshie.

The accompanying sketch will help members of the Society to identify all these mountains. The heights are:—Sgoran Dubh (3658); Braeriach (4248); Angel's Peak (4095); and Cairntoul (4241). The distance of these peaks from Perth, in a direct line, is about 50 miles.

While they are not visible from Corsiehill they are well seen on a clear day from Deuchny Hill, which makes an excellent view point now that the wood which formerly covered it has been cut down.

It may also be noted here that on looking southwards from Murrayshall Hill the Lammermuirs are visible to the east and the Pentlands to the west of the Fife Lomonds. Among the Pentland summits there may be recognised Carnethy, Scaldlaw, East Kip, and West Kip. I am informed that the revolving light of the Bell Rock Lighthouse can be seen from the same hill on a clear night.

Mountains seen from King's Seat.

Members of the Society who are interested in the identification of the mountains seen from the neighbourhood of Perth will find it useful to examine the horizon from a number of points lying, say, to the north-east of the city. Thus they might take in succession, Kinnoull Hill, Deuchny Hill, Murrayshall Hill, Shian Hill (the prominent little hillock beyond the Muir of Durdie Road), Dunsinnan and King's Seat. The last of these, the well-known summit in the Sidlaws, is about 10 miles from Perth. It is 1235 feet in height.

When on King's Seat one very clear day a few years ago I made some notes on the mountains, mostly to the west and north, visible from that hill, and these particulars are now set down in the hope that they may be of some use.

From west to east the following mountains are prominent—

Ben Ledi, over Balmalcolm Farm.

Ben Vorlich and *Stuc a Chroin*, over Dunsinnan Gate Lodge—a red-tiled roof.

Ben Lawers, with its adjoining peaks, Beinn Ghlas, An Stuc Meall Garbh and Meall Gruaidh, makes one of the most impressive hill groups seen from King's Seat. The guide line is the prominent whitewashed shooting lodge of Tullybeagles to the west of Glengar.

Cairn Mairg and the Glenlyon hills form the next high group, between Ben Lawers and Schiehallion, which needs no guide line for its identification.

Next appears the rounded summit of *Farragon*, and if the day be clear two distant hills will be seen peeping over the nearer horizon line, somewhat to the right of Farragon. These are doubtless on the county march about Dalnaspidal, and they may be Sgairneach Mor and A' Mharconaich.

Ben Dearg appears between Ben Vrackie and Beinn a' Ghlo.

Beinn a' Ghlo is seen over Burrelton.

Beinn Bhuirich (Vuroch) is almost in front of Carn nan Gabhar, the highest summit in the Beinn a' Ghlo range.

The Cairngorm tops are not seen so well as from hills nearer Perth, as several of them are now hidden by Carn an Righ, but to the left of *Sgoran Dubh* another high mountain has come into view which is not seen from the heights near Perth. This is *An*

Sgarsoch (3300 feet), which lies on the march between Perthshire and Inverness-shire, near the source of the river Feshie. Sgarsoch is seen over Woodside.

Carn an Righ and *Glas Thulachan* are seen over Blairgowrie.

Mount Blair, over west end of Coupar-Angus.

Glas Maol, *Cairn na Glasha*, *Caenlochan Glen* and *Monega*, over Coupar-Angus.

Carn Bhinnein, over Old Rattray.

The *Cairnwell* is hidden by Mount Blair.

Lochnagar shows behind Mayar.

Driesh is seen over Alyth.

North Berwick Law is visible from King's Seat.

X.—*Museum Notes by John Ritchie, F.R.A.I., Curator.*

(Taken as read 10th December, 1920.)

The following are a few notes which may be of interest to members of the Society, viz. :—

A Wild Cat *(Felis catus*, L.*)* was caught in a trap at Glenlyon in November, 1919.

A Badger *(Meles taxus*, Schreb.*)*, female, was caught at Dupplin in September, 1920.

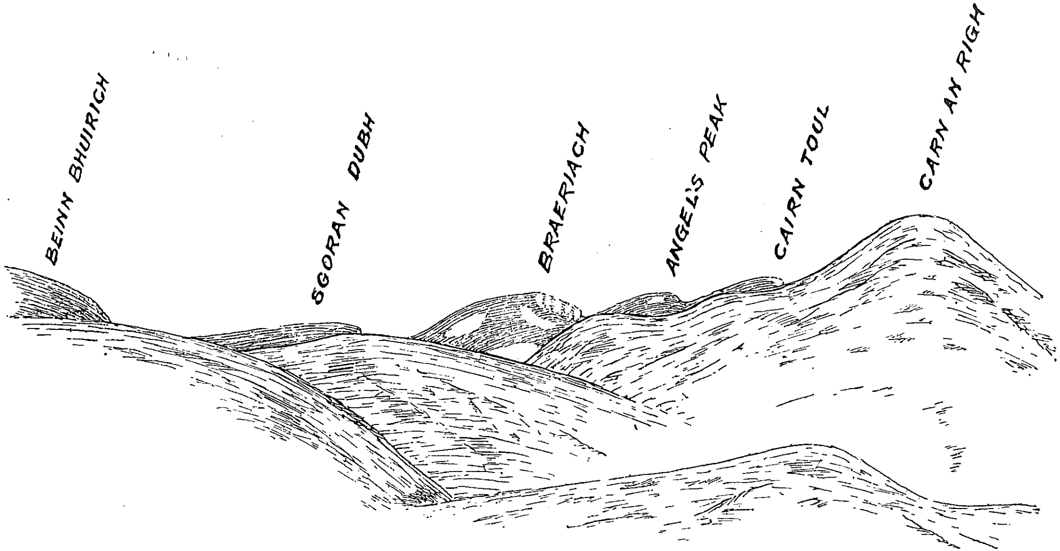
A Waxwing *(Ampelis garrulus*, L.*)* was killed in Carse of Gowrie in December, 1920.

During the summer several Longicorn Beetles of the Species *Acanthocinus œdelis* were caught at Luncarty and at Stanley, the probability of this being owing to the fact of so much of our native wood having been cut down.

Sawflies seem to be on the increase throughout Perthshire, many specimens of *Sirex gigas* having been sent into the Museum during the last year. Besides *Sirex gigas* we received several examples of *Sirex cyaneus* F. They were obtained from a coalhouse in Craigie district from firewood which had been obtained locally. Mr. Blair, of the British Museum, to whom I submitted a specimen, tells me that it is a N. American species which is now to be found occasionally in Britain.

Both the Convolvulus Hawk *(Phlegethontius convolvuli)* and the Tiger *(Chelonia caja)* Moth were captured on several occasions.

Antiquarian members may be interested in the finds made at the excavation in St. John's Place, Perth, where the foundations were being dug for a Picture Palace. The finds comprised ironwork of various kinds, leather of shoes, scabbard, sheaths, etc., a hoard of about 1128 gold and silver coins, and a beautiful bronze pot, all belonging to the 15th century.



SUMMITS IN THE CAIRNGORM RANGE,
SEEN FROM NEIGHBOURHOOD OF PERTH.

Plate 16.

XI.—*The Ciliata.*

By JAMES CRAIGIE.

(Read 14th January, 1921.)

The Ciliata may be briefly defined as Protozoa which are permanently provided with cilia. As their inclusion under the Protozoa implies, they are unicellular organisms. But here we look in vain for the simplicity of structure and function which characterises the typical cell. Stein, in his "Organismus der Infusionsthiere," remarked, "The adult Infusoria must ever be considered doubtful single-celled organisms, for they are not simply cells that have undergone further development, but the original cell-structure has given place to an essentially different organisation entirely foreign to typical cells." Nevertheless they are single cells. But it is a far cry from the comparatively simple Amœba to Vorticella, which boasts, among other organs, a complicated musculature and two nuclei of very different function; where the evolutionary impulse has obtained development, not by the tissue method, but by the production of a complexity of intracellular organs.

The simplest part of a Ciliate is the body-substance or endoplasm. As in all Protozoa, this is alveolar in structure. It may be compared to an emulsion where fluid droplets are enclosed in the meshes of a continuous, liquid, interalveolar substance. Only, the alveoli are far from uniform in size and contain granules of various kinds, inert and functionless or playing a definite part in the cell economy. The most important endoplasmic inclusions are food particles in various stages of digestion and assimilation. Reserve stores of food, fat globules, and waste and excretory products are also found. Other inclusions are pigments derived from the colouring matters of the food. In some species constant coloured spots, aggregations of pigment granules, occur. Sometimes various organisms are found living in the endoplasm. Green algal cells, Zoochlorellæ, are found in some species as symbionts. Chlorella vulgaris, more often than not, occurs in Paramœcium bursaria. It is injested with the food, but succeeds in resisting digestion. Species of the suctoria pass their embryonic phases in some of the Ciliata, especially Paramœcium and Stylonychia. Occasionally bacteria gain entrance to the organism, and rapidly multiplying, destroy it. A characteristic of endoplasm is its constant movement, shown by the streaming of the granules. This circulation varies greatly in different species and at different times in the same species, but never entirely ceases. Cyclosis, similar to that seen in some plant cells, is well marked in some species, *e.g.,* Paramœcium bursaria.

The endoplasm, concerned directly with the assimilation of food, shows little difference from that of Amœba. It is in the ectoplasm that we find the characters that sharply mark off the Ciliata from other Protozoa. The seat of locomotion and reaction to stimuli, it shows structural adaptation to environment in a striking way. Excluding the dimorphic nuclei, all the organs characteristic of the Ciliata arise from this outer layer.

Most external is the pellicle, homologous with the external membrane of the metazoan cell. It is formed by the condensation of the outer interalveolar lamellæ. In the Hypotricha it lies directly on the endoplasm and is usually thin and very flexible. Usually, however, a cortical layer intervenes between it and the endoplasm. Arising from the pellicle by conversion or secretion we have the lorica or theca of Folliculina and Tintinnus, the jelly-like matrix of Ophridium and the remarkable armour-plating of Coleps. This latter is a tight-fitting, horny product, arranged in four girdles composed of fifteen separate elongate pieces. Each component has a straight and a serrated edge. The neighbouring pieces slightly overlap and the serrations provide gaps through which the cilia protrude. In addition there are supplementary candal and dentate mouth pieces. Striations—longitudinal, spiral, or transverse—are well marked in some species. For the most part they indicate the insertion of the cilia or are due to the myonemes lying basal to them.

Lying internal to the pellicle is the important alveolar layer. From it the myonemes and the cilia arise. The cilia appear to be merely prolongations of it through the pellicle. They are fine, similar, even threads of apparently homogenous structure, arranged in rows. Yet in some unexplained way they are capable of regular rapid motion. The movement of a cilium is one of rhythmic curvature and slower relaxation. They act together, not sychronously, but in order, one slightly later than its predecessor, producing a wave effect comparable to that of the wind on a field of corn. Functionally, cilia may be divided into two groups; the body system, locomotor in function, and the oral system, which wafts a current of fluid with its suspended food particles towards the mouth. Both systems are modified in various ways, and this forms the basis of classification. Free-swimming forms, such as Prorodon, are clothed completely with simple cilia, of even length except for a slight elongation in the oral region. The body cilia in forms which habitually live on a substratum and are flattened tend to be confined to the ventral region, the dorsum often being completely bare except for a few setæ of evidently tactile function. Or they may be reduced apart from this habit of life, being completely absent during the sedentary stages of some genera, *e.g.*, Vorticella, or present as one or more girdles in their migratory phases or permanently in other genera, *e.g.*, Didinium.

In the more differentiated forms the body cilia are not present as such, but are modified into organs called cirri, characteristically found in the Hypotricha. By suitable treatment these organs may be broken up into their component cilia. Sometimes they occur with the end frayed out into their component parts. But they do not develop by the fusion of tufts of cilia; they arise from the ectoplasm as cirri. In the Heterotricha and Hypotricha an adoral row of membranelles is present. Like cirri they can be reduced to component threads. They are plate like in form, and are composed of fused, parallel, transverse lines of cilia. The third set of organs which are modifications of the ciliary system are the undulating membranes. They are confined to the oral region and are primarily formed by the fusion of longitudinal rows of cilia. They may be present in the pharynx or at the edge of the mouth, *e.g.*, in the Trichostomata. Small and difficult to observe in some species, they are a striking feature in others, such as Pleuronema chrysalis, where an enormous protrusible bag can be extended before the mouth. Membranes are also found in the Hypotricha, one being present along the right peristome border. Finally they are present in Peritricha, where they pursue a spiral course round the anterior extremity, varing from $1\frac{1}{2}$ to 5 turns, and then dip down into the mouth.

The myonemes are the contractile organs of the Ciliata. They lie in the peripheral alveolar layer from which they arise, though they may be found displaced into the cortical layer, or even the endoplasm. They lie in minute canals which, in some cases, they completely fill. The cilia seem to be connected with them by minute fibrils. With one or two exceptions they are absent in the Holotricha. Holophyra and Prorodon are the most notable. Among the Heterotricha some species, *e.g.*, Stentor, Spirostomum, are extremely well endowed with myonemes. Contraction takes place with lightning rapidity, rendering the task of fixation in the extended state practically impossible except by special methods.

But it is in the Vorticellæ and similar genera that we find the highest development of the musculature. In this group the sedentary zooid secretes a contractile stalk which can roll up tightly in a spiral manner, this action being accompanied by a sphincter-like action of the peristome collar enclosing the mouth and disc. Apart from the musculature of the pedicle various sets of myonemes are found in the zooid itself. Most easily found are those fibres which run from the centre of the disc to its periphery, then down the sides to the level of the origin of the secondary ciliary girdle from where they converge to the attachment of the pedicle and blend with the conspicuous muscle strand of the latter. In addition to this, two circular and one longitudinal layers have been described externally. A long fibre, winding spirally from the posterior end to the centre of the disc, recorded by Lachmann and also by Stein is considered by Entz to give the annulate appearance to the bell. The other circular layer, also composed of a continuous fibre, lies deep in the peristome disc to which it is confined. Between these two sets fine longitudinal fibres run from the centre of the disc to the posterior end. The stalk itself consists of a flexible outer wall, containing a fluid substance in which the myoneme strands run. These are divisible into three sets; a longitudinal spasmoneme, the continuation of the inner long myonemes of the bell, a coiled spironeme and an axoneme regarded by Entz as a kind of nerve centre. They are obviously antagonistic in action, but which is responsible for the retraction of the stalk is an unsettled point.

The cortical layer lies intermediate between the alveolar layer and the endoplasm. It forms a stratum of varying thickness, sometimes distinguished with difficulty, occasionally greatly thickened and forming the denser parts of the body, *e.g.*, the tail of Stentor. In this layer are found the trichocysts and the pulsating vacuoles. The trichocysts are minute rod or spindle-shaped bodies lying perpendicular to the surface, sometimes projecting into the streaming endoplasm and occasionally carried away by it. On irritation they explode and throw out threads five to ten times their length. Their function is presumed to be, for the greater part, defensive, but Maupas has described their use as offensive weapons in some of the carnivorous Ciliata, which employ them for paralysing their prey. They are not universally present in the Ciliata; it is in the Holotricha that they are found most characteristically, where they may be distributed all over the body or confined to special regions. One species of the Peritricha, Vorticella umbellaria, carries even more deadly weapons—nematocysts, ten to twenty in number. These, as in the Cœlenterata, contain a spirally wound thread which can be launched with deadly effect.

The vast majority of the Ciliata are holozoic in nutrition. Some are truly parasitic, living in the contents of the alimentary tract of animals, *e.g.*, Balantidium. Opalina, which inhabits the frog, has reached a degree of parasitism that it possesses no mouth, but absorbs nutritive fluid through the whole body surface. Entz records an interesting observation in Vorticella companula. He found it coloured by a diffuse green pigment, and the animal, in addition to feeding as such, able to assimilate like a plant. Some Ciliata absorb all food matter that comes their way, be it animal or plant. Others have an extremely limited dietary, such as Actinobolus radians, which confines itself to feeding on Halteria grandinella. These it captures by the trichocysts situated in batteries at the end of its protrusible tentacles.

Referring to the dominating character of the mouth in the Ciliata, Manpas says, " Nutrition in its manifold phases in these minute beings absorbs and completes their entire existence. This function assumes with them an intensity which, I believe, is equalled nowhere else in the animal kingdom. They are gluttons *par excellence,* absorbing and digesting night and day without repose. It results that an apparatus charged with such an intense function becomes modified, diversified, and developed to an astonishing degree, especially striking when it is remembered that they are unicellular organisms." The primitive position of the mouth is terminal, but it tends to be displaced backwards, sometimes occupying the posterior third of the body. When not terminal an adoral furrow of varying development may lead up to it. The special adoral organs, the membranelles and membranes, have already been mentioned. These are absent in the Gymnostomina, the more primitive of which have simply an aperture for a mouth and swallow their food. In this order a peculiar accessory apparatus may be found in the pharynx. It consists of bars secreted by the ectoplasm, which separate on food taking. In the rest of the Ciliata the mouth is perpetually open to receive the food particles swept towards it by the vibration of the adoral organs. The mouth leads to a pharynx or œsophagus of very variable development which may bear cilia or membranes and which opens into the endoplasm.

The current of fluid exerts a pressure on the exposed endoplasm at the proximal end of the pharynx. A cavity is formed in which the food particles collect. This vacuole, containing a certain amount of fluid, is, after a period, dragged away by the streaming of the plasm, and a new one forms. After a storage period, during which the water is absorbed, the vacuole reforms. The food substances are broken down by enzymes acting in an acid medium and the products are absorbed. Proteins are the main nutritive substances utilised. Emulsification of fats is disputed, but of the carbohydrates starch can be partially digested. Undigested residues are ejected by a special opening, the cytopyge.

As a result of the method of food taking a considerable amount of water is absorbed. To get rid of this and the dissolved salts is the first function of the pulsating vacuoles. Other functions have been ascribed to them which, though not actually proved, very probably are carried out. The end products of protein metabolism cannot be allowed to accumulate in the cell. From the katabolism of the protein molecule in the higher animals the purine derivatives are formed, and, one step further, urea. Another inevitable result is the formation of carbon dioxide. As far as our physiological knowledge goes we must assume that these end products, purines and carbon dioxide, are formed in the Protozoa. This matter cannot be discussed here, but the interesting experiments of Griffiths may be mentioned, where in Paramœcium and Vorticella he obtained, by the murexide test, evidence of the presence of uric acid in the pulsating vacuoles themselves.

The pulsating vacuoles vary in number from one to a hundred, but they are fixed in position and are always situated in the cortical plasm. From feeding canals, running in the cortical plasm, fluid flows to the vacuole. Of these only the main and largest are discernible, but probably there is an extensive system of fine afferent branches. Certainly in some species numbers of canals can be rendered visible by special treatment where normally none can be detected. Distinctive arrangements of canals and vacuole can be seen in various species. Spirostomum has a terminal vacuole and one long feeding canal running the length of the body. Urocentrum has also a terminal vacuole, fed by four longitudinal canals. Two vacuoles with numerous canals are found in Paramœcium. In Vorticella the vacuole is anterior, and discharges into the vestibule which separates mouth and pharynx. Over the site of the vacuole there is a minute pore in the pellicle, sealed internally by a thin layer of plasm. As the fluid accumulates and the vacuole increases in size this layer thins out. It finally gives way and the fluid is discharged. Thus a rhythmic systole and diastole take place. Some, including Delage, have invoked contractility of the wall in explaining the systole of the vacuole, but for this there is little evidence.

One of the most striking characteristics of the Ciliata is the (normally) dimorphic nucleus. Opalina is probably the only form in which it does not occur, and only one other Protozoon, Polykrikos, a flagellate, possesses such a differentiation. Chromatin, the essential constituent of nuclei, is an absolute necessity for the life of the cell. It may be active, functioning in the vegetative processes and in simple division, or germinative, of potential energy, giving rise to future vegetative chromatin in descendants after passing through the mechanisms of nuclear division. By separation and segregation of these two kinds the nuclear apparatus of the Ciliata arises. The vegetative chromatin, actively participating in the life of the cell, is present in the large macronucleus. The macronucleus contains the dormant chromatin destined to function in future cells.

The usual form of macronucleus is spherical or oval, but it may assume most diverse shapes. It may be greatly elongated and often flattened, usually curved, as in Euplotes and Vorticella. In double or multiple nuclei, *e.g.*, those of Stylonychia, Loxodes, a membraneous filament connects the components. Two species of Spirostomum show an interesting difference. S. teres has simply an elongate nucleus, while in the closely similar S. ambiguum it is moniliform or beaded. This beading is also found in the common species Stentor. With the exception of Loxophyllum, where a permanent spireme is present, the structure of the macronucleus is almost invariably alveolar. It appears solid and completely filled with chromatin. During division the chromatin granules are connected by a linin reticulum. A nuclear membrane is always present.

The micronuclei are often multiple. As their name implies they are bodies considerably smaller than the macronuclei. Their size ranges from 1-10μ. Hard to stain and usually lying attached in a small hollow in the macronucleus, they are often difficult to detect. Generally the chromatin is not uniformly distributed but is massed at some point and achromatin occupies the residual space. Division, which is preceded by enlargement, is by mitosis. Polar attraction spheres form and the chromatin is grouped into chromosomes.

In the majority of macronuclei division is much simpler. It is probably, not by amitosis, strictly speaking, but by a degenerate form of mitosis of which only the initial stages remain. We find all degrees of complexity in the mechanism, from a simple drawing out into two equal parts to the metazoic-like process in Spirochona. Both nuclei divide in simple division. In this process the fission of the cell is transverse (longitudinal in Vorticella, etc.). As the nuclear division proceeds a new adoral zone is formed in the posterior body-half. The pulsating vacuoles and other organs are reduplicated. The constriction of the body increases until a fine thread connects the daughter cells. The strain of the swimming movements, which are uninterrupted during division, finally ruptures the connecting strand and the cells separate to lead independent lives. Unequal division, in some forms, simulates budding, *e.g.*, Spirochona.

The question of senescence and rejuvenescence in the Protozoa has been the subject of much interesting controversy. From their methods of division they are potentially immortal, for no part of the original organism is lost; all descendent cells have the same faculty of dividing. Yet after a varying number of divisions, usually 300-500, degenerative changes appear. Weakness, dwarfism, and deformity are the visible signs of this, comparatively speaking, old age, a senility corresponding to that, not of an individual of the higher animals, but of the germ plasm itself. However, this senescence does not inevitably result in death. Normally vitality is restored by a rejuvenating mechanism known as conjugation. The essence of it is nuclear reorganisation.

Briefly, the process is as follows. The conjugants partly fuse together, usually in the oral region, and the opposed ectoplasmic surfaces are absorbed. The macronucleus disintegrates and disappears. The micronuclei involved divide two or more times. All the resultants of each degenerate except one. This remaining one divides into two pronuclei. Migration of one of each pair of pronuclei over into the other conjugant follows. Denoting the pairs as follows: a, a′; b, b′; exchange brings about this arrangement: b, a′; a, b′. These pairs now fuse together and by further division give origin to new macro- and micro-nuclei. Their nuclear apparatus restored, the conjugants separate and resume division. The conjugants are usually of the same dimensions. But macro- and micro-conjugants are found, *e.g.*, in the Vorticellidæ. Some species of Epistylis afford typical examples. The microgametes develop in fours or eights. They leave the parent colony and swim actively about by means of a posterior girdle of cilia. Ultimately they fuse permanently with a stalked macrogamete.

The primary function of this mechanism is the restoration of vital power which somehow or other gradually weakens as an uninterrupted series of simple divisions proceeds. Whether senescence is an inevitable concomitant of protoplasmic activity, or whether it can be indefinitely postponed by environment, artificial or otherwise, is a question by no means absolutely settled. But this much is certain, that the phenomenon is normally of constant occurrence in the Ciliata, and, what is more important, is, by conjugation, rapidly and effectively combated.

Encystment is a process almost peculiar to the Protozoa. With exceptions such as Macrobiotus and some of the Rotifers, it is unknown in the Metazoa. In the Ciliata it usually occurs when the organism is in danger of drying or when the environment becomes too foul. But it may take place after engorgement with food or before division. The process is preceded by a gradual slowing of movement. The mouth disappears, the ciliary appendages are absorbed, body inclusions are voided, and a gelatinous casing is secreted. This hardens to a chitinous cyst, rounded and variously decorated with spines. The only nuclear change is a slight decrease in size. For a time the pulsating vacuole continues to function, expelling fluid between the organism and the cyst wall.

To this protective faculty of encystment the wide distribution of the Ciliata is partly due. When, say, a pool dries up, their microscopic, resistant cysts are scattered far and wide by the wind. A suitable environment being reached, the cyst is ruptured and the organism resumes an active existence after redeveloping its appendages. Another factor is the wide range of fluid media to which they can adapt themselves, this of course excluding the parasitic forms inhabiting the Metazoa. Cold reduces their activity, but most survive temperatures approaching freezing point. Enchelys, Nassula, and Amphileptus have been reported from the waters of the Ischian hot springs. Very many species are both marine and fresh water. The salt concentration of the medium can experimentally be greatly varied, provided the transition be continuous and gradual enough. They have even been accustomed to normally toxic concentrations of such substances as mercuric chloride. But they will not survive in chemically pure water or in fluid containing too great an amount of toxic organic matter. Add their power of rapid multiplication to their air-borne method of distribution and their wide range of environment and you have the explanation of their sudden appearance in a suitable medium, a phenomenon which, in spite of the work of Spallanzani, did so much to delay the full exceptance of Harvey's axiom, *ex ovo omnia.*

LIST OF SPECIES OF INFUSORIA FOUND IN DISTRICT ROUND PERTH.

Sub-Class I. CILIATA.

Order I. HOLOTRICHA. Except for a tendency to lengthen in the vicinity of the mouth, the cilia are similar in size. In typical forms they completely clothe the body, but in others they may be restricted to special regions.

Sub-Order 1. GYMNOSTOMATA. The mouth remains closed except during the ingestion of food. It has no undulating membrane connected with it.

Family 1. Enchelidæ. The mouth is terminal or sub-terminal; the pharynx tubular and usually straight.

Holophrya ovum, Ehrbg.	E., T., W.
H. discolor, Ehrbg.	E., M., P-Q.
Urotricha lagenula. Ehrbg.	P-Q.
Enchelys farcimen, Ehrbg.	P-Q., B.
Prorodon teres, Ehrbg.	W., M., P-Q., M-M.
P. margaritifer, C. & L.	W., E.,
P. niveus, Ehrbg.	M-M.
Lagynus ocellatus, Daday.	W.
Lacrymaria olor, O.F.M.	E., W., M., P-Q., M-M.
Plagiopogon coleps, Stein.	P-Q.
Coleps hirtus, O.F.M.	W., M., P-Q.
C. uncinatus, C. & L.	E., W., B., P-Q., M-M.
Didinium nasutum, O.F.M.	W.
D. balbiani, Butsch.	B., M-M.
Mesodinium pulex, C. & L.	W., T.
M. acarus, Stein.	M.

Family 2. Trachellidæ. The body is distinctly bilateral or asymmetrical, usually compressed. There is often a proboscoid prolongation in connection with the mouth.

Lionotus fasciola, Ehrbg.	E., W., M., T.
L. varsaviensis, Wrz.	W., T.
Loxophyllum meleagris, Ehrbg.	E., W., M.
L. armatum, C. & L.	M.
Trachelius ovum, Ehrbg.	M., T., M-M.
Dileptus anser, O.F.M.	T., W., P-Q.
D. anas, O.F.M.	W.
Loxodes rostrum, O.F.M.	E., W., P-Q.

Family 3. Chlamydodontidæ. The body is reniform or oval, often flattened, in which case the dorsal cilia are reduced or entirely absent. A smooth tube or a rod armature supports the pharynx.

Nassula ornata, Ehrbg.	T., M.
Chilodon cucullus, O.F.M.	W., M., B., M-M.

Sub-order 2. TRICHOSTOMATA. The mouth is always open, its borders or the pharynx being supplied with one or more undulating membranes.

Family 1. Chilliferidæ. The peristome area is absent or only slightly developed. The mouth is in the anterior body-half or close to the middle.

Trichoda pura, Ehrbg.	B.
Glaucoma scintillans, Ehrbg.	T., B., M., P-Q.
Frontonia leucas, Ehrbg.	E., W., M-M.
Colpidium colpoda, Ehrbg.	E., W., T., P-Q.
Plagiopyla nasuta, Stein.	T., P-Q.
Loxocephalus granulosus, S.K.	M., M-M.
Colpoda cucullus, Ehrbg.	W., M.

Family 2. Microthoracidæ. Markedly asymmetrical. The mouth is in the posterior body-half. Cilia often reduced.

Cinetochilum margaritaceum, Ehrbg. T., B., P-Q., W.

Family 3. Paramæcidæ. Peristome area large, triangular. Thickly and evenly ciliate. Pharynx tubular and bearing an undulating membrane, usually of considerable length.

Paramæcium aurelia, O.F.M.	T., W., P-Q.
P. caudatum, Ehrbg.	E., W., M., B., P-Q., T.
P. bursaria, Ehrbg.	E., M., M-M.. P-Q.
P. putrinum, C. & L.	B.

Family 4. Urocentridæ. With discrete ciliary fields, chiefly two broad encircling bands. Mouth ventral, central. Pharynx long and tubular.

Urocentrum turbo, Ehrbg. E., W., T.

Family 5. Pleuronemidæ. The pharynx is not infrequently absent. From the left border of the peristome an undulating membrane arises, sometimes encircling its posterior end. The right border has a less developed membrane or a row of cilia.

Lembadion bullinum, O.F.M.	B.
Pleuronema chrysalis, Ehrbg.	W., T.
Cyclidium glaucoma, Ehrbg.	E., W., M., P-Q.

Family 7. Opalinidæ. The main characteristic is the absence of mouth and pharynx.

Opalina ranarum, Purkj.	Parasite of Frog.

Order II. HETEROTRICHA. Possessing a sinistropic adoral zone of membranelles.

Sub-order 1. POLYTRICHA. Ciliary coating uniform.

Family 1. Plagiotomidæ. Peristome narrow, gutter-like. Mouth situated centrally or in posterior body-half.

Conchophthirius anodontæ, Ehrbg.	Body mucilage of fresh-water mussel.
Blepharisma lateritia, Ehrbg.	B., M-M.
Metopus sigmoides, C. & L.	E., T., W., B.
Spirostomum ambiguum, Ehrbg.	E., M., M-M.
S. teres, C. & L.	W., T., M.

Family 2. Bursaridæ. Peristome broadly triangular and deeply excavate.

Balantidium coli, Malm.	Parasite of Pig.
Condylostoma stagnale, Wrz.	M., M-M.

Family 3. Stentoridæ. Adoral spiral well developed. Peristome small, displaced anteriorly, so that in some cases its plane is at right angles to the longitudinal axis of the body.

Climacostomum virens, Ehrbg.	W.
Stentor polymorphus, O.F.M.	E., I., T., M-M., P-Q.
S. niger, Ehrbg.	M-M.
S. caeruleus, Ehrbg.	T.
Caenomorpha medusula, Perty.	W., P-Q., M-M.

Sub-order 2. OLIGOTRICHA. Cilia reduced and limited to certain areas.

Family 2. Halteridæ. No paroral cilia; any body cilia present take the form of leaping setae.

Halteria grandinella, O.F.M.	W., B., P-Q.
Strombidium claparedi, S.K.	P-Q.

Family 3. Tintinnidæ. Paroral cilia present, body attached by a stalk to a theca.

Tintinnidium fluviatilis, Stein.	P-Q.

Order III. HYPOTRICHA. Characterised by dorso-ventral flattening and marked differentiation of the cilia. Except for the presence of dorsal bristles, the cilia are confined to the ventral surface, are frequently fused to form cirri, etc., and form a sometimes very complicated oral system.

Family 2. Oxytrichidæ. Fusion of cilia more or less extensive; in primitive forms, almost invariably, the frontal and posterior cilia are differentiated. Contractile-vacuole and nucleus situated on the left side.

Kerona polyporum, Ehrbg.	T.
Urostyla grandis, Ehrbg.	M.
Stichotricha secunda, Perty.	M., W.
Amphisia diademata, Rees.	W.
Uroleptus piscis, O.F.M.	W., M., P-Q.
U. violaceus, Stein.	T.
U. ratulus, Stein.	W.
Pleurotricha lanceolata, Ehrbg.	M-M.
Gastrostyla steinii, Eng.	P-Q., W.
Oxytricha ferruginea, Stein.	M.
O. pellionella, O.F.M.	B., W., P-Q.
O. parallela, Eng.	B. P-Q.
Stylonychia mytilus, Ehrbg.	B., W., M., P-Q.
S. pustulata, Ehrbg.	B., E., I., M., M-M., P-Q., T., W.
S. histrio, Ehrbg.	W., M.

Family 3. Euplotidæ. Cilia and cirri considerably reduced, but the anal cirri are always present. Contractile vacuole situated on the right side.

Euplotes charon, O.F.M.	B., M., W., P-Q.
E. patella, Ehrbg.	W., P-Q.
Aspidisca costata, Duj.	T., P-Q., W.
A. turrita, C. & L.	W.

Order IV. PERITRICHA. Adoral zone a dexiotropic spiral. Body cilia absent or present as secondary girdles.

Family 3. Vorticellidæ. Sedentary forms with a temporary or permanent secondary girdle of cilia.

Sub-family 1. Urceolarinæ. Secondary girdle permanent, enclosing an adhesive disc.

Trichodina pediculus, Ehrbg.	I., T.

Sub-family 2. Vorticellinæ. Secondary girdle not permanent. A contractile peristome fold encloses the peristome. Often attached through the medium of a pedicle, branching or unbranched, rigid or contractile.

Scyphidia physarum, C. & L.	T.
S. rugosa, Duj.	P-Q.
Gerda glans, C. & L.	T.
Vorticella nebulifera, Ehrbg.	I., M., T.
V. alba, From.	E., B.
V. telescopica, S.K.	P-Q.
V. campanula, Ehrbg.	E., I., T., P-Q.
V. nutans, O.F.M.	W., B.
V. microstoma, Ehrbg.	E., T., M-M.
V. convallaria, Linn.	P-Q.
V. spectabilis, S.K.	T.
Carchesium polypinum, Linn.	T.
C. lachmanni, S.K.	I.
Zoothamnium simplex, S.K.	E.
Z. affine, Stein.	P-Q.
Epistylis digitalis, Ehrbg.	P-Q., T.
E. steinii, Wrz.	E.
E. flavicans, C. & L.	I.
E. umbilicata, C. & L.	T.
E. anastatica, Linn.	T., P-Q.
E. plicatilis, Ehrbg.	T.
Rhabdostyla ovum, S.K.	P-Q.
Opercularia lichtensteinii, Stein.	T.
Cothurnia imberbis, Ehrbg.	P-Q.
Vaginicola crystallina, Ehrbg.	W.

Sub-Class II. SUCTORIA.

Family 4. Podophryidæ. More or less globular in shape, stalked or unstalked. Tentacles numerous, may be confined to the apical region, styliform and capitate.

Sphærophrya pusilla, C. & L.	W., Host.—Paramæcium caudatum.
S. stylonychiæ, S.K.	M., Host.—Stylonychia mytilus.
Podophrya steinii, C. & L.	M-M.
P. carchesii, C. & L.	T.
P. mollis, S.K.	W.
P. cyclopum, C. & L.	P-Q.

Family 5. Acinetidæ. Tentacles capitate, numerous. Thecate, stalked or unstalked. Division endogenous.

Acineta lemnarum, Stein.	T.

LIST OF ABBREVIATIONS.

B.	Newhouse Quarry, Burghmuir.
E.	Backwaters of River Earn, 2 miles above Bridge of Earn.
I.	Pond, North Inch.
M.	Ponds, North of Deuchny Wood.
M-M.	Methven Moss.
P-Q.	Perch Quarry, Muirhall.
T.	Overflow of Lade, Tulloch.
W.	Woody Island.

The above list, although it can make no pretence of being an exhaustive one, considering the class of organisms with which it deals, gives, at least, an indication of the commoner species which may be met with in this district. The localities from which the material was drawn show considerable differences. The ponds north of Deuchny Wood disappear completely after a spell of dry weather, and each time they reform the ciliate population has to develop from cysts, air borne or survivals from a previous fauna. The other localities never dry up completely and provide hauls most of the year round. Certain sedentary types can always be obtained from the overflow of the Lade at the Tulloch. It is well aerated by a plentiful growth of Canadian pond weed, and the bottom is covered with a rich stratum of decomposing organic material. In marked contrast to this is the small side stream at the Woody Island. It offers a suitable multiplying ground for organisms carried down by the Tay, and as regards population is the scene of incessant change. Most of the species of Hypotricha recorded have been obtained from it though they never occurred in any numbers.

The record of species dates from the late summer of 1919. The examination of material was, at first, carried out in the Museum, and for the facilities for the work the writer desires to express his thanks to the Town Council and to Mr. Ritchie, to the latter, in addition, for his liberal assistance and advice.

XII.—*A Descriptive Catalogue of Stone Implements in the Perth Museum.*

By JOHN ASHER, F.S.A.Scot.

(Read 11th February, 1921.)

This Catalogue has been prepared for the purpose of introducing members of the Perthshire Society of Natural Science to the study of stone implements, and of persuading them to use their influence in procuring additions to the Museum Collection.

The student of antiquities is generally a collector, and he should remember that the chief object in collecting stone implements is not to amass specimens, but to ascertain and record the facts connected with them. All the circumstances relating to the discovery of a tool should be noted, particularly its position and association with any weapons or ornaments that may be discovered along with it. Without such information, isolated specimens are of little scientific value. Placed in a museum, however, beside similar objects whose records are known, a stone implement may, by comparison, have a story to tell. In particular, the recording of Perthshire antiquities is desirable, and with the aid of the Society it should be possible to make the Archæological Collections in the Museum completely representative of the antiquities of the county.

In this list the objects are described in the order of their Museum numbers, so that the note on each implement may be readily found. There are in the library of the Society copies of all the publications to which reference is made.

I am indebted to the President of the Society, Mr. George F. Bates, B.A., B.Sc., for the identification of many of the stone materials. Mr. Bates points out that it is almost impossible to speak with certainty of the exact classification of the stone in many cases, as it is not possible to submit the rock to detailed examination. I am indebted also to Mr. John Ritchie, F.R.A.I., Curator of the Museum, for photographing specimens, and to Mr. R. R. Boog Watson for looking up references in the Reports of the Smithsonian Institution.

No. in Museum Index.	Length in Inches.	Weight in Ounc's.	Stone.	Locality.	Donor.	Remarks.	References.
1 Pl. IV., 8	$24\frac{3}{4}$	43	Fine grained basalt	Mangaia Hervey Islands	Mr. John H. Dixon, 1917.	A ceremonial adze. Cp. with adzes used by the Tahitians and South Sea Islanders generally.	Avebury, Prehistoric Times, 7th ed., pp. 471, 472. Brit. Mus. Hbk. to Ethnographical Collections, p. 17.
9 Pl. IV., 12	$12\frac{3}{4}$	$31\frac{1}{4}$	,,	New Zealand	Mr. Ramsay, 1843.	A patoo-patoo, merai, mere, or meri.	Brit. Mus. Hbk. to Ethnographical Collections, p. 175. Evans, Ancient Stone Implements of Gt. Br., pp. 47, 202.
9a	$14\frac{1}{2}$	36	,,	,,	,,	Merai. These spatulate clubs were used by men of high rank, chiefly for killing prisoners. They were attached to the wrist by a strap which passed through the hole, the boring of which was performed from opposite sides by means of a stick dipped in wet emery powder. Merais were family heirlooms and possessed names. Cp. " Excalibur," the sword of King Arthur. The Peruvians had weapons like these—one of dark brown jasper and another of " a greenish amphibolic stone " being known. Cp. American Indian merais with blades approaching them in form. Note the decoration on the ends.	Cat. Anthropological Mus., Mar. Col., Aber., p. 242. Avebury, Prehistoric Times, 7th ed., p. 466. Smithsonian Contributions, 1879, pp. 219, 220. Smithsonian Contributions, 1884, Vol. I., pp. 766, 767. Smithsonian Contributions, 1896, pl. 42.
237	$9\frac{1}{2}$	5		,,	Mr. John H. Dixon.	A flax pounder. The stone has been worked to a shape convenient for holding in the hand.	Evans, Ancient Stone Implements of Gt. Br., pp. 222, 458.
782 Pl. IV., 14	13	$54\frac{3}{4}$	Fine grained basalt	Australasia		Cp. this axe head with the one of dark grey flint found in a field in Roxburghshire, and with a similar celt of aventurine quartz from the same county. A jadeite axe of like form was found on the banks of the Ericht, and an adze of greenstone at Glenluce. Note the hafting of a New Caledonian axe of jade.	Proc. Berwickshire Nat. Club, 1876-1878, p. 544. Proc. Berwickshire Nat. Club, 1885-1886, pp. 116, 117. Anderson, Scot. in Pagan Times, pp. 343, 345. Brit. Mus. Hbk. to Ethnographical Collection, p. 123.

No. in Museum Index.	Length in Inches.	Weight in Ounc's.	Stone.	Locality.	Donor.	Remarks.	References.
783 Pl. IV., 7	$4\frac{3}{8}$	4	Quartzite	Australia		A common form of Australian knife with grip of black boy gum covered with skin. The Hupas of California hafted their obsidian knives with otter skin.	Cat. Nat. Mus. of Antiquities of Scot. (1892), p. 107. Smithsonian Contributions, 1888, p. 64, pl. 96. Evans, Ancient Stone Implements of Gt. Br., p. 264.
784 Pl. IV., 6	$6\frac{5}{8}$	$37\frac{1}{2}$	Fine grained basalt	W. Australia		This axe was not hafted, but held in the hand by the black boy gum at the butt. The irregularities at one side are due to the natural fissure of the stone. Note the striation at the edge. The sharpening was done on a fixed grindstone and the axe rubbed in a direction parallel to its length. Australian axes were also hafted.	Cat. Anthropological Mus., Mar. Col., Aber., p. 279. Evans, Ancient Stone Implements of Gt. Br., pp. 150, 152.
785	$6\frac{3}{4}$	$22\frac{3}{4}$	Andesite	New Zealand		An axe with faces very slightly rounded and of unequal breadth, sides flat and tapering towards the butt, which is slightly chipped, edge more rounded on one face than on the other, cross section roughly rectangular. The hafting of axes should be studied.	Brit. Mus. Hbk. to Ethnographical Collections, p. 13. Evans, Ancient Stone Implements of Gt. Br., p. 149. Anderson, Scot. in Pagan Times, Br. and St. Ages, p. 351. Smithsonian Contributions, 1879, p. 237. Smithsonian Contributions, 1896, Frontispiece, p. 324.
786 Pl. IV., 11	$4\frac{9}{10}$	$8\frac{1}{4}$	Jade	,,		This axe has the appearance of having been cut at the sides by sawing and the edge ground in the direction of its length, a method not usually employed by people of primitive culture, but which was sometimes adopted by the Maories.	
787	$6\frac{1}{4}$	$20\frac{1}{3}$	Fine grained basic igneous rock			The shape of this axe has been determined chiefly by the natural form of the slab. One side has been sawn. The butt is chipped and the edge has been blunted and chipped, probably by use.	

788 Pl. I., 10	$4\frac{7}{8}$	4	Flint	Arbuthnot	Mr. James Thomson, 1840.	A triangular celt of a type not common in Scotland, chipped all over, except at the cutting edge, which has been ground and polished. The long edges have been originally quite regular. Cp. this axe with the Fordoun black flint axe and with the chipped flint axe with polished edge found at Pleshey, Essex.	Essex Naturalist, Vol. XV., pl. I. Proc. Berwickshire Nat. Club, 1882-1883, pl. 3.
789 Pl. I., 7	7	$8\frac{1}{4}$	,,	Pitlandie, Moneydie	,,	This celt, found near the Cromlech on the farm of Pitlandy, is beautifully chipped on one face, while the other has been partly polished. The broad end has been ground and polished to a curved edge. Few flint implements of large size have been found in Scotland, as the material was scarce.	
790 Pl. IV., 3	$1\frac{1}{16}$	$1\frac{1}{4}$	Jade	S. Pacific Islands		A very small axe, roughly triangular, with rounded butt. It has been polished to a cutting edge on the flat faces, but shows the natural surface of the stone at the sides. This axe is even smaller than one from the Shannon. Cp. it with the similar implements from Guernsey and Ephesus.	Avebury, Prehistoric Times, 7th ed., p. 91. Evans, Ancient Stone Implements of Gt. Br., p. 115. Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 98.
790a Pl. IV., 9	$2\frac{7}{8}$	$3\frac{3}{4}$	Felsite	,,		A beautiful symmetrical axe polished over its whole surface and in perfect condition.	
791 Pl. IV., 1	$2\frac{1}{4}$	$\frac{3}{4}$	Jade	,,	Mr. James Thomson, 1840.	A polished chisel of oval cross section, probably hafted like the New Zealand chisel described by Evans.	Evans, Ancient Stone Implements of Gt. Br., p. 158.
792	$5\frac{5}{8}$	$6\frac{7}{8}$	Greywacke			A rudely-chipped axe ground at the cutting edge.	
792a	4	$8\frac{1}{4}$	Fine grained schist			An axe ground over the whole surface. The butt is unsymmetrical because of the grain of the stone.	
792b	$3\frac{1}{2}$	$5\frac{1}{4}$	Fine grained basic igneous rock			A rough-faced axe ground at the cutting edge only. The edges taper to the butt.	

No. in Museum Index.	Length in Inches.	Weight in Ounc's.	Stone.	Locality.	Donor.	Remarks.	References.
792C	3	$5\frac{1}{2}$	Fine grained diorite			A South Pacific type of axe not unlike No. 790 in form.	
793	$5\frac{9}{16}$	14	Andesite			This axe is somewhat adze shaped and has an edge slightly concave. Note on the edge the longitudinal striation due to the grinding.	
794	$2\frac{1}{2}$	$3\frac{1}{2}$	Fine grained diorite	New Zealand		A sinkstone grooved longitudinally. See the illustration of a specimen from Scotland.	Cat. Nat. Mus. of Antiquities of Scot. (1892), p. 71.
1278 Pl. I., 4	$2\frac{1}{2}$	$6\frac{1}{2}$	Fine grained basalt		From Dr. Lauder Lindsay's Collection, 1903.	A wedge-shaped axe or chopper. Several wedge-shaped implements have been found at Lauderdale.	Proc. Berwickshire Nat. Club, 1876-1878, pl. 9.
1409	$2\frac{9}{16}$	$3\frac{1}{2}$	Argillaceous sandstone	Williamston	Mr. Robert T. Bruce, 1918.	A heart-shaped perforated stone. Many of the perforated stones are merely net or line sinkers. Some may have been stone hammers, like the fighting clubs of New Guinea. Cp. with these the digging sticks of the Bushmen of South Africa.	Cat. Nat. Mus. of Antiquities of Scot. (1892), pp. 56-58. Munro, Anc. Scot. Lake Dwellings, p. 171. Br. Mus. Hbk. to Ethnographical Collections, pp. 131, 212. Wood, Nat. Hist. of Man, Vol. I,, p. 254.
1411 Pl. III., 25	$1\frac{5}{8}$	$\frac{1}{7}$	Flint	Greenhill, Dunning	Mr. W. R. Anderson, Dunning, 1905.	A beautiful specimen of a tapering arrow head with tang and barbs.	
1412	$1\frac{7}{8}$	$1\frac{1}{4}$	,,	Elcho Nunnery	Mr. A. Gray, 1912.	Cp. this flint borer with No. 1809.	Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 49. Evans, Ancient Stone Implements of Gt. Br., pp. 289-291.
1413	2	$4\frac{1}{2}$	Flint	Barnhill	Mr. Neil Paton, 1905.	This flint was picked up in an earth house at Barnhill. A striking platform has been formed, and from it at least one	

						good flake has been struck. On the side remote from the larger flat side, other flakes have been struck from an old rough flattish part, and it is probably owing to the roughness of this surface that the irregular fractures have been produced.	
1414	$1\frac{1}{8}$	$\frac{1}{6}$	,,	Kinnoull Hill	Mr. Neil Paton, 1915.	A flint scraper which has been broken and cemented.	
1415	$3\frac{3}{4}$ (dia.)	14	Sandstone	Almondbank	Miss Mary Ross, Goodlyburn, 1917.	A perforated stone found in a field.	See under No. 1409.
1417	$2\frac{1}{2}$	$\frac{19}{20}$	Flint	Abernyte	Mr. Mason, Dundee, 1907.	An unfinished flaked flint picked up by a farm labourer in 1906. Note the traces of polishing on one side of the broader end.	
1418a	$1\frac{3}{4}$	$\frac{1}{2}$	,,	Carsie, Blairgowrie	Mr. Cunnison, Farmer, 1908.	A worked flint probably used as a scraper.	
1419	$1\frac{1}{2}$ (av.)	$\frac{2}{5}$ (av.)	,,	Callerfountain	Mr. G. Valentine, Perth, 1911.	Three "strike-a-light" flints, used with fleerishes, found in a rabbit burrow. Note the jagged edges. Scraper-like flints were used with nodules of iron pyrites to produce fire.	Cat. Nat. Mus. of Antiquities of Scot. (1892), p. 336. Anderson, Scot. in Pagan Times, Br. and St. Ages, p. 376.
1421	$1\frac{1}{2}$	$\frac{1}{10}$	,,	,,	Mr. G. Valentine, Perth, 1909.	A flake with beautifully worked edges and broken point found in a rabbit burrow. Note the secondary chipping.	
1422	$\frac{13}{16}$	$\frac{1}{28}$	,,	,,	Mr. G. Valentine, Perth, 1915.	A small arrow head with tang and barbs. For the classification of arrow heads read Evans and Avebury.	Moir, Pre-Palaeolithic Man, p. 44 and pl. 16. Avebury, Prehistoric Times, 7th ed., pp. 101-103. Evans, Ancient Stone Implements of Gt. Br., pp. 332-352. Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., pl. 4. Cat. Nat. Mus. of Antiquities of Scot. (1892), pp. 13-16.
1424 Pl. III., 7	$1\frac{1}{4}$	$\frac{1}{14}$	,,	Wellbank, Rossie Priory	L. Thomson, 1911.	The edge of this flint is beautifully chipped, but the point and the ends of the barb are broken.	

No. in Museum Index.	Length in Inches.	Weight in Ounces.	Stone.	Locality.	Donor.	Remarks.	References.
1426	3⅜	4¼	Mica-schist	Blair-Atholl	Sergt. Barlass (per Mr. J. A. Donald).	A perforated stone, much weathered and with a piece broken off one side. The stone was probably round originally, but is now worn to a heart shape.	See under No. 1409.
1428	1⅜	⅛	Flint	N. America (?)	Mr. A. M. Rodger, Perth.	This arrow head was picked up on the North Inch, Perth, but it is of a common American type.	
1435 Pl. I., 8	10⅛	48½	Indurated volcanic ash	Muir of Thorn	Mr. Alex. Miller, 1917.	A beautiful Neolithic axe of large size found in 1844. The whole surface is polished except where there are a few chips. One side is nearly straight, the other slightly curved towards the top. Axes of this form were usually hafted by passing the butt through a hole in the handle, at some little distance from the end.	Evans, Ancient Stone Implements of Gt. Br., pp. 138, 139.
1436 Pl. I., 5	9⅛	37	Fine-grained basalt	Redgorton	Mr. G. Cunningham Roy, 1907.	Note the thick grey patina on this axe and the colour of the basalt where chipped at the butt end. The stone was found in a field in 1850.	
1437	4¼	25	Dolerite	Quarrymill, Perth	Mr. A. Gray, 1911.	An anvil stone with indented hollow. Anvil stones were usually of larger size than hammer stones, and indented on one side only. Cp. with palaeolithic anvil stone.	Cat. Nat. Mus. of Antiquities of Scot. (1892), pp. 47, 48. Proc. Essex Field Club, Vol. III., p. 135.
1438	3¼	15½	Fine grained granite	Clatchard, Newburgh	Mr. A. Gray, 1914.	A naturally formed hammer stone with the ends roughened by use.	
1439	4⅝	19½	Dolerite	Muirhall Farm, Perth	Mr. A. Gray, 1911.	A naturally formed stone with a hollow on each of the two flat faces. It has been used as a hammer stone and very probably held in the hand without a haft.	Proc. Berwickshire Nat. Club, 1876-1878, pl. 1.

1440	$2\frac{1}{4}$	$2\frac{1}{2}$	Basalt	Pitlochry	Mr. R. F. Macaulay, 1915.	An oval tool stone with two hollows on opposite sides, probably for the fingers.	
1443	$3\frac{3}{8}$	$7\frac{1}{4}$	Felsite			An oval tool stone. The use of these artefacts is not thoroughly understood, and, as the depressions are very deep in many of the stones, some antiquaries believe the implements were mounted in handles.	Avebury, Prehistoric Times, 7th ed., pp. 99-101. Evans, Ancient Stone Implements of Gt. Br., pp. 213-218. Munro, Anc. Scot. Lake Dwellings, pp. 56, 173. Cat. Nat. Mus. of Antiquities of Scot. (1892), pp. 53-55.
1445 Pl. I., 3	$3\frac{5}{8}$	$7\frac{1}{2}$	Grit	Milton Farm, Ballindean	L. Thomson, 1911.	A polished axe head, slightly chipped, found 1907.	
1447 Pl. I., 11	$3\frac{3}{4}$	$9\frac{3}{4}$	Fine grained schist	Carsie, Blairgowrie	Mr. James Welsh, 1917.	A partly polished rectangular axe with part of one side removed. The axe was found in a field.	
1448 Pl. I., 12	$6\frac{1}{16}$	$20\frac{3}{4}$	Banded greywacke	Stanley	(Purchased).	This polished axe, tapering to the butt and with oval cross section, was found in a drain, 1905.	
1449 Pl. I., 1	$3\frac{3}{4}$	7	Fine grained dolerite	Blair-Atholl	(Purchased, 1917).	This appears to be part of a longer axe. Observe the reground edge and the patination on the older surface.	Avebury, Prehistoric Times, 7th ed., p. 93.
1450a	$2\frac{1}{2}$	$\frac{1}{2}$	Flint	Fayum, Egypt	Mr. H. W. Seton-Karr, Wimbledon, of the British Military Service in Egypt.	A javelin or arrow head with one face flat. There is often difficulty in distinguishing javelin from arrow heads, as there is regular gradation in size from the large javelin to the small arrow point. Cp. the best chipping on implements found in Britain with that on these Egyptian artefacts.	Evans, Ancient Stone Implements of Gt. Br., p. 330. Proc. Essex Field Club, Vol. II., p. 30.
1450b	$2\frac{1}{2}$	1	,,	,,	,,	On the side of this flint opposite from the cortex note the patina, which is of great value in distinguishing old flint surfaces from those formed by recent fracturing. Its colour and thickness depend not only on age but on the nature of the material in which the stone has been embedded.	Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., pp. 7, 23, 92, 106, 109, 125, 137, 138.

No. in Museum Index.	Length in Inches.	Weight in Ounc's.	Stone.	Locality.	Donor.	Remarks.	References.
1450c	$2\frac{3}{4}$	$1\frac{3}{4}$	Flint	Fayum, Egypt	Mr. H. W. Seton-Karr, Wimbledon, of the British Military Service in Egypt.	The form of this flint is somewhat like that of a Danish axe. The tool has probably been used with a haft.	Avebury, Prehistoric Times, 7th ed., p. 96. Evans, Ancient Stone Implements of Gt. Br., p. 62.
1450d	$2\frac{1}{2}$	1	Agate	,,		A flint shaped roughly like the sector of a circle. With the straight edges chipped it resembles a double scraper.	
1450e	3	1	Flint	,,	,,	Note the patina and the truncated flake-scars on this point.	
1450f	$1\frac{3}{4}$	$\frac{1}{2}$	Cher-tose flint	,,	,,	A triangular arrow point. The form is irregular but balanced.	
1450g	3	$\frac{3}{4}$	,,	,,	,,	An irregularly chipped point with concoidal ripplings on the flatter face.	
1450h	$2\frac{1}{2}$	$\frac{3}{4}$	Flint	,,	"	An oval worked implement from a curved flake.	
1450i	$1\frac{7}{8}$	$\frac{1}{2}$	,,	,,	,,	A triangular arrow point.	
1451a	$5\frac{1}{2}$	$\frac{3}{4}$	,,	,,	,,	The broad end of this long point (" lame pointue ") is straight, and chipped to a bevelled edge.	
1451b	$2\frac{5}{8}$	$\frac{1}{2}$	,,	,,	,,	An indented arrow or javelin point with one barb removed.	
1451c	3	1	,,	,,	,,	An oval tool, broken and roughly chipped at the edge.	
1451d	$2\frac{1}{4}$	$\frac{1}{2}$	,,	,,	,,	A broken point. Note the red colour where the patina has been chipped.	
1451e	$2\frac{5}{8}$	$\frac{1}{2}$	,,	,,	,,	A saw. Saws were sometimes mounted with their backs inserted longitudinally in handles considerably longer than the flints, so as to make the implements double handed. In Egypt corn sickles were made by inserting serrated flints in curved handles. Cp. with Scottish saws.	Munro, Prehistoric Problems, Ch. 8, especially pp. 310-315 and p. 327.

1451f	$2\frac{3}{4}$	$\frac{3}{4}$	,,	,,	,,	A peculiar arrow or javelin point with the straighter edge damaged.	
1451g	$2\frac{1}{8}$	$\frac{1}{2}$	,,	,,	,,	A saw.	
1451h	$2\frac{1}{4}$	$\frac{1}{2}$	,,	,,	,,	A pointed saw.	
1451i	$3\frac{3}{4}$	1	,,	,,	,,	An implement resembling "pointe en feuille de laurier." The chipping is chiefly at one edge.	
1451j	$2\frac{13}{16}$	1	,,	,,	,,	The point of this implement has probably been damaged.	
1452a	$4\frac{15}{16}$	$1\frac{7}{8}$	,,	,,	,,	Note the unusual curve on the edge of this knife. The end for insertion in a handle appears to have been broken. Cp. with American hafted knives.	Brit. Mus. Gd. to American Antiquities, p. 22. Report U.S.A. National Museum, p. 749 and pl. 1.
1452b	$2\frac{3}{8}$	$1\frac{1}{4}$	Variegated flint	,,	,,	A triangular shaped scraper which may have been used with a handle, but a scraper edge has been chipped all round.	
1452c	$3\frac{1}{8}$	$\frac{1}{2}$	Flint	,,	,,	A bent flake knife. Cp. with knives from Assuan, Nos. 2022, 2023, 2024.	
1452d	$3\frac{1}{4}$	$1\frac{1}{4}$	,,	,,	,,	A knife or scraper. Note the concoidal ripplings. Cp. these blades with Scottish types like the specimen from Balveny, Banffshire. Large knives were rare in Scotland, because of the scarcity of flint.	Cat. Nat. Mus. of Antiquities of Scot. (1892), p. 2.
1452e	$1\frac{3}{4}$	$\frac{3}{4}$	,,	,,	,,	A broken point with a beautiful patina.	
1452f	$2\frac{1}{4}$	$\frac{3}{8}$	,,	,,	,,	A point with one edge serrated.	
1452g	$3\frac{5}{8}$	1	,,	,,	,,	A roughly chipped curved knife flake.	
1452h	$3\frac{3}{8}$	1	,,	,,	,,	A borer, probably used for wood. Notice how the cutting edges are worked on one side only, and compare the implement with Nos. 1809 and 1412.	Report U.S.A. National Museum, 1904, pl. 11., No. 241.
1452i	$3\frac{1}{4}$	$\frac{3}{4}$	,,	,,	,,	A knife.	
1452j	3	1	,,	,,	,,	Note the natural butt on this implement.	
1453a-j Pl. III., 5, 8, 12, 13,16,17, 22,23,27, 28	$1\frac{1}{2}$ (av.)	$\frac{1}{6}$ (av.)	,,	,,	,,	Indented arrow heads. Note the irregular forms. Arrow heads with unequal barbs or wings are common in Yorkshire. The finer chipping on flint implements was not generally effected by blows, but by pressure with a point of bone or horn.	Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 137. Moir, Pre-Palaeolithic Man, pl. 2. Evans, Ancient Stone Implements of Gt. Br., pp. 34, 35. Avebury, Prehistoric Times, 7th ed., pp. 98, 99 Report U.S.A. National Museum, 1904, pl. 10.

No. in Museum Index.	Length in Inches.	Weight in Ounc's.	Stone.	Locality.	Donor.	Remarks.	References.
1454a	$2\frac{1}{2}$	$\frac{1}{5}$	Flint	Fayum, Egypt	Mr. H. W. Seton-Karr, Wimbledon, of the British Military Service in Egypt.	A knife flake.	
1454b	2	$\frac{1}{6}$	,,	,,		A flake knife or scraper.	
1454c	$1\frac{3}{8}$	$\frac{1}{7}$	,,	,,		A beautifully chipped leaf-shaped arrow head.	
1454d	$1\frac{1}{4}$	$\frac{1}{20}$	,,	,,		Small arrow head finely chipped.	
1454e	$1\frac{3}{8}$	$\frac{1}{7}$	,,	,,		Probably a scraper.	
1454f	$2\frac{1}{8}$	$\frac{1}{7}$	,,	,,	,,	A knife flake or scraper.	
1454g	$1\frac{5}{16}$	$\frac{1}{7}$	,,	,,	,,	A broken point with one edge badly chipped.	
1454h	$1\frac{1}{4}$	$\frac{1}{14}$	,,	,,	,,	An arrow head, lozenge shaped, but thicker than most British specimens of similar form.	
1455 Pl. II., 5	$7\frac{1}{4}$	21	,,	,,	,,	This implement worked to a fine point is a characteristic palaeolithic flint. Although most of the implements in the Fayum collection are palaeolithic in type, they were not discovered under the same geological conditions as the river drift implements of Europe. For the smaller implements palaeolithic age has not been claimed. Cp. these implements with the paleoliths described and illustrated in "Prehistoric Times."	Report U.S.A. National Museum, 1904, pp. 745-751, with accompanying 12 plates. Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., pp. 104, 105, frontispiece and pl. 3. Avebury, Prehistoric Times, 7th ed., Ch. 11. Evans, Ancient Stone Implements of Gt. Br., Chs. 22, 23.
1456	$5\frac{1}{4}$	21	Quartzite or indurated sandstone	,,	,,	A roughly chipped implement, probably unfinished. Cp. the irregular flints from Fayum with similar flints from Virginia.	Smithsonian Contributions, 1896, pl. 4.
1457	$5\frac{7}{8}$	$19\frac{1}{2}$	Ferruginous quartzite	,,	,,	A roughly rostro-carinate implement. The cutting or chopping edges are at the sides, the ventral surface is nearly flat, and part of the dorsal surface remains.	Moir, Pre-Palaeolithic Man, Ch. 5 and Ch. 3, pl. 4. Lankester, Phil. Trans. Roy. Soc., May, 1912.

1458	4	16	Quartzite or indurated sandstone	,,	,,	Chopping tool.	
1459	$4\frac{1}{2}$	18	,,	,,	,,	Chopping tool. These implements may have been used after the manner of the Stoke Newington specimens.	Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 27.
1460	$5\frac{1}{2}$	$12\frac{1}{2}$	Grit	,,	,,	An implement of the same class as No. 1465, but more roughly chipped.	
1461	3	6	Quartzite or indurated sandstone	,,	,,	A roughly chipped instrument resembling Nos. 1458 and 1459.	
1462	$3\frac{3}{4}$	$4\frac{1}{2}$	Ferruginous quartzite	,,	,,	A chisel-shaped palaeolith.	
1463	5	9	Grit	,,	,,	A typical pointed palaeolithic implement.	
1464 Pl. II., 4	$4\frac{3}{4}$	17	Basalt	,,	,,	Note the thick butt of hand axe type.	
1465 Pl. II., 6	5	$11\frac{1}{2}$	Quartzite	,,	,,	This ovate implement has been worked all round to a cutting edge. The butt has been worked, probably for the insertion of a handle.	
1466	$2\frac{5}{8}$ (dia.)	$14\frac{1}{2}$	Quartz	,,	,,	A quartz ball used for chipping. Cp. with spherical quartz pebble found in Lochlee Crannog and hammer stones for flaking flint.	Munro, Anc. Scot. Lake Dwellings, p. 74 Smithsonian Contributions, 1896, p. 423. Proc. Essex Field Club, Vol. III., p. 135.
1467	$\frac{3}{4}$	$\frac{1}{40}$		,,	,,	Seven exceptionally small arrow points of various forms.	Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 115.
1476	$\frac{3}{4}$ (av.)	$\frac{3}{20}$ (av.)	Flint		Mr. H. H. Greig, 1901.	Old gunflints. Gunflints should be compared with French strike-a-lights. Evans gives an account of gunflint manufacture.	Evans, Ancient Stone Implements of Gt. Br., p. 283 and pp. 17-19.

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1479	1¾	$\frac{2}{7}$	Flint	Colloch Hill, Kinross-shire	Miss Gray, 1917.	An unfinished implement found in 1914. Note the patina on old scars.	
1481	1⅜ (dia.)	1		Site of City Hall, Perth	Mr. A. Gray, 1917.	A rudely-decorated spindle whorl, found in 1909 during the excavations for the foundation of the new hall.	Cat. Nat. Mus. of Antiquities of Scot. (1892), pp. 79, 83. Evans, Ancient Stone Implements of Gt. Br., pp. 390-393. Munro, Anc. Scot. Lake Dwellings, p. 213.
1511	1½ (dia.)	1	Clay slate	Auchterarder	Mr. Robert Guthrie, 1915.	A spindle whorl with smooth surface.	
1512	$1\frac{1}{16}$	$\frac{1}{7}$	Flint	Old Road above Parkfield	Mr. R. R. B. Watson, Perth, 1917.	One edge suggest gunflint cutting. Note the scraper chipping of the curved edge. Cp. this flint with a modern French strike-a-light. Note the characteristic scraping edge on Esquimaux scrapers.	Evans, Ancient Stone Implements of Gt. Br., p. 283. Avebury, Prehistoric Times, 7th ed., p. 95.
1517(1) Pl. II., 7	4¾	19⅛	Flint	Northfleet, Kent	The Associated Portland Cement Manufacturers, Ltd., per Mr. Reginald A. Smith, of the British Museum.	Cp. this palaeolith with the Gray's Inn Lane implement. These flints from Northfleet represent a series of types. Cp. with these the various drift types. A large flint knife from Grayford resembles some of the Northfleet specimens.	Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., Frontispiece and p. 31. Evans, Ancient Stone Implements of Gt. Br., p. 522; Chs. 22, 23; pls. 1, 2. The Essex Naturalist, XII., p. 54.
1517(2)	3⅝	4⅝	,,	,,	,,	Note the concoidal ripplings and truncated scars. The various terms used in speaking of flint fracture and flint implements should be known.	Moir, Pre-Palaeolithic Man, pp. 13, 14, and pls. 1, 2.
1517(3)	4	7¾	,,	,,	,,	Where there has been recent chipping, observe the thickness of the patina.	
1517(4)	4¾	12	,,	,,	,,	This flint is partly patinated on one side.	
1517(5)	4	10¼	,,	,,	,,	Part of the striking platform is seen. Note one or two flake-scars with ledge, produced fortuitously or by careless or unskilled flaking.	

1517(6)	3$\frac{5}{8}$	2$\frac{1}{2}$	,,	,,	,,	The positive cone of percussion is well shown, as well as an éraillure.	
1517(7)	5	7$\frac{1}{2}$	,,	,,	,,	A considerable part of the striking platform is shown here.	
1517(8)	5$\frac{1}{2}$	11$\frac{3}{4}$	,,	,,	,,	Note the irregular chipping. The broad end has been broken.	
1517(9)	5$\frac{1}{8}$	7	,,	,,	,,	A sharp-edged tool of regular form.	
1517(10)	4$\frac{3}{4}$	4$\frac{1}{2}$	,,	,,	,,	Part of the cortex of the block is shown.	
1517(11)	5	4$\frac{1}{3}$	,,	,,	,,	The positive cone of percussion is well marked and a large part of the striking platform shown.	
1517(12)	3$\frac{1}{4}$	2$\frac{1}{6}$	,,	,,	,,	Observe the fissures on the flake-scars on the positive cone.	
1517(13)	7	10	,,	,,	,,	A long flake, probably struck from a core prepared like the Pressigny nuclei. The well-defined positive bulb shows concoidal ripplings. Cp. the large flint knife from Grayford.	Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 95. Evans, Ancient Stone Implements of Gt. Br., pp. 26, 27. The Essex Naturalist, XII., p. 54.
1517(14)	6$\frac{3}{4}$	8$\frac{1}{6}$	,,	,,	,,	A long flake struck from near the outside of the block after it had been prepared by the removal of small flakes. Part of the cortex is shown.	
1517(15)	5$\frac{1}{8}$	4$\frac{1}{2}$	,,	,,	,,	An irregular flake struck from near the surface of the block.	
1517(16)	4$\frac{7}{8}$	4	,,	,,	,,	A well-formed flake struck from a large core.	
1517(17)	5$\frac{1}{4}$	6$\frac{1}{2}$	,,	,,	,,	Note the marks on the cone of percussion of this well-struck flake.	
1518	4$\frac{5}{16}$	12$\frac{1}{2}$	Fine grained basalt	Chipigini, Guntakal, India	Colonel Cardew, 1919.	An implement of conical form, probably an incomplete chopping tool.	
1519	2$\frac{7}{8}$	6$\frac{1}{2}$	Medium grained basalt	,,	,,	An axe of flat oval section with butt wanting, and one of the edge facets badly chipped. The tool has probably been polished all over its surface.	
1520	2$\frac{1}{4}$ (dia.)	8	Coarse grained basalt	Guntakal, Anantapur, Madras	,,	A spherical neolithic crusher, broken on one side. Cp. with the Kent cavern implement of similar form.	Evans, Ancient Stone Implements of Gt. Br., p. 457.

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1521	2¾	9	Medium grained basalt	Bellǻry	Colonel Cardew, 1919.	An axe of oval cross-section, with butt wanting and edge much worn.	
1522	2¼	2¼	,,	,,	,,	The tapered butt of an axe of oval cross-section.	
1523	3⅝	8	,,	Madras Presidency	,,	An axe butt, badly chipped.	
1524	4	6	,,	Bellǻry	,,	An axe, roughly triangular and chipped over its whole surface.	
1525	4¾	10¾	Fine grained basalt	Madras Presidency	,,	This axe-shaped implement is badly chipped, but it appears to have been ground and polished to a cutting edge at the broad end. A part only of the original surface is shown.	
1526	2¾	6½	Coarse grained basalt	,,	,,	An axe head with the butt wanting and the surface partly disintegrated.	
1527	2⅜	4	Medium grained basalt	,,	,,	A triangular axe with butt wanting. It is polished all over and the edge is quite straight except at the corners.	
1528	3¼	6	Basalt	Bellǻry	,,	A well formed axe butt of oval cross-section.	
1529	2⅞	4¼	Medium grained basalt	Guntakal, Anantapur, Madras	,,	An axe point showing edge ground and polished on both sides.	
1530	4¾	11¼	Basalt	Madras Presidency	,,	A well formed axe of flat oval section. The original surface is shown on one side only.	
1531	2½	7⅞	Fine grained basalt	,,	,,	Part of an axe showing a ground and polished edge.	
1532	2¼	3	Coarse grained basalt	,,	,,	The edge end of a very flat axe.	

1533	4	6	Basalt	,,	,,	An axe head. The form is well shown, but the edge is badly damaged.	
1534	$3\frac{7}{8}$	25	,,	Guntakal, Anantapur	,,	Part of a neolithic mealing stone. The fragment is horse-shoe shaped and $1\frac{1}{8}$ inches thick. One face is perfectly plane, the other slightly convex. Cp. with saddle quern and American mealing plate. An illustration of wokas on a mealing stone is shown. Observe that the mealing stone is the lower.	Cat. Anthropological Mus., Mar. Col., Abdn., p. 13. Smithsonian Contributions, 1899, pl. 3. Smithsonian Contributions, 1902, pl. 7.
1535	$2\frac{7}{8}$	$4\frac{1}{3}$	Medium grained basalt	Guntakal	,,	The edge of this axe is in good condition, but the butt is damaged and the sides are irregular.	
1536	$2\frac{3}{4}$	2	,,	Belláry	,,	A small triangular chipped axe in good condition.	
1537	$2\frac{1}{4}$ (dia.)	$8\frac{1}{2}$	Grit	Guntakal, Anantapur	,,	A spherical crusher showing marked signs of wear on two opposite sides. Cp. with No. 1520.	Evans, Ancient Stone Implements of Gt. Br., p. 457.
1538	$2\frac{3}{4}$	$4\frac{1}{3}$	Medium grained basalt	,,	,,	The flatness of one face of this axe is due to the fissure of the stone. Part of the polished surface remains, and the edge is badly broken.	
1539	$2\frac{1}{2}$	3	,,	Belláry	,,	This appears to be part of an axe head broken longitudinally. Observe portions of the ground edge.	
1540	$3\frac{1}{2}$	10	Basalt	Chipigini, Guntakal	,,	This is part of an old implement which seems to have been cut recently at one side.	
1541	$3\frac{3}{4}$	15	,,	,,	,,	An axe with edge and butt wanting.	
1542	$3\frac{3}{4}$	$4\frac{1}{3}$	W'ther'd basalt	Guntakal, Anantapur	,,	An axe coarsely chipped on one side.	
1543	$3\frac{1}{2}$	16	Basalt	Belláry	,,	The butt of a thick axe of large size.	
1544	2-5	$2\frac{5}{8}$ (av.)	Chertose flint	Rohri Hills	The British Museum per Sir C. Hercules Read, 1916.	Ten cores from the Avebury collection. Observe the striking platforms and negative bulbs of percussion. The largest core has been used as a hand hammer. Cp. with flint cores from Craigsfordmains and with American obsidian cores.	Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 114. Evans, Ancient Stone Implements of Gt. Br., pp. 18, 249, 457. Brit. Mus. Gd. to American Antiquities, p. 12. Proc. Berwickshire Nat. Club, 1894-1895, p. 160.

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1544a	1½	$\frac{1}{11}$	Chertose Flint	Rohri Hills	The British Museum, per Sir C. Hercules Read, 1916 (Avebury Col.)	A small rectangular knife flake. Cp. with the minute Danish flake from the same collection.	Avebury, Prehistoric Times, 7th ed., p. 85.
1544b	1¾	$\frac{1}{14}$	,,	,,	,,	A trimmed rectangular flake, narrower than the last.	
1545	4¼	4¼	,,	Scauring Channel, S. Canal	,,	A flint core. See under No. 1544.	
1546 Pl. II., 9	3⅛	4⅞	Flint	Gravels of the Test at Dunbridge, Hants	The British Museum (The Richard Jones Col.)	A palaeolithic hand axe with orange-coloured patina.	Proc. Soc. Ant., London, Vol. XXIV., p. 109.
1547 Pl. II., 3	4⅝	11	,,	Gravels of the Test at Romsey, Hants	,,	A roughly chipped palaeolith with a broken point. The end of the butt is polished and the point of impact shown. Cp. with palaeoliths from Grays (Essex) and from Madras.	The Essex Naturalist, Vol. XIII., p. 112. The Essex Naturalist, Vol. II., pp. 98, 99.
1548 Pl. II., 2	4¼	8½	,,	Egyptian Desert	The British Museum, per Sir C. Hercules Read, 1916.	A patinated palaeolith chipped over the whole surface.	
1548a Pl. II., 8	4	8	,,	,,	,,	A palaeolith implement with a rich patina. Part of the cortex of the block has been left unchipped.	
1549	2½	1⅛	,,	Rohri Hills, Lower Indus	,,	A scraping and cutting tool. The positive cone of percussion and an éraillure with fissure markings are shown.	
1550	1⅓-7⅜	$1\frac{1}{10}$ (av.)	,,	Holywood, Co. Down	Mr. James Macdonald, 1912.	Seventy-two roughly formed patinated flint palaeolithic implements which have a water-worn appearance. They were found in an embankment forming a raised beach,	Avebury, Prehistoric Times, 7th ed., p. 422. Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 15.

						10 to 20 feet high, by the side of Belfast Lough. Note points and scrapers of various forms, and observe the resemblance of many of these implements to eoliths. It has been contended, however, that fortuitous movement of flints grinding against one another under pressure will produce chipping similar to that on eoliths.	Moir, Pre-Palaeolithic Man, Ch. 3. The Quarterly Journal of the Geological Society, Vol. LXXVI., No. 303, article on "A Natural Eolith Factory."
1551	$1\frac{5}{8}$-$4\frac{1}{4}$	$1\frac{2}{5}$ (av.)	,,	,,	,,	Fifty-eight flints of the same class as the last, but of more regular form. There is one well-formed knife flake with serrated edge. Observe the porcelainous patina on some of the flints. A few of the stones suggest well-known eolithic forms.	
1552			,,	,,	,,	Flints from the same collection, which have been labelled "Doubtful" by Mr. J. Reid Moir, F.R.A.I., Ipswich.	
1553			,,	,,	,,	Flints labelled "Natural" by Mr. Reid Moir.	
1554	$4\frac{1}{2}$	$1\frac{5}{8}$	,,	Brandon, Suffolk	Professor James Geikie.	A neolithic knife. There is an unusually large scar on the positive cone of percussion and the negative cone of the ridge flake is clearly shown. It was from long flakes of this type that gunflints were usually cut. American flint knives have been preserved with their handles.	Evans, Ancient Stone Implements of Gt. Br., pp. 17-19. Avebury, Prehistoric Times, 7th ed., p. 86. Brit. Mus. Gd. to American Antiquities, p. 22.
1555	6	$17\frac{1}{2}$	Fine grained basalt	Great Britain?	(Purchased, 1905).	A polished axe of oval cross-section, with obliquely-cut polished butt.	
1556	$4\frac{1}{2}$	$4\frac{1}{2}$	Flint	Caversham, Reading	(1913).	A knife flake.	
1557 Pl. II., 10	$4\frac{1}{2}$	12	,,	,,	,,	A palaeolith of drift type, which has been broken and cemented. Although part of the cortex at the butt has been left, the implement is comparatively thin there, and was probably mounted. Read Evans for palaeolithic types, and compare these and the Egyptian forms with specimens from Madras.	Evans, Ancient Stone Implements of Gt. Br., Chs. 22, 23. Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., pl. 3. The Essex Naturalist, Vol. II., pp. 98, 99. Avebury, Prehistoric Times, 7th ed., p. 360.

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1558 Pl. II., 1	4½	9⅙	Flint	Caversham, Reading	(1913).	An implement of the same type as No. 1557. The butt end has been chipped quite thin, and has evidently been formed for mounting.	
1559	2⅜	5½	Fine grained basalt			An axe of unusual form. From the slope of its polished faces it does not appear to have been much shortened at the butt. As this end is too small to give a proper grip, the axe might have been mounted in a handle, where the butt was fixed in the wood, without passing through its substance. The chipped appearance of the axe, however, suggests that it might have been used as a wedge.	Proc. Berwickshire Nat. Club, 1876-1878, pl. 9.
1560	4⅜	21½	Coarse grained basalt	Nr. Giants Causeway	Mr. A. M. Rodger, Perth, 1903.	A perforated stone hammer with picked decoration. The hole has the appearance of having been picked from both sides and then roughly ground. Note the signs of use at one end only. Decorated implements of this class were often used as maces. Some were attached to the handle by a leather thong, and if this implement were so hafted the roughened surface might have been used to grip the leather. Fighting hammers of various forms were used by primitive people in recent times.	Evans, Ancient Stone Implements of Gt. Br., pp. 194-197. Cat. Anthropological Mus., Mar. Col., Abdn., p. 85. Brit. Mus. Hbk. to Ethnographical Col., p. 131.
1561	3⅞	2	Flint	,,	,,	This neolithic implement has been carefully chipped on both sides of the straight edges, as if meant originally for a lance head. The ground edge, however, implies that the tool must have been used as a chisel or knife, and when so employed it must have been hafted, perhaps like an	Avebury, Prehistoric Times, 7th ed., pp. 497, 498.

						Esquimaux knife. Cp. the quality of the secondary chipping with that on the smaller Fayum implements.	
1562 Pl. III., 4	$3\frac{1}{2}$	$1\frac{1}{4}$	,,	,,	,,	A neolithic lance head.	
1563 Pl. III., 15	$2\frac{1}{4}$	$\frac{1}{3}$	,,	,,	,,	A neolithic barbed arrow head.	
1564 Pl. III., 24	$2\frac{1}{4}$	$\frac{1}{2}$	,,	Wisconsin, U.S.A.	Mr. Neil Paton, Perth, 1905.	A typical North American arrow head. There is much valuable information on American flint implements in the Smithsonian Contributions :—	
						On the manufacture of arrow points by the Apaches.	Smithsonian Contributions, 1879, p. 381.
						On arrow heads.	Smithsonian Contributions, 1882, p. 696.
						On stone chipping.	Smithsonian Contributions, 1885, Vol. I., p. 871.
						On the Hupa manufacture of arrow heads and hafts.	Smithsonian Contributions, 1886, Vol. I., p. 225.
						On flint chipping by the Pottawatomie Indians.	Smithsonian Contributions, 1887, Vol. I., p. 601.
						On arrow heads.	Smithsonian Contributions, 1892, p. 558.
						On the making and mounting of an arrow point.	Smithsonian Contributions, 1893, p. 631.
						Illustrations of Indian spear heads.	Smithsonian Contributions, 1901, pls. 13-23.
1565 Pl. III., 9	$1\frac{3}{4}$	$\frac{1}{10}$	Fine grained basalt	Okanagan Lake, Br. Columbia	Miss Young, 1908.	An American arrow head. Note the dents for fixing the cords that bind the arrow head to the shaft.	
1566 Pl. III., 18	$1\frac{3}{4}$	$\frac{3}{7}$	Chertose flint	Kentucky Caves	Mr. Erskine Beveridge, Dunfermline.	A "squatter" point. Cp. this implement with the stone blades on American old toggle heads.	Smithsonian Contributions, 1900, p. 266.
1567 Pl. III., 1	$2\frac{3}{8}$	$\frac{1}{5}$	Flint		Mrs. Crawford Smith, Perth, 1917.	A tanged arrow head with a twisted point. Although twisted edges were sometimes the result of the form of the flint, they were often made deliberately.	Evans, Ancient Stone Implements of Gt. Br., p. 520.

No. in Museum Index.	Length in Inches.	Weight in Ounc's.	Stone.	Locality.	Donor.	Remarks.	References.
1569	2	$\frac{3}{5}$	Flint	Tentsmuir	(Purchased).	Probably a broken spear point.	
1570a, b	1	$\frac{1}{20}$	,,		(Purchased).	Small tanged arrow heads which all appear to be faked. Note the form and compare the crude chipping with that on genuine points. The flat colour points to recent working. The methods of forgers should be studied and the work of "Flint Jack" examined.	Evans, Ancient Stone Implements of Gt. Br., pp. 145, 575. The Essex Naturalist, Vol. I., pp. 88, 89.
1571	$3\frac{1}{8}$	$\frac{7}{8}$	Flint	Edge of Lough in North Ireland	Miss Layard, Ipswich, 1908.	The broad end of this flint has been broken since the flake was chipped. Note the thickness of the porcelainous patina.	
1571a	$2\frac{7}{8}$	$2\frac{1}{4}$	,,	,,	,,	The ventral surface of this implement may have been formed by thermal fracture. Note the double-edged beak shape.	
1571b	$3\frac{1}{8}$	$1\frac{3}{4}$	,,	,,	,,	A flake similar to No. 1571, but broader.	
1587	$\frac{15}{16}$		,,		Mr. Alex. Beattie, Elgin, 1911.	A gunflint made in Inverness.	Evans, Ancient Stone Implements of Gt. Br., pp. 17-19, 283.
1589	$1\frac{5}{16}$	$\frac{1}{14}$	,,	Culbin Sands	,,	A lozenge-shaped arrow head. There is a special collection of implements from the Culbin sands in the National Museum of Antiquities of Scotland.	Cat. Nat. Mus. of Antiquities of Scot. (1892), pp. 90-95.
1590	$1\frac{1}{4}$	$\frac{1}{4}$	,,	,,	,,	A typical thumb scraper. Scrapers of many forms have been found in Scotland. Occasionally they are discovered in prehistoric graves, with nodules of iron pyrites. Cp. the longer Morayshire forms with the La Madelaine round-ended scraper. Note the slender scraper from Torrs, Old Luce.	Cat. Nat. Mus. of Antiquities of Scot. (1892), pp. 6, 7. Smithsonian Contributions, 1896, p. 372. Munro, Prehistoric Scotland, p. 166. Anderson, Scot. in Pagan Times, Br. and St. Ages, p. 376.
1591	$\frac{15}{16}$	$\frac{1}{7}$	,,	,,	,,	Note the cortex and the chipping away from the flat surface.	

1780	$2\frac{1}{4}$	$\frac{2}{3}$	,,	Bailbrook	Miss Crichton, 1919.	A large arrow head with barbs and broad tang found in a deposit of sand, 15 inches below the surface in Bailbrook Gardens, 1892.	
1781 Pl. I., 14	$3\frac{7}{16}$	9	Coarse Dolerite	,,	,,	An axe with butt broken off and surface slightly disintegrated, found in a sand deposit, $1\frac{1}{2}$ feet below the surface, 1892.	
1808 Pl. I., 2	$3\frac{3}{8}$	8	Dolerite	Megginch	Lent by Mr. R. R. B. Watson, 1920.	An axe head with broken butt.	
1809 Pl. III., 19	$1\frac{1}{4}$	$\frac{1}{9}$	Quartz	Murrayshall Hill	,,	A drill point. Note the smooth surfaces leading to the point. Cp. with the borer from Craigsfordmains and with other drill points.	Munro, Prehistoric Scotland, p. 154. Avebury, Prehistoric Times, 7th ed., p. 239. Smithsonian Contributions, 1894, pp. 625, 681-683. Proc. Berwickshire Nat. Club, 1894-1895, p. 161. The Essex Naturalist, Vol. I., p. 127.
1810 Pl. III., 21	$1\frac{3}{4}$	$\frac{1}{4}$		The Tay at Perth	,,	A lozenge-shaped arrow head with edge chipping unfinished.	
1811 Pl. III., 20	$1\frac{1}{4}$		Flint	Pole Hill	,,	A triangular arrow head with one side of the base broken. The other two edges are neatly chipped on one side. Cp. this point with one shown in the Essex Naturalist.	The Essex Naturalist, Vol. XVI., pl. 4.
1900 Pl. IV., 13	$6\frac{1}{2}$	$21\frac{3}{4}$	Basalt	New Zealand	Mr. John H. Dixon, 1917.	A somewhat adze-like polished axe of rectangular cross-section, with the sides tapering slightly to the butt.	
1901 Pl. IV., 2	$2\frac{5}{8}$	$2\frac{1}{2}$	Jade	,,	,,	A peculiar Maori axe with an adze edge. The stone has been perforated at the butt, at right angles to the plane of the flat faces. The small hole may have been used for a suspending string, or may have been connected with a method of hafting. Read the " Smithsonian " note on perforated stones.	Smithsonian Contributions, 1884, Vol. I., p. 815.

No. in Museum Index.	Length in Inches.	Weight in Ounces.	Stone.	Locality.	Donor.	Remarks.	References.
1935	$2\frac{1}{2}$ (dia.)	14	Diorite	Patagonia	Mr. Duncan Kyle, 1920.	A Patagonian bola or sling stone. The war club of the Arizona Apaches is a bola with a tough hide handle attached. North American Indian sinker stones sometimes, like those from the Illinois river, resembled Patagonian bolas in form. Cp. bolas with Peruvian throwing stones.	Brit. Mus. Hbk. to Ethnographical Collection, p. 289. Wood, Natural History of Man, Vol. II., pp. 522, 524. Evans, Ancient Stone Implements of Gt. Br., p. 377. Smithsonian Contributions, 1879, pp. 224, 233. Smithsonian Contributions, 1887, Vol. I., p. 686, pl. 2.
1959	$1\frac{7}{16}$	$\frac{3}{5}$	Flint			A gunflint.	
1962 Pl. I., 6	$8\frac{1}{4}$	$49\frac{1}{4}$		Luncarty	Mr. Thomson, 1840.	The oblique edge of this fine polished celt is probably not due to wear, but is connected with the method of hafting. The implement was found in 1831. Axes with similar edges have been found at Morpeth, Philiphaugh, Manderston, and Abernethy.	Evans, Ancient Stone Implements of Gt. Br., pp. 96, 138. Proc. Berwickshire Nat. Club, 1876-1878, pl. 8, 1. Proc. Berwickshire Nat. Club, 1894-1895, pl. 1. Munro, Prehistoric Scotland, p. 373.
1998 Pl. I., 9	$4\frac{3}{4}$	11	Fine grained schist	Dunning	Mrs. Christie Drum of Garvoch, 1921.	A polished axe, chipped in parts, found in a field near the farmhouse. The bent form of the axe is due to the natural fissure of the stone.	
1999	7	$47\frac{3}{4}$	Amygdaloidal andesite	Tentsmuir	Mr. Alex. Speedie, 1921.	A large hammer stone with hollows on two opposite sides.	Evans, Ancient Stone Implements of Gt. Br., Ch. 10.
2002	$2\frac{15}{16}$	$\frac{3}{4}$	Flint	Kirkton of Mailer	Mr. William Roy, 1921.	A scraper, the form of which is not unlike that of an Esquimaux woman's knife. Note the chipping where the edge is thickest. Scrapers were of various sizes up to about five inches in length.	Smithsonian Contributions, 1884, Vol. I., p. 764. Proc. Essex Field Club, Vol. III., p. 126.
2003	$1\frac{5}{8}$	$\frac{2}{7}$	,,	,,	,,	This may be a double-edged scraper or an unfinished arrow head. The edge is chipped on one side only.	

2004	$1\frac{1}{4}$	$\frac{1}{14}$	,,	,,	,,	A scraper. Note the chipping on one edge.	
2005	$1\frac{3}{8}$	$\frac{1}{16}$	,,				
2006	$1\frac{1}{2}$	$\frac{1}{11}$	,,	,,	,,	An unfinished arrow head.	
				,,	,,	An imperfect arrow head, perhaps rejected for flaw.	
2007	$1\frac{1}{8}$	$\frac{1}{11}$	,,	,,	,,	A roughly leaf-shaped arrow head. Note the reduction of the convex face by chipping.	
2008 Pl. III., 14			,,	,,	,,	Three tapering, tanged, and barbed arrow heads. The tang is very wide in No. 2009, probably because of the thinness of the flake.	
2009 Pl. III., 26	$1\frac{1}{4}$ (av.)	$\frac{1}{13}$ (av.)	,,	,,	,,		
2010 Pl. III., 3			,,	,,	,,		
2011 Pl. III., 10	$\frac{11}{16}$		,,	,,	,,	A very small arrow head, nearly perfect in form, with tang and barbs. It is long in proportion to its breadth, and is beautifully chipped all round on both faces.	
2012	$2\frac{5}{8}$	$4\frac{1}{2}$	Argillaceous sandstone	,,	,,	A stone bored from both sides and probably used as a net sinker.	
2013	$3\frac{1}{4}$	$1\frac{1}{2}$	Flint	Windyedge Bin, Aberdalgie	,,	A long leaf-shaped flint, chipped on one side of edge only, and slightly curved with the flat face inwards. The use of implements of this kind is uncertain, but they were probably used for cutting and scraping purposes. With handles they might have served as wood borers. Implements somewhat similar to this and associated with interments are described by Evans. Cp. with the flint implement from a chambered cairn at Unstan, Orkney.	Evans, Ancient Stone Implements of Gt. Br., pp. 295, 296. Anderson, Scot. in Pagan Times, Br. and St. Ages, p. 299.
2014	$2\frac{3}{4}$	$2\frac{1}{2}$	,,	Muirton of Balhousie	,,	A perforated stone with the hole roughly picked, and chiefly from one side. The object is oval in form, and the hole is near one end. This patinated stone may have been carried as a charm, but many bored stones were merely net sinkers.	Evans, Ancient Stone Implements of Gt. Br., p. 421.

No. in Museum Index.	Length in Inches.	Weight in Ounc's.	Stone.	Locality.	Donor.	Remarks.	References.
2015 Pl. III., 6	$\frac{13}{16}$ (av.)	$\frac{1}{19}$ (av.)	Flint	Muirton of Balhousie	Mr. William Roy, 1921.	Three small arrow heads, barbed and tanged.	
2016 Pl. III., 2			,,	,,	,,		
2017 Pl. III., 11			,,	,,	,,		
2021	$2\frac{1}{4}$	$\frac{3}{4}$	,,	Nr. Murray's Asylum		A typical form of scraper.	Munro, Prehistoric Problems, p. 327.
2022	$2\frac{1}{8}$	$\frac{1}{4}$	,,	Assuan, Egypt	,,	A saw. Flint saws were generally mounted, and some serrated flints were used in the manufacture of bone needles.	Munro, Prehistoric Scotland, p. 164. Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 53.
2023	$2\frac{1}{4}$	$\frac{2}{13}$	,,	,,	,,	Note the secondary chipping at one side of the percussion end. Cp. Nos. 2018-2024 with knives from the Danish shell mounds.	Avebury, Prehistoric Times, 7th ed., p. 84. Evans, Ancient Stone Implements of Gt. Br., pp. 251, 262.
2024	$2\frac{1}{4}$	$\frac{1}{6}$	,,	,,	,,	The form of the flake suggests that its narrow end was meant to be fixed in a handle. Cp. with Esquimaux scraper in handle and with hafted blade from Swiss lake dwelling.	Evans, Ancient Stone Implements of Gt. Br., p. 268. Brit. Mus. Gd. to Antiquities of Stone Age, 2nd ed., p. 129.
2027	$2\frac{3}{8}$	$\frac{1}{2}$	,,	Methven Moss	,,	A curved scraper, skilfully chipped on the convex edge. The hollow edge was probably meant for scraping, but has been partly rendered irregular by the removal of a large flake.	
2029	$1\frac{3}{8}$	$\frac{1}{5}$	,,		,,	A roughly chipped flint. The form indicates an unfinished arrow point, but on one side there is a scraper edge.	
2030	$1\frac{1}{2}$	$\frac{2}{13}$	,,		,,	A double scraping point.	
2036	1	$\frac{1}{20}$	,,		,,	An unfinished and damaged arrow point.	
2037	$\frac{15}{16}$	$\frac{1}{5}$	Clay slate(?)		,,	A small broken whetstone or slickstone, perforated at one end.	Cat. Nat. Mus. of Antiquities of Scot. (1892), p. 51. Munro, Anc. Scot. Lake Dwellings, p. 170.

2045	$1\frac{3}{8}$ (dia.)	1	Argillaceous sandstone	Cultmalundie	,,	A spindle whorl.	Cat. Nat. Mus. of Antiquities of Scot. (1892), pp. 79, 80. Proc. Berwickshire Nat. Club, 1894-1895, pl. 1 and p. 168. Evans, Ancient Stone Implements of Gt. Br., pp. 390-393.
2107 Pl. I., 13	$4\frac{1}{8}$	6		North Inch, Perth		This well-formed axe was dug up during the excavation of a sand pit on the North Inch, 1920. The pit was four feet deep, but the exact depth at which the stone lay is not known.	
2125	$1\frac{3}{4}$ (dia.)	1	Sandstone	School House Garden, Forteviot	Mr. Wm. Gordon, Green of Invermay.	A spindle whorl flatter than usual.	Munro, Anc. Scot. Lake Dwellings, p. 172. Evans, Ancient Stone Implements of Gt. Br., p. 392.
2132	$2\frac{1}{8}$ (dia.)	$\frac{3}{4}$	Basalt	West Mains, Gleneagles	Dr. M'Phee, Auchterarder.	A spindle whorl of type similar to No. 2125, much worn and chipped.	
2133	$1\frac{1}{8}$ (dia.)	$\frac{1}{2}$		,,	,,	A spindle whorl with regular radial incised lines.	
2143 Pl. IV., 4	12	$3\frac{3}{4}$	Obsidian	Admiralty Islands	(Purchased 1921).	A hafted obsidian knife or dagger, skilfully flaked and pointed. The handle is composed of a red resinous substance, and is decorated with a coloured rectilinear design. The exposed part of the blade measures 5 inches, and the greatest width of the flake is $1\frac{7}{8}$ inches.	Evans, Ancient Stone Implements of Gt. Br., pp. 21, 22, 250.
2144 Pl. IV., 5	77	$12\frac{1}{2}$	,,	,,	,,	A beautiful obsidian spear. The exposed part of the point is $5\frac{1}{2}$ inches long, and at its widest part measures $2\frac{1}{2}$ inches. The covering, 8 inches long at the junction of the blade and the handle, is strengthened by short pieces of bone, while along each side of the blade, and parallel to its axis, is fixed a sting-ray spine.	Br. Mus. Hbk. to Ethnographical Collections, p. 132.
2145 Pl. IV., 10	$3\frac{3}{4}$	9	Hornblende	Australia	,,	This is an axe-hammer of a well-known Australian type. Two roughly chipped pieces of "firestone" are fixed in a mass of resinous material, in which the handle, $6\frac{1}{2}$ inches long, is also secured. The hammer-stone bears traces of use, but the axe still retains a fair cutting edge.	Evans, Ancient Stone Implements of Gt. Br., p. 152.

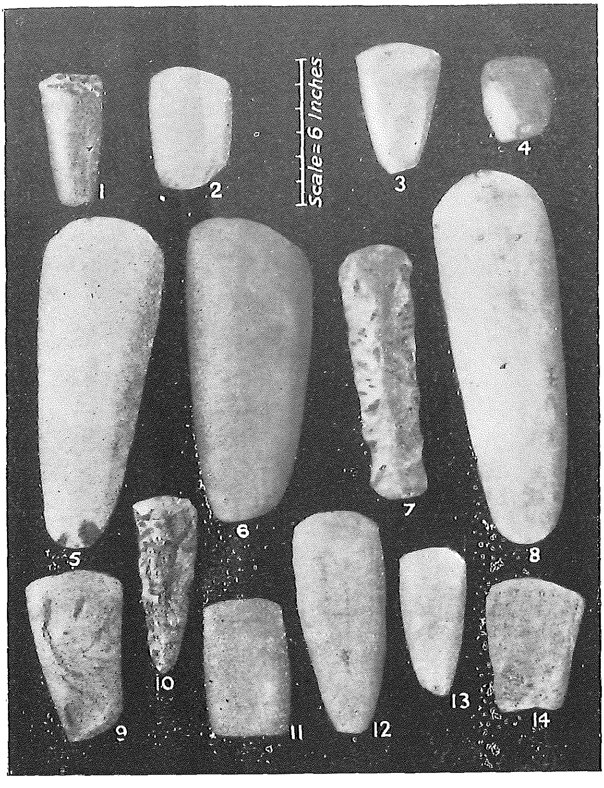

Plate 17. [*Photo. by J. Ritchie.*

Stone Implements (Plate I.).

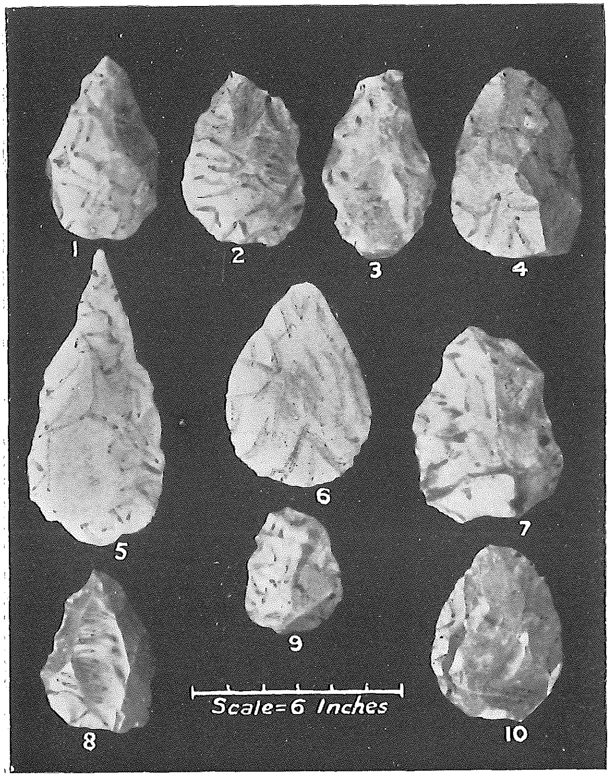

Plate 18. [*Photo by J. Ritchie.*

Stone Implements (Plate II.).

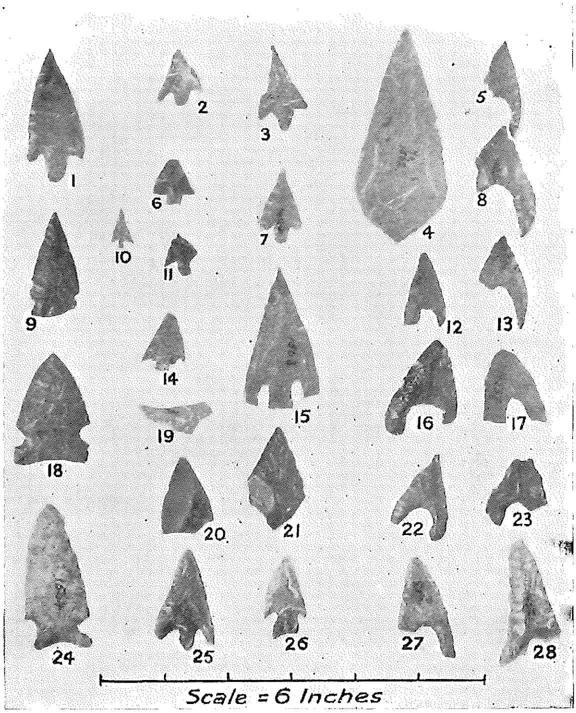

Plate 19. [*Photo. by J. Ritchie.*

Stone Implements (Plate III.).

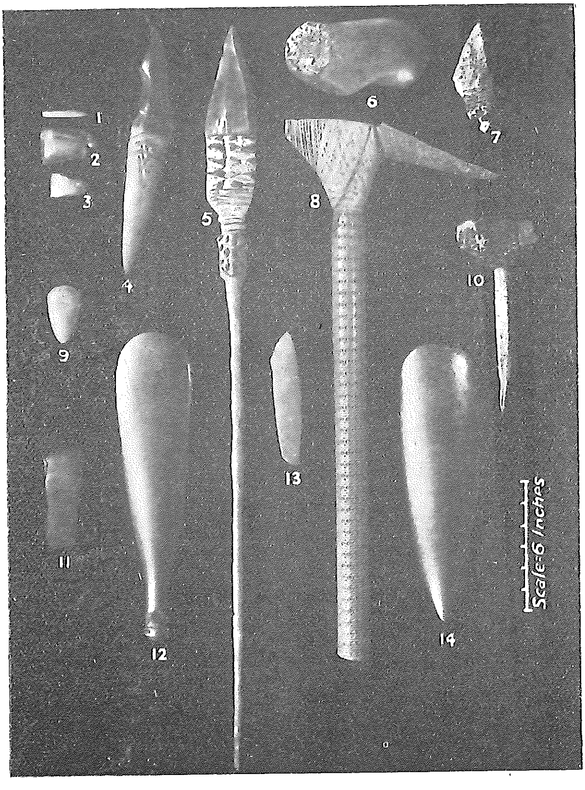

Plate 20. [*Photo. by J. Ritchie.*

Stone Implements (Plate IV.).

XIII.—*Note on Sarcoscypha protracta* (Fr.) *Sacc., in Perthshire.*

By JAMES MENZIES.

(Read 8th April, 1921.)

Mr. Menzies reported having received specimens of this fungus from Dunkeld, where it had been discovered in Inver Wood. He stated that we were indebted for the discovery of this fine addition to the Fungus Flora of the County to a lady, Mrs. O'Callagan, temporarily resident in that locality, and interested in fungi. She submitted her specimens to Mr. Charles M'Intosh, who determined the species. In its brilliant colour and white tomentose exterior the plant has some resemblance to the well-known *Sarcoscypha coccinea*, but easily separated from that species by its slender stem, in growing on the ground, and microscopically by the very large sporidia. The fungus is rare in Britain, and so far as is known has only been found by the late Professor Trail on the banks of the Dee, near Ballater,

The Distribution of the Perthshire Flora.

By J. R. MATTHEWS, M.A., F.L.S.

(Read 7th April, 1922.)

INTRODUCTION.

During the past fifty or sixty years, the geographical distribution of plants has attracted a considerable amount of attention, and an increasing interest in the subject has been apparent of late by the publication of numerous papers relating to distributional problems in different parts of the world. In the opinion of some writers the subject remains still the fundamental problem in Evolution, "that grand subject, that almost keystone of the laws of creation," as Darwin wrote to Sir Joseph Hooker. In the *Origin of Species*, one of the most remarkable contributions ever made towards a solution of the great problems of Evolution, Darwin summarises his own views on the subject as follows:—"If the difficulties be not insuperable in admitting that in the long course of time all individuals of the same species, belonging to the same genus, have proceeded from one source, then all the grand leading facts of geographical distribution are explicable on the theory of migration, together with subsequent modification and the multiplication of new forms."

By different authors the subject has been treated along different lines. On a broad ecological basis we have the well-known volumes of Schimper, Warming and others, while from a more geological aspect we have English contributions associated with such names as Edward Forbes, Darwin, Wallace, Hooker, Clement Reid, and Guppy, to mention only a few. The last named author has elaborated a "Theory of Differentiation" in his interesting volume, *Plants, Seeds, and Currents in the West Indies and Azores*. Dr. Guppy's ideas are not far removed from those of Dr. Willis who, in a long series of papers which have appeared in recent years, has brought into prominence a theory which he has termed "Age and Area," a theory based on much statistical evidence derived from a study of the distribution of plants in Ceylon, New Zealand and its neighbouring islands. The "Age and Area" hypothesis is now accepted by many as an established law in plant distribution. Put briefly, it states that the older a species is in a country the wider will be its range. This, as the main contention, is what one would expect, but the problem of distribution is so complex that it is doubtful if any *single* hypothesis will provide the whole solution. Later we shall notice in greater detail the "Age and Area" law when we come to consider its applicability to the Perthshire Flora, for my present purpose is not the discussion of geographical distribution on the grand scale, but an enquiry into certain aspects of the distribution of the native plants of our own county of Perth. Though the investigation be thus circumscribed, it remains essentially a part of the greater problem and in particular it is intimately bound up with distribution in Britain as a whole.

Distribution of Plants in Britain.

The origin and distribution of the British Flora has been the subject of much writing and discussion, and the question is yet so far from being answered conclusively that a brief review of the opinions expressed by leading authorities may here be allowed.

According to one school of thought the rigours of the climate during the Ice Age were such as to destroy the great bulk, if not all, of Britain's pre-glacial flora, which seems to have resembled very closely the present plant population, although, according to Clement Reid (1908) it was slightly more temperate. But to what extent exactly did glaciation destroy the earlier flora is just the question which has evoked considerable difference of opinion. It may be that a definite answer is impossible. Yet until some general agreement is reached on this fundamental question, all attempts to trace the migration of the re-distributed flora must be largely speculative. Mr. Clement Reid (1911), it is true, is emphatic in maintaining that the starting-point is perfectly definite. "We have merely to account," he says, "for the incoming of our existing flora, after an earlier assemblage had been swept away almost as completely and effectually as the celebrated volcanic eruption wiped out the plants of Krakatoa." If this view be the correct one the problem is certainly simplified, for if all the pre-glacial plants were destroyed, we must look mainly to those parts of the European continent which escaped the extreme climatic conditions of the Ice Age for the source of that flora which re-populated our islands after the cold period passed away. While Clement Reid strongly believes in the destruction of the flora during the Ice Age, he does not necessarily accept a theory involving re-immigration over land connections. Rather he believes that the steady change and increase of our flora may be sufficiently explained by chance and occasional introduction of seeds, due mainly to birds driven by exceptional gales, although other animals have played their part, especially when the Straits of Dover were much narrower or non-existent.

But well-known peculiarities in the distribution of certain elements of our flora have made it difficult for some to accept Reid's views entirely. Mr. Lloyd Praeger (1910) contends that the Portuguese and Iberian plants of the south-west of Ireland are "relics of a vegetation which once spread along a bygone European coast-line which stretched unbroken from Ireland to Spain." This conclusion agrees with that of Edward Forbes, who, in a remarkable paper published in 1846, argued that the Lusitanian element in south-west Ireland constitutes the oldest portion of the British Flora, its limitations and isolation pointing to its antiquity. Dr. Scharff on zoological grounds has arrived at similar conclusions, believing that the mass of the fauna (and therefore the flora) survived the Glacial Period in Ireland.

If this be so, one would expect that at least in the southern fringe of England, which was iceless, a considerable flora would certainly survive, and for information regarding the nature and extent of such a flora we have to turn to the succession of events as traced in the geological record. A large amount of work has been done in the study of plant-bearing deposits of glacial and post-glacial times, and it is impossible here to do more than mention the results of but a few investigators. The whole matter, too, is complicated from the point of view of plant distribution by the fact that divergent opinions are held regarding the number and extent of glacial phases.

In 1888 Reid and Ridley gave an account of fossil plants obtained from the lacustrine deposit at Hoxne in Suffolk. The basal beds contained temperate plants, but above these an arctic plant-bed occurred bearing such plants as *Salix polaris*, *S. herbacea*, *S. myrsinites*, and *Betula nana*. This in itself would seem sufficient evidence to show that in the south of England a change from temperate to arctic conditions had taken place in glacial times. More recently, remains of arctic plants have been found in alluvial deposits in Devon, and though plants have not been obtained, remains of arctic mammals occur in profusion in Wiltshire (Reid, 1911). Still more recently, Prof. J. E. Marr and Miss E. W. Gardner (1916), in an examination of Pleistocene deposits around Cambridge have revealed the existence of an arctic flora in the Barnwell-Station pit which they have referred to "one of the latest, if not the latest stage, of the Pleistocene deposits of the district." This arctic flora has been fully described in an interesting paper by Miss M. E. J. Chandler (1921), and comparison is drawn with the arctic plant-bed of the Lea Valley described by Mr. C. Reid (1916). The flora of the Cam Valley, as seen in the Barnwell Bed, though including numerous temperate plants, is distinctly more arctic in character than that of the Lea Valley, but there is yet insufficient evidence to say whether the Cam Valley flora existed during a period of maximum cold or whether it lived before or after the climax of a glacial period.

In Scotland, attention was drawn by Bennie (1894) to the occurrence of arctic plant-beds, resting directly upon the boulder clay, in the neighbourhood of Edinburgh, and again, in 1896, to similar lacustrine deposits near Auchtertool in Fifeshire. These deposits provided, among some two dozen species determined, *Salix herbacea, S. polaris*, and *S. reticulata.* During the period 1905 to 1911 extensive investigations of the plant-remains in the Scottish peat mosses were carried out by F. J. Lewis, whose results have been published in a series of papers in the *Transactions* of the Royal Society of Edinburgh. The chief stages in the general sequence of vegetation, over the areas studied, since the later phases of the glacial period are summarised by Lewis as follows :—

1. An arctic-alpine vegetation resting on the moraine laid down by the last *mer de glace*.
2. A forest of birch and hazel.
3. A layer of arctic-alpine plants occurring down to sea-level in Shetland.
4. A forest of pine, birch and hazel occurring up to 3,200 feet above sea-level.
5. A layer of peat accumulated from the period of stage 4 to the present day, consisting entirely of moorland plants.

These changes are described by Lewis as post-glacial "in the sense that they occurred later than the last ice-sheet." The successional development indicated by the several stages clearly points to climatic fluctuations which must have been sufficiently long and pronounced to change the distribution of the flora in the north of Britain. But the stages do not give any information about the chain of events during the maximum glaciation of the country. "The first arctic bed contains an arctic-alpine flora which existed over wide areas near sea-level, but it is impossible to say from the evidence of the plants whether all traces of glaciation had vanished from Britain at that time or whether certain regions were still under ice."

Investigations similar to those of Lewis and with somewhat similar results have been conducted on the Continent especially in Denmark and Scandinavia. A comparison of all the results has been made by Samuelsson, while an interesting review and discussion is to be found in a recent paper by Wille (1915) on the Flora of Norway and its immigration. It is difficult, however, to correlate results without definite knowledge of the age of the several deposits which have been described, yet the prevalence of a pronounced arctic flora—the *Dryas* flora—towards the close of the last glacial stage suggests that only arctic species, if any, could have survived the period of maximum glaciation, at least in northern latitudes. The possibility of survival of a considerable assemblage in the south of England is suggested by the association of arctic and temperate plants found in the Pleistocene Beds of the Cam Valley, so that from the south of England, and not exclusively from the Continent, migration northwards may have commenced after the retreat of the ice-sheet.

I should like to suggest, also, that the problem before us cannot be divorced from a consideration of the views of anthropologists on the movements of man in Britain. A discussion at the recent meeting of the British Association in Edinburgh on the origin of the Scottish people is interesting in this connection in giving the latest opinions regarding the arrival of man in Scotland. It has been estimated that about 13,000 years have elapsed since the beginning of emergence of Scotland and Scandinavia from the ice cap of the last glacial period, and while some contend that man existed in Scotland as far back as 10,000 years ago, while the Highland valleys were filled with ice, others make the date more recent by a few thousand years. Wille, in the paper already cited, states that man has lived in Norway about 7,000 years. These figures are interesting even if they give but an approximation to the length of time during which the migrations of man must also have affected, directly or indirectly, the migrations of plants. It will be acknowledged, at all events, that within historic time man's activities have profoundly influenced plant distribution within our own country.

I have ventured to give this brief and incomplete outline of the historical succession not because of any positive conclusions that can be reached, but because of the importance of bearing in mind what evidence we do possess regarding the changes in distribution which plants must have undergone in comparatively recent times.

Thirty-one years have elapsed since Dr. Buchanan White delivered a Presidential Address to this Society on the Origin of the Flora of Perthshire. The address, which was published in the Society's *Proceedings* (1891) and later in the *Flora* itself, contains the following sentences:—" I have been speaking of the British Flora and Britain, but with the object of attempting to show that what concerned these in remote ages may have a more modern application to the Perthshire flora and to Perthshire. . . . . Perthshire is not cut off by the sea from the rest of Britain, therefore the methods by which the British Flora reached Britain, when there was a land connection, may have always been, and still be, operative as regards Perthshire in relation to the rest of Britain, provided that climatic conditions are favourable and that there is room." Dr. White's paper concludes with a detailed account of all the species having doubtful claims to be native within the county.

To endeavour to trace the arrival and past migrations of the several species which now comprise the flora of Perthshire would be an arduous, if not impossible task, although I can imagine no more interesting or instructive aspect of Field Botany than that which seeks to follow the migration of plants to-day. But in the following pages I shall endeavour to indicate the *mass* distribution of the present flora of our county and, as far as possible, use the available data to illustrate some of the more recent views regarding problems of distribution.

General Analysis of the Perthshire Flora.

As a basis for analysis the "Flora of Perthshire" and "Additions to the List of Perthshire Plants" have been used. Flowering plants only are dealt with, and with few exceptions only species appearing under the usual "formula" in the "Flora" have been admitted to the list which has been compiled. Aliens and most of the doubtful natives have thus been excluded. It has been necessary further to modify the list in regard to the number of species admitted under critical genera. In *Hieracium, Rubus* and *Salix* no attempt has been made to include all the micro-forms or hybrids since their distribution in Britain is incompletely known. With these and a few other unimportant modifications, the list of Flowering Plants in Perthshire reaches a total of 738 species.

Estimates of the total British Flora vary according to opinion regarding the value to be attached to certain species, particularly those of critical genera, and according to varying opinion regarding the indigeneity of numerous species. For my own purposes, taking a somewhat conservative view, I have placed the number of British flowering plants at 1377, of which England possesses 1295, Scotland 1026, and Ireland 942. These figures themselves point to the thinning out of our flora as distance from the main centre of distribution increases. As the British flora may be regarded as a reduced Continental one, so may the Scottish flora be looked upon as a reduced English flora, for numerous species do not cross the border, although the arctic element is distinctive in being more fully represented in Scotland. When we proceed as far north as Perthshire, we find the flora still further reduced, due partly, of course, to the much more limited area involved, but also to the fact that numerous plants which reach Scotland do not appear farther north than the Border or Lowland provinces of Watson.

On the basis of the figures given above, then, the Perthshire flora constitutes about 54 per cent. of the entire British flora, and about 72 per cent. of the total Scottish flora.

Within the Watsonian vice-counties of Perthshire, the 738 species of the local flora are distributed as follows:—601 in 87 West Perth, 693 in 88 Mid Perth, and 684 in 89 East Perth.

Mid Perth is thus shown to be the richest of the three vice-counties, but if the arctic flora, which is centred in this area, be excluded, it will be found that East Perth is not poorer but richer in actual number of species. This fact is of considerable interest, for the concentration of the flora east of the rivers Tay and Garry suggests questions regarding the points of arrival and further migration of plants within the county. These matters will receive fuller consideration when further details of regional distribution have been given.

Regional Distribution in Perthshire.

The figures given for the three Watsonian vice-counties of Perthshire fail to illustrate certain interesting distributional features which become obvious when the divisions employed in Dr. White's *Flora* are adopted. For the purpose of indicating the range of each species, the county is divided first into two regions—Lowland and Highland—these being separated by a line which follows the "Great Fault" passing across the county from north-east to south-west. These two primary divisions are further sub-divided according to the drainage system into five districts in the Lowland area and eight in the Highland. We will not enter here into the geological and topographical features of the several districts, these and other topics being fully discussed in the *Flora* itself. It will be useful, however, to recall and reproduce certain facts given by Dr. White, and these are presented in Table I.

TABLE I.

District.		Area in sq. ml.	Area above 1000 feet in sq. ml.	Area above 2000 feet in sq. ml.	Area above 3000 feet in sq. ml.	Highest point in feet.	Peaks above 3000 feet
Lowland	Forth,	296	70	1	0	2363	0
	Earn,	220	20	$\frac{1}{10}$	0	2179	0
	Perth,	93	$\frac{3}{4}$	0	0	1098	0
	Isla,	144	1	0	0	1235	0
	Gowrie,	89	$\frac{1}{20}$	0	0	1235	0
Total for Lowland area,		842	91	1	0		0
Highland	Forth,	167	93	16	1	3827	7
	Earn,	135	100	15	$\frac{1}{8}$	3224	3
	Perth,	142	107	15	0	3048	1
	Isla,	222	174	30	$\frac{1}{2}$	3445	5
	Lomond,	33	25	6	$\frac{1}{3}$	3708	7
	Breadalbane,	445	340	90	9	3984	34
	Rannoch,	310	235	42	2	3757	16
	Atholl,	293	272	100	4	3671	16
Total for Highland area,		1747	1346	314	17		89

The position of the thirteen districts and the area above 1,000 and above 3,000 feet are indicated in Map I.

It is well known that Perthshire possesses a number of species which occur only in the Highland districts and, in contrast to these, a considerable assemblage restricted to the Lowland region. The former, which may be conveniently described as the entirely Highland element of the flora, numbers 89 species, the latter, or entirely Lowland element, numbers 103. Thus, of the total flora, the Lowland districts share 649 species and are slightly richer than the Highland districts with 635. And it is interesting to remember that the area of the former is less than half the area of the latter. The purely Highland and purely Lowland species, representing over 25 per cent. of the county flora, are among the rarest plants in Perthshire, while the remaining 546 species are more widely distributed, although some of them prove to be either essentially Lowland or predominantly Highland in their range. But before dealing in detail with these rarer and more restricted elements, we may first examine the distribution of the flora as a whole. In Table II., there is given the number of species recorded from each of the thirteen districts.

TABLE II.

Total number of species—738.

District.		No. of Species.	Percentage of Total Flora.	Area in square miles.
Lowland	Forth, - - -	491 (542)*	66.5 (73.4)	200 (296)
	Earn, - - -	543	73.6	220
	Perth, - - -	533	72.2	93
	Isla, - - -	538	72.9	144
	Gowrie, - - -	568	77.0	89
Highland	Forth, - - -	407	55.2	167
	Earn, - - -	446	60.4	135
	Perth, - - -	465	63.0	142
	Isla, - - -	534	72.4	222
	Lomond, - - -	245	33.2	33
	Breadalbane, - -	552	74.8	445
	Rannoch, - -	443	60.0	310
	Atholl, - -	456	61.8	293

* Dr. White included in Lowland Forth certain areas now outside Perthshire. The alteration of the county boundary reduces the extent of Lowland Forth and excludes a number of plants—frequently maritime—from this district as re-adjusted. See note in *Flora of Perthshire*, p. 1.

It is unnecessary to discuss the figures of Table II. in detail. They illustrate for the several districts that the flora of the Lowlands is richer, in point of numbers, than that of the Highlands. It is true that Breadalbane with 552 species does not fall far short of Gowrie with 568, but we must bear in mind that the former is five times the area of the latter, and, as is well known, furnishes a number of peculiarly arctic species not found in any other district of Perthshire. The data presented in Table II. are expressed cartographically in Map II.

The concentration of species in Gowrie suggests interesting problems regarding the arrival and migration of plants in our county. We have seen that there is a considerable amount of evidence to show that during the period of maximum glaciation the flora of Britain was reduced to a comparatively limited and essentially arctic one, occupying probably only a southern fringe. As the climate of the glacial period ameliorated, these southernly-situated yet arctic plants would be among the first to move northwards. Whether at a somewhat later period a migration from the East was also involved may be a little more difficult to decide, although it seems probable that such a movement did occur. But, to quote Dr. White, the plants to arrive first were "the northern and alpine species, and to attain the mountain ranges where they now survive they had to cross the lowland plains and valleys." If, however, our arctic-alpine species did survive the Great Ice Age on the mountain tops, which lifted themselves above the general level of the ice-sheet, it will still be true that they are the oldest members of our local flora, having held their own not only throughout the glacial period but during the succeeding changes. This suggests that the summits of our higher mountains would be secondary centres of dispersal, a fact which at once leads to complexity greater than already exists on the theory that the present Perthshire flora is entirely post-glacial.

But for the moment we will confine our attention to the Lowland or temperate species, the great majority, if not all of which, it will be admitted, must have arrived after the retreat of the ice. We will obtain a fairly close approximation to the number of this temperate element if we remove those species which are entirely or essentially Highland in their distribution. This differentiation is quite arbitrary of course, but by whatever standard we decide whether a plant is a temperate species or not, the actual number of doubtful cases in our present series is too small to affect the general results. Of the 738 species in Perthshire there are 133 which are Highland or chiefly so, leaving 605, or 82 per cent. of the whole flora which may be regarded as mainly temperate. Of these, 183 are entirely or essentially Lowland in their range, the remainder being more widely distributed, penetrating along the valleys into the Highland region and often reaching a considerable altitude.

If it be allowed that these 605 species are post-glacial in their origin in Perthshire we may obtain some idea of their paths of migration by mapping their present distribution. This might be attempted for individual species, but here we must be content with a consideration of the mass. In Table III. is given the incidence of these 605 species in the several districts of the county.

TABLE III.

Total flora, excluding entirely and chiefly Highland species—605.

District.		No. of Species.	Percentage.
Lowland	Forth,	482	79.6
	Earn,	528	87.2
	Perth,	517	85.4
	Isla,	514	84.9
	Gowrie,	553	91.4
Highland	Forth,	365	60.3
	Earn,	394	65.1
	Perth.	424	70.0
	Isla,	454	75.0
	Lomond,	208	34.4
	Breadalbane,	446	73.7
	Rannoch,	377	62.3
	Atholl,	384	63.4

Thus, when we exclude the Highland and essentially Highland plants, we arrive at the rather interesting fact that Gowrie, with an area of only 89 square miles, possesses a flora equal to 91.4 per cent. of the temperate flora of the whole county. Lowland Earn provides a number of species not found in Gowrie, so that, if we take the two districts together, nearly 95 per cent. of this temperate flora can be accounted for. The concentration of the mass of the flora in the Lowland region in contrast to the Highlands is obvious from the figures given in the Table, but if a closer comparison be desired we may consider the first four Lowland districts and the respective Highland area, i.e., Lowland and Highland Forth, Earn, Perth, and Isla. Here we have two roughly parallel strips of the county, approximately equal in area, the one Lowland, the other Highland. The former districts possess, on the average, 510 species, the latter 409. We may therefore picture this temperate flora reaching Perthshire from an outside source by the ordinary methods of dispersal, and spreading fairly uniformly and extensively over the low-lying ground, but extending more slowly into the

Highland parts of the county. Doubtless the Lowland region offers greater possibilities, presenting fewer barriers than the Highland districts. But doubtless, also, the time factor plays a part, since the concentration of species in the Lowlands must mean that the plants arrived in that region first, whence they have spread into the interior and, given time, they may there become more abundantly represented. Further, the actual migration into Perthshire would seem to have been more by way of the Tay valley than across the line of the Forth, since Lowland Forth, of all the Lowland districts, shows a marked paucity in the number of species. Thus, whatever the general direction of the mass movement through Scotland as a whole and whatever the past relations of land and water, the distributional facts now presented suggest that in Perthshire the flora entered mainly from the east and that migration followed, generally speaking, the river systems, for there occurs a gradual thinning out of the plant population as we pass into the interior of the county, along the Tay and its main tributaries. (See Map III.).

It is not suggested, of course, that certain species may not have reached Perthshire at more points than one, or that one and the same species may not have arrived in the county at more than one time. There are, for instance, several plants occurring in the Forth area which are absent from the Tay. Again, it is not suggested that the whole problem of distribution, even in a small area, is solved by a consideration of the mass. The problem is far too intricate and can only be satisfactorily solved when all the ecological factors affecting the life of the species are taken into account and fully understood. During recent years, ecological studies have gone far towards an explanation of the peculiar distribution of some of our native species, and although Perthshire has not figured largely in this work, it is interesting to recall that in the pioneer ecological surveys of this country, the county was among the first areas to be examined (R. Smith, 1900), while the local distribution of the arctic-alpine element has been dealt with by Professor MacNair (1898). Yet, in spite of the inevitable omission of details, it is hoped that the broad outlines of distribution given above may serve a useful purpose.

Degree of Rarity.

In the foregoing pages reference has been made to the fact that numerous species show a restricted range. We may now proceed to examine the data which will furnish more precise information regarding the degree of rarity of Perthshire plants. This can be obtained by arranging the 738 species according to the number of districts in which they occur. The facts are set out in Column A. of Table IV.

TABLE IV.

Occurring in :—	A No. of Species.	B Widely distributed.	C Entirely Lowland.	D Chiefly Lowland.	E Entirely Highland.	F Chiefly Highland.
One district	75		40	0	35	0
Two districts	41		27	3	11	0
Three ,,	43		18	7	10	8
Four ,,	31		11	13	4	3
Five ,,	27		7	15	3	2
Six ,,	36			19	9	8
Seven ,,	41			23	8	10
Eight ,,	35	20			9	6
Nine ,,	34	27				7
Ten ,,	30	30				
Eleven ,,	42	42				
Twelve ,,	113	113				
Thirteen ,,	190	190				
Totals	738	422	103	80	89	44

If we call those species which are found in one to seven districts rare or relatively rare, and those occupying eight to thirteen districts common or relatively so, we obtain 294 species in the former category and 444 in the latter. Since, however, there are eight Highland to five Lowland districts it is possible that a species may be relatively common yet exhibit a distribution entirely or essentially Highland. I have therefore carried the analysis of the rarer species, so far as it concerns Highland plants, up to nine districts, and find 22 species either Highland or mainly so occupying eight or nine districts. This leaves 422 common species with a wide or more general distribution throughout both regions of the county. These, occurring in eight to thirteen districts, are detailed in Column B. The remaining 316 rarer species of the flora are detailed under several headings in Columns C, D, E, and F of Table IV., and will be dealt with in the sequel.*

Turning to the numbers of the widely-distributed species (Column B) we find that they form an increasing series from only 20 limited to eight districts to 190 occurring in all the districts. These facts indicate that the great majority of the members of this portion of the flora, at least, have been sufficiently long in the

* The terms rare and common as used throughout this paper do not refer to abundance of individuals, but to the range of distribution of species as indicated by the number of districts from which they are recorded. Thus, a species recorded from eight or nine districts is regarded as common though in actual abundance of individuals it may be deemed rare in the several districts where it occurs. Or, a species found in a few districts only is rare in the present connection though in actual numbers it may be common in those districts.

county to become widely dispersed, only a comparatively small number, possibly of slightly later arrival, being somewhat, though not much more, restricted. This view, of course, applies to the average case. It is perfectly true that in particular cases local conditions and special modifications may have been such as to allow of the rapid spread of one species and not of another, so that a recently arrived species under conditions favourable to it may have outstripped a species which has actually existed longer within the county. Considered broadly, however, the above explanation appears feasible.

But, as we have seen, the flora is not composed entirely of widely-distributed species, and the point which I here wish to introduce, in contrast to what has been said about the widely-distributed element, is illustrated by the figures of Column C, which give the incidence of 103 species occurring exclusively in the five Lowland districts. It will be seen that the numbers form a descending series in contrast to those of Column B. These rarer species comprise a majority with a very limited distribution and a minority having a wider distribution, i.e., within the Lowland region. We may here argue that only the *minority* have had time to spread very far, whereas in the widely-distributed series the *majority* have spread not only through the Lowlands but into the Highlands as well.

Observations such as these, but on a much more extensive and exhaustive scale, led Dr. Willis to enunciate his hypothesis of "Age and Area." The theory, as has been stated already, took definite shape after detailed study of the distribution of the floras of Ceylon, New Zealand, and other islands, where, in all cases, it was found that widely-distributed species (wides) were always graded upwards from a few of small distribution area to many having a wide distribution (cf. Column B, Table IV.). On the other hand, species peculiar to the area in question (endemics) graded downwards from many having a small range to a few with a wider range. In other words, the average area occupied by widely-distributed species was always found to be greater than the average area occupied by endemics. The hypothesis, first stated in 1915, has passed through several modifications, its most recent expression in 1919 taking the following form:—"The area occupied at any given time, in any given country, by any group of allied species, at least ten in number, depends chiefly, so long as conditions remain reasonably constant, upon the ages of the species of that group in that country, but may be enormously modified by the presence of barriers such as seas, rivers, mountains, changes of climate from one region to the next or other ecological boundaries, and the like, also by the action of man and by other causes." The theory, it will be observed, is limited by numerous reservations, yet its main contention that, on the average, the longer a species exists in any given reasonably uniform area the wider will be its range in that area, is surely a very possible one. So numerous are the reservations, however, that it would not be surprising if the theory were found to be inapplicable to the flora of a country like Britain or any part of it. Yet it is interesting to find that the numbers relating to the widely-distributed portion of the Perthshire flora agree so remarkably well with the requirements of the theory. And again, taking the entirely Lowland species, we may for our present purposes compare these with the "endemics" of Willis's investigations, since, within the limits of Perthshire, a species found only in the Lowland region is endemic to that area. These rarer species, as already pointed out, fall into a descending series, thus agreeing with the general theory, not because they are really endemic, however, but because they are, it would seem, at an early stage of invasion. They are, on the average, the youngest species of the county.*

We may carry the analysis of the rarity of the flora a little further. The entirely Lowland element (103 species) we have already mentioned. Entirely Highland species (89) are detailed in Column E of Table IV. But in addition to these there is a considerable number of comparatively rare species (124) which occur in both regions. They overlap, but they are either more widely distributed in the Lowlands (80 species) or they occupy a wider range in the Highlands (44 species). The former, described as chiefly Lowland species, are dealt with in Column D, the latter, chiefly Highland plants, are detailed in Column F. A few species, equally Lowland and Highland, in respect of the number of districts they occupy, are included in the chiefly Lowland element. Further details regarding the distribution of these several portions of the flora may best be treated separately. (See Appendix for lists of rarer species).

Entirely Lowland Species.

The regional distribution of species, 103 in number, which do not extend beyond the Lowland districts is shown by the following table :—

TABLE V.

Lowland	No. of Species.
Forth,	27
Earn,	46
Perth,	37
Isla,	37
Gowrie,	80

* I have dealt with the Distribution of Perthshire Plants in relation to "Age and Area" in a paper published in *Annals of Botany*, July, 1922.

These figures bring out the interesting fact that as many as 80 of the 103 Lowland plants occur in Gowrie, leaving only 23 variously scattered in the other four districts. The increase in the number of species with increasing area may be illustrated in the present series as follows:—

Gowrie,	80
Gowrie + Earn,	92
Gowrie + Earn + Isla,	98
Gowrie + Earn + Isla + Perth,	101
Gowrie + Earn + Isla + Perth + Forth,	103

There can be little doubt that the hypothesis of "Age and Area" is applicable to this restricted Lowland flora of Perthshire. Reference has already been made to the fact that these 103 species form a very regular descending series from 40 occurring in one district to 7 occupying all five districts. Their degree of rarity is high, and it is suggested that this restricted Lowland flora is, on the whole, of comparatively recent introduction, having yet had insufficient time to spread very far, although there is no reason to suppose that some, certainly not all, of the constituent species may not in the future extend their range within the county. It is obvious that certain types will be restricted by certain definite ecological boundaries. For example, we should not expect maritime forms in Perthshire beyond the limits of the Gowrie district, but, excluding these, there seems nothing to prevent certain of the other species which are at present Lowland ultimately finding their way farther into the interior.

The concentration of species in Gowrie, already commented upon when speaking of the flora as a whole, is a prominent feature in the distribution of the entirely Lowland element. (See Map IV.) Even the removal of the maritime species from the list still leaves Gowrie with a largely preponderant number of species. Nearly 80 per cent. of the entirely Lowland element occurs in this district and 27 of the 40 (67.5 per cent.) restricted to a single district belong to Gowrie. Unless we assume a wholesale destruction of species in other districts, the apparent explanation of this concentration in Gowrie is that the species have arrived in that district first. If this be true for the entirely Lowland element of the Perthshire flora may it not also apply to the temperate flora as a whole? Topographical features, it should be remembered, are in favour rather than against such a view.

Entirely Highland Species.

These number 89 and their incidence in the several Highland districts is shown in Table VI., and cartographically in Map V.

TABLE VI.

Highland	No. of Species.	Area above 3000 feet in sq. ml.	Peaks above 3000 feet.
Forth, - - -	23	1	7
Earn, - - -	33	$\frac{1}{8}$	3
Perth, - - -	13	0	1
Isla, - - -	45	$\frac{1}{2}$	5
Lomond, - - -	32	$\frac{1}{3}$	7
Breadalbane, - -	70	9	34
Rannoch, - - -	39	4	16
Atholl, - - -	45	2	16

We are here concerned with an element of our flora which has provided a favourite subject for discussion. Dr. White's opinion is already known to us, and I think Professor MacNair (1898) holds a similar view regarding the origin of our arctic species, which constitute the majority of these entirely Highland plants. He goes further, however, to show that altitude alone is not the determining factor in the distribution and survival of the alpine flora of Perthshire by pointing out that the presence of a band of sericite schist stretching from Ben Lui through Breadalbane to Canlochan is the chief factor influencing the distribution of our local alpines. So, while Breadalbane is the richest district it is not necessarily because it has the largest area of high ground or the greatest number of high peaks, but because it embraces that band of schistose rocks which produce the fine, friable, micaceous soil in which many of our rarer arctic species have been able " to maintain an existence in the great struggle which has exterminated them from the plains, the hills, and the majority of even our highest summits." It is a theory claiming edaphic conditions as the dominant factor and suggesting a process of selection, competition leading ultimately to the restriction of the alpine flora to those areas where the combination of soil factors is best suited to the growth of the plants concerned. But if we knew more of the biology of arctic plants we should probably find that epedaphic factors play their part as well.

In the case of the arctic-alpine element of the Perthshire flora the applicability of the " Age and Area " law does not seem possible. It is ruled out, I think, by its own admitted limitations. The arctic species are rare, not like the purely Lowland species because they are still young in the county, but because they are either slowly disappearing or they have failed in general to widen their range. I cannot admit all these arctic-alpines as recent arrivals, although perhaps a few of them might be regarded as such. Whether they survived the period of maximum glaciation on nunataks, or whether they represent the van of an arctic flora advancing northwards as the Ice Sheet retreated, there is good reason to regard most of them as relics of a former much more widely distributed palæarctic flora, most of which has retired still further north, finding its headquarters at the present day in Scandinavia. The possibility of survival on nunataks since pre-glacial times has been favourably considered by some, but it will be difficult to prove any direct connection between the present arctic flora of our high summits and the pre-glacial flora of these heights. There may have been since glacial times a long drawn-out movement to and fro, up and down our hills, but whatever the past history of our arctic species, we have at present only the remnants of an arctic flora, which, as proved by the fossil record, was unquestionably at one time more widely distributed in Britain than it is to-day. Competition has been perhaps the most potent factor in the squeezing out of this earlier flora under pressure of an incoming Lowland flora which has now established itself fairly generally throughout the country.

Perthshire has shared the process, and although it is not easy to reconstruct the picture in detail, a faint outline may possibly appear from an examination of the distribution of those plants which at present overlap a little into one region or the other—Lowland and Highland—but which belong essentially to one or the other.

The Rarer Overlapping Species.

Turning again to Table IV., we find there are 80 somewhat rare species distributed chiefly in the Lowland districts. They show an increasing series of numbers from 3 occupying two districts to 23 occurring in seven districts. They may be compared with the series of widely-distributed plants though in fact they are, on the average, intermediate in commonness between the entirely Lowland and widely-distributed elements. They are common in the Lowlands but rare in the Highlands. But in their invasion of the county they are ahead of those species still restricted to the Lowlands. One may argue, therefore, *other things being equal,* that they have existed in the county longer than the purely Lowland element. (See Map VI.).

On the other hand, there are 44 species (Column F, Table IV.) which have a distribution predominantly Highland. But, as in the case of the entirely Highland plants, the figures for these 44 species do not show any regular gradation up or down, and if they re-immigrated after the glacial period, it is suggested that they either at once established themselves in greater force in the Highland region or, if they gradually traversed the Lowland region, then they have there undergone disintegration of area.

The details of the regional distribution of these overlapping floras are set out in Table VII.

TABLE VII.

District.		Chiefly Lowland Species (80).		Chiefly Highland Species (44)	
		No.	Percentage.	No.	Percentage.
Lowland	Forth,	49	61.2	9	20.4
	Earn,	66	82.5	15	34.1
	Perth,	59	73.7	16	36.3
	Isla,	57	71.2	24	54.5
	Gowrie,	59	73.7	15	34.1
Highland	Forth,	13	16.2	19	43.1
	Earn,	9	11.2	19	43.1
	Perth,	22	27.5	28	63.6
	Isla,	38	47.5	35	79.5
	Lomond,	1	1.2	5	11.4
	Breadalbane,	35	43.7	36	81.8
	Rannoch,	7	8.7	27	61.4
	Atholl,	14	17.5	27	61.4

The data for the chiefly Lowland plants give evidence of fairly uniform distribution in the Lowland districts, although the Tay areas are each richer than Lowland Forth. If we trace these 80 species into the Highlands we find, as we might expect, a considerable number reaching Highland Isla, Perth, and Breadalbane, yet it is rather remarkable that while Lowland Earn possesses 66, only 9 occur in Highland Earn.

Of the 44 species which exhibit a predominantly Highland range, the greatest concentration occurs in Breadalbane, as is the case with the entirely Highland species. But an interesting feature about these 44 overlapping species is their comparative commonness in the Lowland districts. They are commoner in the Lowlands than the chiefly Lowland species are in the Highlands. The latter, I believe, may be regarded as being in an early phase of invasion of the Highlands. Many of them may never become much more prevalent there than they are now, just as many of the purely Lowland species may never reach the Highland valleys, for every species must have its own peculiar barriers, its own limitations to the area it may occupy. But have those plants, which are now mainly Highland, always been so? Is their centre of distribution in the Highlands, and are they descending into the Lowlands? Or are they suffering from competition and undergoing disintegration of area in the Lowland region? If, by any natural cause, *Polygonatum verticillatum, Festuca sylvatica, Potamogeton praelongus, Subularia aquatica,* and *Cochlearia alpina,* all of which occur in several of the Highland districts, should disappear from Lowland Isla; *Drosera anglica* and *Salix lapponum* from Lowland

Forth; and *Arctostaphylos Uva-ursi* from Lowland Earn, we shall have to add eight species to our list of entirely Highland plants.

We shall not seek, at present, to enter upon purely speculative flights, but it would appear that in the rarer overlapping elements of the Perthshire flora we are presented with what may amount to a test question regarding the problems we have had before us.

In the preceding pages, and in the accompanying maps, a number of facts relating to the distribution of plants within Perthshire, well known in a general way to local students of the flora, have been gathered together and set down in tabular and cartographic form. This is perhaps the chief value of the present communication, and I leave it to those who are interested to interpret the facts according to their own proclivities. No one is more aware than the writer how difficult and often dangerous it is to generalise in biological work from mere statistics, and if definite conclusions have not been forthcoming, it is hoped that the suggestions brought forward, however theoretical they may be, may draw attention to a line of thought which adds an increasing fascination to the study of a local flora.

In conclusion, I desire to express my indebtedness to Mr. R. M. Adam for help in the preparation of the maps illustrating this paper.

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APPENDIX.

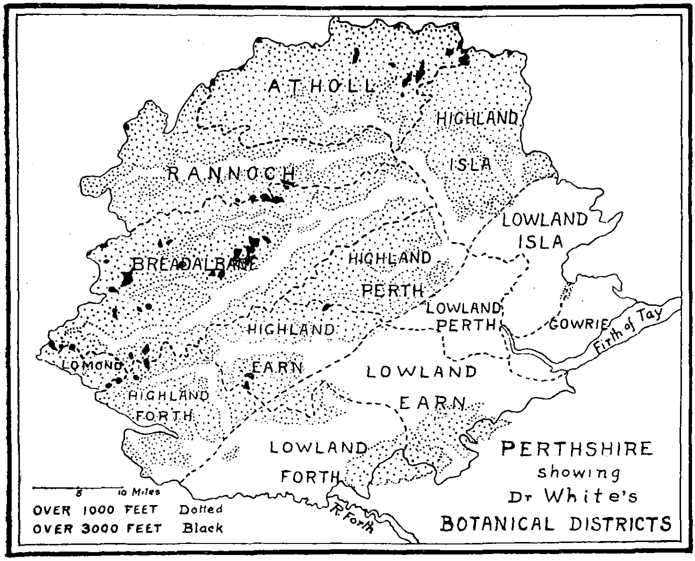
Since it is obviously desirable to have some idea of the plants whose distribution has been discussed in this paper, the following lists of the rarer plants of the county have been drawn up.

It may be contended that a number of the species mentioned are not, strictly speaking, members of the category suggested by the name of the list in which they appear. My aim has been, however, to present the facts of distribution as they concern our native plants in the county of Perth. The inclusion of recent records which have accrued since Mr. Barclay's paper (1912) appeared, would involve a few changes in the distributional data (*e.g. Scheuchzeria palustris*), but the general results would remain unaltered. The number of districts from which the species are recorded is placed after the name of each. The names are those of Dr. White's *Flora*.

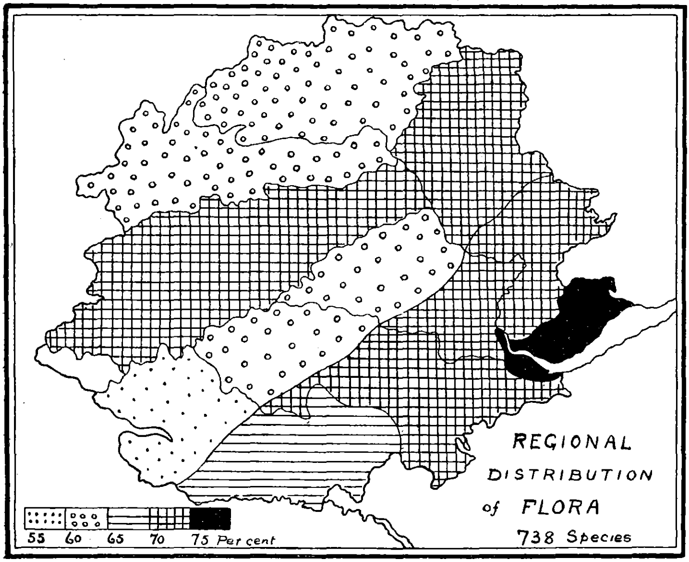
I. Entirely Lowland Species (103).

Ranunculus Drouetii 1.
R. heterophyllus 2.
R. confusus 1.

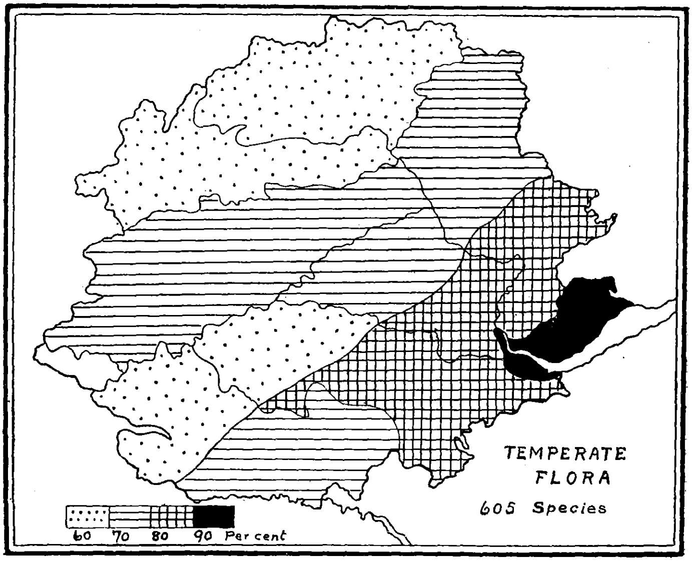
Cynoglossum officinale 1.
C. germanicum 2.
Veronica polita 3.



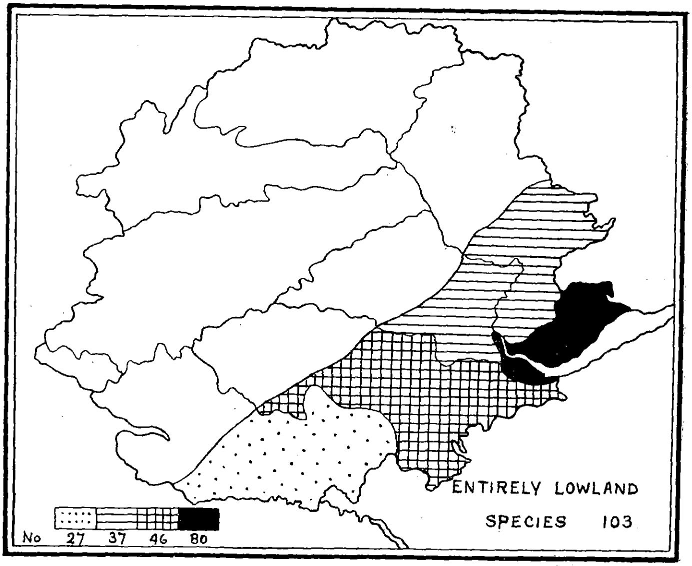
MAP I. **Plate 21.**



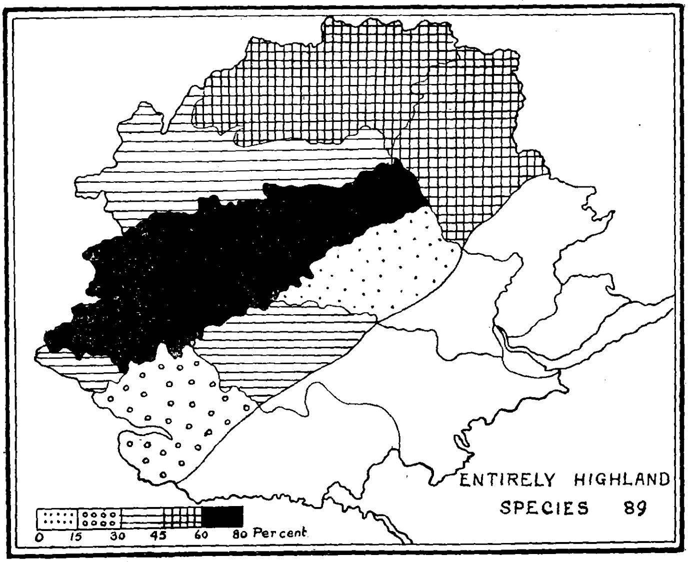
MAP II. **Plate 22.**



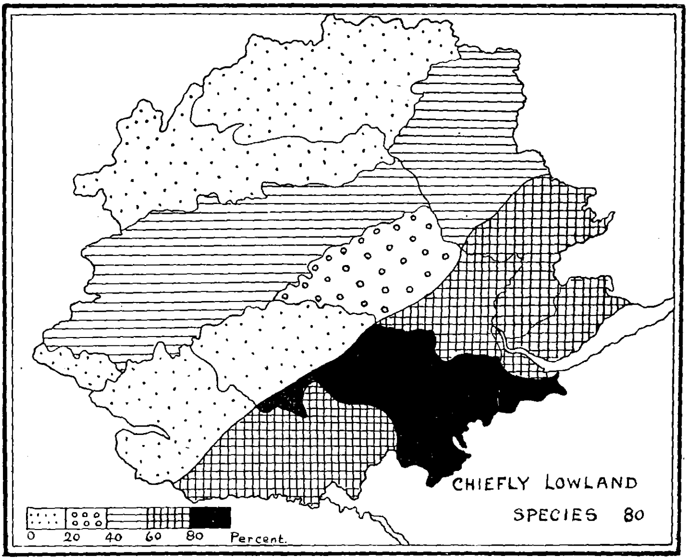
MAP III. **Plate 23.**



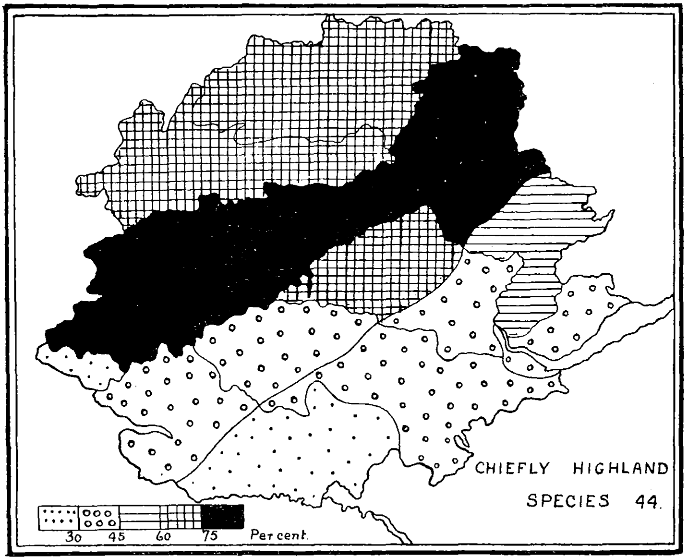
MAP IV. **Plate 24.**



MAP V. **Plate 25.**



MAP VI. **Plate 26.**



MAP VII. **Plate 27.**

R. penicillatus 3.
R. circinatus 3.
R. sceleratus 5.
R. sardous 4.
R. arvensis 2.
Fumaria confusa 2.
Nasturtium palustre 5.
Lepidium campestre 4.
Thlaspi arvense 3.
Reseda lutea 2.
Cerastium tetrandrum 2.
Stellaria palustris 2.
Honkeneja peploides 1.
Sagina apetala 3.
S. maritima 1.
Buda marina 1.
Geranium columbinum 4.
Trifolium striatum 3.
Vicia lathyroides 2.
Rubus caesius 1.
Potentilla argentea 3.
Myriophyllum spicatum 4.
Callitriche vernalis 2.
Epilobium hirsutum 5.
Cicuta virosa 2.
Sium angustifolium 1.
Oenanthe fistulosa 1.
Oe. crocata 4.
Anthriscus vulgaris 1.
Sambucus Ebulus 3.
Valerianella olitoria 3.
V. dentata 1.
Dipsacus sylvestris 2.
Eupatorium cannabinum 4.
Aster Tripolium 1.
Senecio viscosus 4.
Bidens cernua 2.
Arctium intermedium 1.
Centaurea Scabiosa 2.
Carduus nutans 1.
C. crispus 5.
Lactuca virosa 2.
Leontodon hirtus 1.
Campanula glomerata 3.
Andromeda polifolia 1.
Moneses grandiflora 1.
Erythraea Centaurium 5.
Convolvulus arvensis 5.
Lithospermum arvense 4.
V. anagallis 5.
Mentha longifolia 2.
M. viridis 3.
M. piperita 3.
M. sativa 4.
M. rubra 2.
Lycopus europaeus 2.
Calamintha Acinos 4.
Galeopsis angustifolia 1.
Lamium intermedium 1.
Utricularia intermedia 1.
Lysimachia thyrsiflora 3.
Glaux maritima 1.
Plantago coronopus 1.
Atriplex Babingtonii 1.
Polygonum Bistorta 2.
P. minus 3.
P. maculatum 1.
Rumex conglomeratus 2.
R. Hydrolapathum 3.
Euphorbia exigua 2.
Ceratophyllum demersum 1.
Salix triandra 3.
Goodyera repens 4.
Cephalanthera ensifolia 2.
Allium vineale 1.
Juncus Gerardi 1.
Alisma ranunculoides 2.
Triglochin maritimum 1.
Scheuchzeria palustris 1.
Potamogeton lucens 3.
P. decipiens 1.
P. filiformis 1.
Zannichellia palustris 1.
Eleocharis uniglumis 1.
Scirpus maritimus 1.
S. Tabernaemontani 2.
Carex paniculata 2.
C. vulpina 1.
C. acuta 1.
C. pendula 2.
Catabrosa aquatica 1.
Poa compressa 3.
P. palustris 2.
Glyceria plicata 1.
G. aquatica 2.
G. maritima 1.
G. distans 1.

II. Chiefly Lowland Species (80).

Ranunculus trichophyllus 3.
R. floribundus 5.
R. peltatus 7.
R. Lingua 4.
Aquilegia vulgaris 4.
Papaver Argemone 7.
P. Rhoeas 5.
Fumaria pallidiflora 6.
F. densiflora 5.
Nasturtium sylvestre 6.
Arabis perfoliata 4.
Sisymbrium Alliaria 7.
Teesdalia nudicaulis 4.
Reseda Luteola 6.
Viola hirta 3.
Dianthus deltoides 6.
Lychnis viscaria 5.
Githago segetum 7.
Cerastium arvense 7.
Sagina ciliata 4.
Elatine hexandra 3.
Hypericum Androsaemum 2.
H. quadrangulum 7.
Trifolium arvense 7.
Astragalus glycophyllos 7.
A. hypoglottis 7.
Ornithopus perpusillus 6.
Potentilla reptans 5.
Saxifraga tridactylites 3.
Sedum villosum 7.
S. anglicum 6.
S. acre 6.
Callitriche autumnalis 6.
Aethusa Cynapium 4.
Scandix Pecten-Veneris 4.
Conium maculatum 5.
Linnaea borealis 7.
Filago germanica 7.
Anthemis Cotula 3.
Bidens tripartita 6.
Arctium minus 7.
Hieracium umbellatum 7.
Tragopogon pratensis 5.
Echium vulgare 7.
Lithospermum officinale 2.
Lathraea squammaria 6.
Mentha hirsuta 5.
Origanum vulgare 7.
Stachys arvensis 6.
S. Betonica 4.
Lamium hybridum 6.
Centunculus minimus 4.
Rumex acutus 5.
R. conspersus 2.
R. sanguineus 6.
Salix pentandra 6.
S. alba 7.
S. purpurea 7.
Corallorhiza innata 5.
Epipactis latifolia 5.
Gagea lutea 4.
Juncus glaucus 6.
Butomus umbellatus 3.
Potamogeton rufescens 7.
P. nitens 4.
P. angustifolius 4.
P. perfoliatus 7.
P. crispus 6.
P. obtusifolius 5.
Naias flexilis 3.
Rhynchospora alba 4.
Eleocharis acicularis 5.
Scirpus lacustris 5.
Carex disticha 6.
C. teretiuscula 7.
C. paludosa 5.
Milium effusum 6.
Trisetum flavescens 6.
Poa trivalis 7.
Festuca gigantea 7.

III. Entirely Highland Species (89).

Thalictrum alpinum 8.
Arabis petraea 1.
Draba rupestris 1.
D. incana 8.
Thlaspi alpestre 2.
G. nivalis 1.
Myosotis alpestris 1.
Veronica alpina 4.
V. fruticans 4.
Bartsia alpina 1.

Viola Reichenbachiana 1.
Silene acaulis 7.
Cerastium alpinum 6.
C. trigynum 2.
Stellaria umbrosa 2.
Cherleria sedoides 1.
Alsine verna 2.
A. sulcata 2.
Sagina Linnaei 6.
S. nivalis 1.
Astragalus alpinus 1.
Oxytropus uralensis 3.
O. campestris 1.
Vicia Orobus 2.
Lathyrus niger 1.
Rubus chamaemorus 8.
Dryas octopetala 3.
Potentilla Sibbaldi 7.
P. rubens 6.
Rosa hibernica 2.
Pyrus Aria 1.
Saxifraga rivularis 1.
S. cernua 1.
S. stellaris 8.
S. nivalis 6.
S. oppositifolia 8.
Sedum roseum 7.
Epilobium anagallidifolium 7.
Cornus suecica 5.
Galium sylvestre 3.
Erigeron alpinum 1.
Gnaphalium norvegicum 1.
G. supinum 7.
Saussurea alpina 7.
Serratula tinctoria 1.
Vaccinium uliginosum 7.
Phyllodoce caerulea 1.
Loiseleuria procumbens 5.
Pyrola rotundifolia 1.
Gentiana Amarella 1.
Pinguicula lusitanica 1.
Utricularia neglecta 1.
Betula nana 4.
Salix Arbuscula 3.
S. lanata 1.
S. Myrsinites 3.
S. herbacea 8.
S. reticulata 2.
Taxus baccata 1.
Malaxis paludosa 4.
Epipactis atrorubens 1.
Tofieldia palustris 8.
Juncus alpinus 3.
J. castaneus 3.
J. triglumis 8.
J. biglumis 2.
J. trifidus 6.
Luzula spicata 7.
Sparganium affine 6.
Schoenus ferrugineus 1.
S. nigricans 1.
Kobresia caricina 3.
Carex rupestris 1.
C. pauciflora 6.
C. Boenninghausiana 1.
C. alpina 1.
C. rigidia 8.
C. atrata 3.
C. ustulata 1.
C. rariflora 1.
C. vaginata 5.
C. capillaris 6.
C. pulla 3.
Alopecurus alpinus 1.
Phleum alpinum 1.
Deschampsia alpina 3.
Sesleria caerulea 1.
Poa alpina 6.
P. glauca 3.

IV. Chiefly Highland Species (44).

Caltha radicans 3.
Nymphaea pumila 7.
Cochlearia alpina 9.
Subularia aquatica 8.
Potentilla procumbens 8.
Agrimonia odorata 6.
Poterium Sanguisorba 3.
U. vulgaris 6.
Lysimachia vulgaris 4.
Anagallis tenella 3.
Salix Lapponum 6.
Pinus sylvestris 7.
Epipactis palustris 3.
Polygonatum verticillatum 4.

Drosera anglica 5.
Hippuris vulgaris 6.
Callitriche hamulata 8.
Epilobium alsinefolium 8.
Galium Mollugo 6.
Hieracium murorum 7.
H. prenanthoides 9.
H. boreale 5.
Lobelia Dortmanna 9.
Arctostaphylos Uva-ursi 8.
Pyrola media 8.
P. secunda 9.
Melampyrum sylvaticum 7.
Mentha arvensis 7.
Utricularia minor 6.
Convallaria majalis 7.
Potamogeton polygonifolius 9.
P. praelongus 7.
Eleocharis multicaulis 4.
Eriophorum latifolium 9.
Carex aquatilis 7.
C. irrigua 6.
C. Oederi 7.
C. laevigata 3.
Calamagrostis Epigeios 3.
Avena pubescens 7.
Festuca sylvatica 6.
F. rubra 3.
F. duriuscula 9.
F. sciuroides 3.

Charles M'Intosh.

1839—1922.

By JAMES MENZIES.

Charles M'Intosh was born at Inver on the 27th of March, 1839, and died at the home of his brother at Dunkeld on the 5th of January, 1922.

His father was originally engaged in the handloom weaving industry, and when that failed owing to the introduction of the power loom he took up the teaching of music. His son, Charles M'Intosh, very early in life manifested that spirit of inquiry and thirst for knowledge which proved the leading characteristics of his life. He was described by his mother as not like the other children, but was always observing and trying to find out about things.

From the age of six until he was fourteen he received his education at the Free Church School at Birnam, the subsequent two years being spent at the Royal Grammar School at Dunkeld. At the age of sixteen he left school and went to work at the Sawmill at Inver, and two years later had the misfortune to suffer a mutilation of his hand.

Incapacitated for further manual employment, a year later he entered the Postal Service and became rural postman in his own locality, and in this employment he continued for thirty years, retiring five years earlier than the age limit owing to repeated attacks of pleurisy.

M'Intosh was unmarried and spent his whole life in the locality in which he was born, and even in the same house.

His bias towards botanical pursuits seems to have been due to the circumstance that his mother was interested in ferns, and when M'Intosh was about twenty years of age the family acquired a copy of Moor's "British Ferns," and he entered into their collection and study with enthusiasm. Thereafter he continued his collecting in a miscellaneous way. He must have been sorely hampered by the want of books on the subject, as not for a good many years later was he in possession of Hooker's "Student's Flora."

In 1872 M'Intosh attracted the attention of Dr. Buchanan White, then resident in Birnam, and there can be no doubt Dr. White's sympathetic help and counsel had a strong influence in guiding the botanical pursuits of M'Intosh. When in the year following Dr. White removed to Rannoch, and finally to Perth, a considerable correspondence passed between them, and Dr. White's letters I have been privileged to use. Much of this correspondence relates to the flora of the Dunkeld district, in the investigation of which Dr. White had enlisted the help of M'Intosh. That he gave his services freely in this capacity Dr. White's many letters of acknowledgment fully bear out, and the results of his labours in this respect were subsequently of great service in the compilation of the "Flora of Perthshire."

The correspondence mentioned above dates from the year 1873, when we learn that Dr. White wrote to Mr. M'Intosh asking his permission to nominate him as an Associate Member of the Perthshire Society of Natural Science, to which he gave his consent. Shortly afterwards Dr. White wrote advising him as to procuring a Hooker's "Students' Flora," and, learning that he had borrowed a book on Mosses from the library of the Society, he offered him some advice on the collection and study of these plants. M'Intosh made excellent use of this book and others which he subsequently acquired, as he attained to a sound knowledge of the Mosses of his locality, and besides contributing to the Society's collections he formed a fine private collection, which he gifted to the School of Forestry at Dunkeld about a year before his death.

In 1880 Dr. White wrote thanking him for the offer to dry a collection of the plants of his district for the herbarium of the Society, and this promise he amply fulfilled. In 1885 we learn that M'Intosh consulted Dr. White as to the selection and purchase of a microscope, and evidently the instrument was bought shortly afterwards, as the same season Dr. White wrote to him suggesting that with the aid of his microscope he might now take up the study of the Fresh Water Algae. Whether M'Intosh took up the study of the Algae at this time there is no evidence to show, but he eventually did, making a collection of those found in his locality and mounting many sections as microscope slides. Unfortunately his mounting media gave way, and when he showed them to the writer he was about to destroy them. "Oh, well," he said on that occasion, "it cannot be helped, and the knowledge I derived from working at the Algae was the main thing after all." This correspondence with Dr. White closed in 1893 with a letter from the Doctor anent Lampreys and which M'Intosh had sent him.

When he began what was his favourite study, the Fungi, it is now impossible to say. When he met Dr. White in 1872 he was already collecting, and the Doctor spent a great deal of time with him examining the Fungi which M'Intosh collected, Dr. White frequently expressing his surprise and pleasure at the many fine species he was able to find in his locality, and when some years later Dr. White published his "Preliminary List of Perthshire Fungi," M'Intosh's work was incorporated in that list. In 1873 M'Intosh made enquiries of Dr. White if there were any book on Fungi in the Society's library which he could borrow, when the Doctor assured him there was none, but suggested that if he, M'Intosh, would collect those fungi growing on wood leaves, etc., he should get them named for him. Their subsequent correspondence, however, gives no hint that he availed himself of this offer—he was to do this work for himself in after years.

In 1875 M'Intosh was an exhibitor at the great Fungus Show at Perth, and his exhibit excited a good deal of interest, as it contained specimens of the beautiful Pholiota Aureus Var. Vahlii Schum, which had not until then been found in Britain.

In 1887 he acquired a copy of Berkeley's "Outlines of British Fungology," and the same year he was presented by an admirer with a copy of Stephenson's "Fungus Flora," then newly published, and, as he said to the writer afterwards, the latter was a mine of wealth to him. With these books, and now in possession of a microscope, he was able to study the Basidiomycetes in a systematic way, and all his notes on the subject which I have been able to examine date from this time. When, some ten years later, in 1899, the writer first met Mr. M'Intosh, he had a fairly comprehensive knowledge of the Basidiomycetes, and this remained his favourite group. Working for so many years in the same locality, and that a good one for these Fungi, he discovered many fine species and was able to add several new to the "British Fungus Flora." He had also many curious incidents to relate as to the occurrence of certain species, their disappearance in some instances for many years and their reappearance on the original spot. To M'Intosh at least the perennial duration of the Mycelium was a fact which admitted of no doubt.

About 1906 M'Intosh acquired a copy of Massie's "Fungus Flora," which enabled him to widen the scope of his studies, and shortly afterwards, his attention having been called to a copy of

Cook's "Handbook on British Fungi" in the library of the Society, he borrowed the book and added the Pyrenomycetes and Sphaeropsidea to his quest. In the freely wooded country around Dunkeld he was successful in finding many interesting members of these groups, two new to science and three new to Britain. Amongst the latter was one of special interest to those in charge of plantations, Cucurbitaria pithyophila, a parasite on the Scots fir. A collection of these Fungi in the Herbarium of the Society is almost exclusively his own work.

In 1918, learning that the writer was bent on specializing on the Discomycetes with a view to ascertaining what species were represented in the county, he at once offered his help by working up his own locality, and this work he steadily pursued till within two or three years of his death, and in the course of which he was again able to add five species and one variety new to Britain and two new to science. Mr. M'Intosh was a careful and highly competent worker. His specimens sent to me were invariably accompanied by a microscopical diagnosis of the plant showing its distinctive characteristics, and these were models of patient and accurate observation. Much of this work was done when he was considerably over the three score years and ten. Besides all this he found time to collect and study the Uredineæ of his own locality, and he handed over his collection of these to the Herbarium of the Society some two years before his death.

M'Intosh had also a considerable knowledge of the Lichen Flora of the Dunkeld district.

Apart from purely botanical pursuits he was widely interested in Nature, as his "Nature Notes" communicated to the *Transactions* of the Society proved. In Ornithology he was keenly interested, and we find his knowledge and services acknowledged by Harvie Brown, author of the "Fauna of the Tay Basin." In a footnote in that work the author says:—"Mr. M'Intosh is a careful observer, and during a considerable portion of his life has traversed Strathbraan as a regular letter carrier (now retired); his identifications may be relied on as correct. He has sent me notes relating to a wide area around Dunkeld. These, when necessary, I will make mention of in the body of the catalogue resume."

M'Intosh's interest in Meteorology led him to keep an accurate record of the rainfall at Inver for many years, with notes on all the abnormalities of the season and observations of the flood and drought levels of the Tay.

His interest was not confined to the present; the past had also a strong attraction for him, and all the prehistoric remains in his locality were well known to him. During his life time he collected relics of less remote times, and these although valued by him were freely parted with in the public interest.

In music he found much pleasure, both vocal and instrumental. For many years he conducted the psalmody of the Parish Church at Little Dunkeld with marked ability, and in the latter years of his life, when no longer so able to range the hills and woods in botanical pursuits, he spent much time in the composition of music.

As a recreation from more exacting pursuits, M'Intosh possessed a turning lathe with which he gratified his artistic taste in wood turning, and despite his infirmity produced highly creditable work.

From the facts related above it will be learned that M'Intosh was a man of varied interests, and even beyond these special interests he was well informed on many subjects. To those who shared his interest in Nature he was an ideal companion to have for a day in the woods or on the hills of his native place. His keen delight in the study of Nature, as well as the vast amount of knowledge he had acquired on the subject, never failed to impress his visitors. On these occasions his only desire was to bring before his friends all the natural treasures of the locality with which he was so well acquainted. Living in a beautiful part of the country, he invariably guided his visitors so that he was able to bring them out on some commanding eminence, and while he pointed out the geological features of the locality he never forgot to challenge their admiration of the beauty of the landscape of which he was justly proud, and to which long years of familiarity had not dulled his sensibilities. This love for the beautiful was highly characteristic of Mr. M'Intosh. To him the purpling hills, with their ever varying panorama of cloud, mist, and sunshine, the beauty of the flowers and trees, the songs of birds, the harmonies of music, brought intense pleasure, for despite his passion for scientific knowledge he was imbued with the true artistic temperament in no common degree.

A man of simple and unaffected manners, obliging and courteous at all times, he won the respect and esteem of all with whom he came in contact. Often appealed to for the material for nature study by those less fortunately placed, to such appeals he never failed to respond, even although it sometimes cost him a great deal of trouble to secure. From the stores of his own knowledge he was ever ready to help and encourage anyone showing an interest in those subjects which he had specially made his own, and this was very marked in his attitude towards children, for whom he manifested a remarkable fondness, and he was never happier than when trying to imbue them with that love of nature in which he himself had found so much pleasure and happiness. If it be true, as some hold, that the secret of the enjoyment of life is to be found in the multiplication of its interests, then that secret was discovered by Charles M'Intosh, ex-postman, naturalist, musician, and gentleman.

Invertebrate Fauna of Perthshire: The Land and Freshwater Mollusca.

By HENRY COATES, F.S.A.Scot.

I.—INTRODUCTION.

I have given this paper, as a first title, the heading "Invertebrate Fauna of Perthshire,"* in the hope that workers in other branches of natural history may be induced to continue the series. We already have a fairly complete "Flora of Perthshire," published in 1898, from the pen of the late Dr. Buchanan White, comprising the flowering plants of the county, a "Vertebrate Fauna of the Tay Basin and Strathmore," published in 1906, by the late Mr. J. A. Harvie-Brown, comprising the mammals, birds, reptiles and amphibians, and a "Fauna Perthensis; Part 1.—Lepidoptera," published in 1871, also by Dr. Buchanan White, containing an account of the moths and butterflies of the district. We have also the "Geology and Scenery of the Grampians and the Valley of Strathmore," published in 1908, by Mr. Peter Macnair, dealing with the geology of both the Highland and Lowland portions of the county. These are all excellent works of reference in their several subjects, but they do not by any means cover the whole ground of the Natural History of Perthshire. The present paper is offered as a contribution towards the filling up of the gaps still remaining.

As will be seen from the Bibliography which is appended to this paper, the period covered by recorded research in the Mollusca of Perthshire practically coincides with the period covered by the existence of the Perthshire Society of Natural Science. The Society was founded in February, 1867. The first volume of Jeffrey's "British Conchology," dealing with the Land and Freshwater species, was published in 1862, and contains no references whatever to Perthshire. Volume V., however, published in 1869, which has a Supplement, bringing the information up to that date, has references to five outstanding Perthshire species, from data supplied by Dr. Buchanan White. Going still further back, the

* I have used the term "Perthshire" throughout this paper in the wider sense of the area embraced under the three Watsonian Vice-counties, 87, 88, and 89, the first of which embraces Clackmannanshire, and a small portion of Stirlingshire, as well as South-west Perthshire. "Perth West" is always a contraction for "Vice-county 87, Perth West and Clackmannan."

other standard work of a past generation, Forbes and Hanley's "History of British Mollusca," published in 1853, contains no local reference except to the Pearl Fishery of the Tay, which, of course, had been well known both to naturalists and historians for hundreds of years. So also Lovell Reeve's Hand-book on the "Land and Freshwater Mollusks of the British Isles," published in 1863, makes no mention of Perthshire, although he gives records from several other Scottish Counties; and Ralph Tate, in his "Plain and Easy Account of the Land and Freshwater Mollusks of Great Britain," published in 1866, mentions, like Forbes and Hanley, only the Pearl Fisheries of the Tay.

When we turn to the first publication issued by our Society, the "Proceedings for Session 1869-70," we find a very different state of matters. No fewer than seven papers and notes in that little 12mo volume of 105 pages are devoted to the land and freshwater shells of the county, showing that by that time a start had been made in earnest in the investigation of this section of our local fauna. From that time onwards papers and notes bearing on the subject have appeared in our Proceedings and Transactions from time to time, indicating steady progress in the working out of the distribution.

The progress made from this time onwards may be traced from the steadily increasing numbers of the species recorded in the lists which were published at successive dates. Thus we find that the lists contained in the Proceedings for 1869-70, already referred to, contain 44 names; my own list, published in the Proceedings for 1882, contains 51 names; W. D. Roebuck's "Census," published in the Proceedings of the Royal Physical Society in 1890, contained 59 names; L. E. Adams' "Census," published in 1896, contained 68 names; Roebuck's final "Census" of June, 1921, contained 83 names; while my present list contains 93 names. It will thus be seen that within the last fifty years the known Molluscan Fauna of Perthshire has been fully doubled, one new species, on an average, having been added each year.

Turning now more particularly to the last two items in the foregoing statistics, it will be noticed that ten new species have been added to the recorded list since June, 1921, that is, in less than a year. That does not mean that ten new species have been discovered during that period, as the result of field work. One, *Azeca tridens,* had previously been recorded, but was omitted from the 1921 Census through an oversight; two, *Sphyradium minutissimum* and *Valvata cristata,* had been discovered by Mr. Fred. Smith, jun., more than a dozen years ago, but had been omitted to be recorded at the time, and one, *Hyalinia helvetica,* had been omitted by Roebuck as doubtful, but recorded by Taylor in his "Monograph." The remaining six all belong to the *Pisidia,* and have resulted from the re-examination of that critical genus, as explained below.

In addition to these ten new county records, the present list contains no fewer than 27 new vice-county records, distributed over the three Perthshire vice-counties as shown in the following table:—

	Perth West No. 87	Perth Mid No. 88	Perth East No. 89	Total Vice-comital Records
Records in 1921 Census, New Records, - - -	67 6	65 11	64 10	196 27
Records in Present List,	73	76	74	223

It will be noticed from the above table that most of the new records relate to Perth Mid. and Perth East. These are the divisions of the county in which most work has been done by members of our Society. In Perth West most of the spade work was done a number of years ago by an active band of workers who were members of the Stirling Natural History and Archæological Society, under the leadership of the late Mr. Gilbert McDougall. As the result of the combined labours of these workers, both in the East and in the West, during the past fifty years, and also the investigations of Conchologists from a distance who have paid visits to our county from time to time, it is probable that the Molluscan Fauna of Perthshire is now better worked up and recorded than that of any other Scottish county. It is probable also that it contains more records of unique or outstanding interest, such as *Clausilia laminata, Sphyradium minutissimum* and *Limnæa glabra* for Kinnoull Hill, *Valvata cristata* and *Dreissensia polymorpha* for Perth Harbour, *Azeca tridens* and *Succinea oblonga* for Bridge of Allan district, and *Paludestrina jenkinsi* for the lower reaches of the Tay. Of the occasional visitors referred to above, special mention should be made of Mr. William Evans, F.R.S.E., of Edinburgh, who has spent many summer holidays in different parts of Perthshire, such as Callander, The Trossachs, Aberfoyle, and Loch Tay side, and who never failed to improve the occasion by adding to our knowledge of the local fauna, both vertebrate and invertebrate.

With regard to the *Pisidia,* to which reference has been made above, all the Perthshire records in the following list are the result of recent investigation and confirmation by Messrs. Charles Oldham, A. W. Stelfox, and R. A. Phillips, the Referees of the Conchological Society for this very difficult genus of minute bivalves. In November, 1921, I sent to these gentlemen all the specimens in the Perthshire Natural History Musuem, and got them back in February, 1922, after a very careful and thorough examination. At the same time they examined the Perthshire specimens got by my friend Mr. E. Crapper, formerly of Perth, now of Dundee. Within the last year or two it had been decided by the Conchological Society to abandon all the older British records of *Pisidia,* as many of them were unreliable in the light of recent investigation, and a fresh start was made in compiling new records for the Society's Census Books. The nomenclature adopted was, in the main, that of B. B. Woodward's "Catalogue of the British species of Pisidium," published by the Trustees of the British Museum in 1913. In Mr. Roebuck's Census, published in June, 1921, there were only 6 vice-comital records of *Pisidia* for Perthshire. The specimens which Mr. Crapper and I were able to send to the Referees added 15 new records, bringing up the total to 21. Taking the whole area of the county, the result is :—old records, 4; new records, 6; total, 10. The new records, both vice-comital and comital, are all for Perth Mid. and Perth East. When Perth West is worked up in the same way, no doubt equally satisfactory results will be obtained. Even as it is, however, Perthshire now shows a more complete list of records than any other Scottish county. It includes all the species which have been known to occur in Scotland with the exception of *P. henslowanum.* There still remains, however, a large amount of work to be done amongst the lakes, ponds, tarns and sluggish streams of the county before we arrive at anything like a complete knowledge of the distribution of these interesting little bivalves in our midst.

Turning now from the historical to the geographical aspect of our subject, we note first that Perthshire is wholly an inland county, and its molluscan fauna is, therefore, confined to the non-marine—that is, the land and freshwater—species. The lower reaches of the Tay and of its tributary streams, however, near the confines of the county, are slightly brackish, and there at least one species, *Paludestrina jenkinsi,* finds a congenial habitat.

Few counties in Scotland are more favourably situated than Perthshire for the production of a rich and varied Molluscan Fauna. Both its topographical and its geological features contribute towards this result. Its area embraces all elevations from sea level to peaks of over four thousand feet. It is watered by a noble river system, embracing practically the whole basin of the Tay and its tributaries, as well as the north-western portion of the Forth basin. It includes vast tracts of moorland, woodland, and agricultural land. One half of it consists of hard crystalline rocks, the other half of soft sedimentary strata, intermingled with volcanic intrusions. Its hills are cleft by deep shady glens, whose rocks and vegetation are kept moist by the spray from dashing torrents and waterfalls. Both in the Highland and Lowland portions are numerous lakes, ponds, and mountain tarns, as well as weed-choked marshy pools and ditches.

Geologically, the county divides itself into two well defined areas, the Highland portion, lying to the north-west, and embracing a section of the Grampian range of mountains; and the Lowland portion, embracing the valleys of Strathmore and the Carse of Gowrie, with the volcanic ranges of the Sidlaw and

Ochil Hills. These two areas are separated from each other by the line of the Great Fault, which runs diagonally through the county from north-east to south-west, passing nearly through Blairgowrie, Birnam, Crieff, Comrie, Callander, and Aberfoyle, towards the south end of Loch Lomond. To the north-west of this line the rocks consist of the Schists, Quartzites, Slates, Limestones, Diorites, Felsites, and Granites of the very ancient Highland Metamorphic Series. The rocks to the south-east of the line of the Great Fault consist of the Sandstones and Conglomerates of the Old Red Sandstone Series, together with the associated interbedded volcanic rocks of the Sidlaws and Ochils, consisting of Andesites, Basalts, Agglomerate, Tuff, etc. In addition to these, glacial desposits, consisting of Till, or Boulder Clay, and Morainic material, cover large areas both in the Highland and Lowland divisions of the county. Lastly, the well-defined Basaltic Dykes of Tertiary age intersect all the older rocks in a direction approximately from east to west. It will be readily understood that these very varied conditions of rock and soil produce corresponding variations in the type of Molluscan life found in the different regions of the county.

For the purpose of studying zoological and botanical distribution, there are three possible methods of subdividing the area of Perthshire. It may either be divided (1) hydrographically, that is, according to the water-sheds and river systems, or (2) petrographically, that is, according to the geological structure and rock formations, or (3) by a combination of these two methods. Neither the first nor the second method is ideally appropriate, for, as will have been gathered from the previous remarks, the trend of the river systems cuts clean across that of the geological or stratigraphical systems. For this reason the third, or combined, method has much to recommend it, the only drawback being that it is somewhat complicated. This last method was the one adopted by Dr. Buchanan White for his Flora of Perthshire. He divided the county into thirteen districts, eight of these being in the Highland division, and the remaining five in the Lowland division. For botanical research this may not be too minute a sub-division, but in the case of the Mollusca such small areas do not seem to be necessary. The Conchological Society of Great Britain and Ireland therefore adopted the system laid down by H. C. Watson in his "Cybele Britannica," published in 1859, which divides Perthshire according to the first method described above, namely, the river systems. For the sake of uniformity, I have adopted the same method in the present paper. It has to be borne in mind, however, that each of the Watsonian divisions of the county embraces a Highland portion and a Lowland portion, so that they cannot be regarded as at all homogeneous. The divisions are three in number, and are as follows:—(1) vice-county No. 87, Perth West and Clackmannan, embracing the whole of that portion of South-West Perthshire whose waters drain into the river Forth; (2) vice-county No. 88, Perth Mid., embracing the portion of Central

Perthshire whose waters drain into the River Tay, and which lies to the west of the Garry, Tummel, and Tay; and (3) vice-county No. 89, Perth East, embracing that portion of Perthshire whose waters drain into the River Tay, and which lies to the east of the Garry, Tummel, and Tay. Vice-county 87 is sometimes named "Perth South," and vice-county 89 "Perth North"; but on the whole I think the terms "East" and "West" are more appropriate. Strictly speaking, "Perth South-West" and "Perth North-East" would be more accurate, but in this case accuracy must yield to brevity.

There is hardly any limit to variety of places where land and freshwater mollusks may be found in our county. The land species should be looked for under stones and logs by the edge of fields; on old moss-covered walls and ruins; on moist rocks; among rank vegetation, such as nettles, umbelifers, rushes, and long grass; in old moist pastures; on the trunks of trees; on fungi in the autumn woods; among moss, dead leaves, and decaying ferns; in fields, woods, moorlands, wastelands, and gardens; in hedgerows, and by the banks of streams and ditches, and on ivy-clad cliffs. Even our cellars and outhouses, if they are not unreasonably dry, are pretty sure to yield a few slugs and *zonites*. Freshwater species may be looked for in nearly all watery places, whether flowing or stagnant, such as lakes, ponds, tarns, weedy pools, marshes, ditches, rivers, streams, dead-waters, disused quarries, etc. They may even be found out of the water altogether, among the moss and other vegetation kept soaked by the spray from mountain torrents and waterfalls.

Certain regions of Perthshire have received more attention from the conchologist than others. Thus the districts around the City of Perth, on both sides of the River Tay, including Kinnoull Hill, Moncreiffe Hill, Quarry Mill Den, the Muir of Durdie, Stormontfield, and Glenfarg, with the Tay, and its immediate banks, have been pretty carefully worked. In the Carse of Gowrie, the deep glens which seam the flanks of the Sidlaws, as well as many parts of the Carselands, such as Errol, Longforgan and Invergowrie, have been visited from time to time. In Strathearn, Forgandenny and the Dead-waters of the Earn have yielded a number of interesting species. The region around Blairgowrie, and the chain of lochs which stretch from there to Dunkeld, have proved rich hunting grounds. In the Highland portion of the county, the parts which have received most attention are Dunkeld, Birnam, and Inver; Ballinluig, Pitlochry and Moulin; Glen Tilt, Aberfeldy, Killin and Kenmore, and Loch Tay side generally, as well as Ben Lawers and Drummond Hill. As already indicated, certain parts of the south-west corner of the county have been pretty carfully scrutinised, such as the Trossachs, the Pass of Leny, Aberfoyle, Callander, the waters of the "Lake District," and the country around Bridge of Allan and Dunblane. My experience, after collecting in all these districts for more than forty-five years, has led me to the conclusion that the Highland regions of the county are richer than the Lowland regions, both in the variety of species and the abundance of specimens, but that in the Lowland regions the specimens are better developed, both as regards size and colour. This may perhaps be accounted for, on the one hand, by much greater variety in the rocks of the Highlands, including limestones and the many gradations of the schistose formations; and, on the other hand, by the greater richness of the soil and vegetation of the Lowlands, due to the friable nature of the sandstones and other sedimentary rocks.

It is interesting to note how many species of Mollusca, and even how many rare and notable species may be collected without going outside the Borough Boundaries of the City of Perth. The gardens and waste grounds yield more than half a dozen species of slugs, including *Limax maximus, Agriolimax agrestris, A. lævis, Arion ater, A. subfuscus, A. hortensis*, and *A. circumscriptus*. On old walls, and in quarries and odd corners, may be found several of the commoner *Zonitidae* and *Helicidae*, as well as rarer species, such as *Hyalinia lucida, Hygromia striolata* and *Pyramidula rupestris*. The larger *Helices*, such as *H. aspersa, H. nemoralis, H. hortensis*, and *Arianta arbustorum*, are found in several localities, both in Kinnoull and Craigie. Of Freshwater Mollusca we have several species, ranging in size from the lordly pearl mussel (*Margaritana margaritifera*) to the minute *Pisidium casertanum*, inhabiting the Tay where it flows through the centre of the town. As we have already seen, the Old Harbour shelters such rare mollusks as *Dreissensia polymorpha* and *Valvata cristata*, as well as other three species of *Pisidium*,— *P. lilljeborgii, P. Milium*, and *P. pulchellum*,—while the Town's Lade yields the equally rare *P. amnicum*. In the Town's Lade is also got another rare bivalve, *Sphærium lacustre*, while *S. corneum* is got in the Harbour. *Paludestrina jenkinsi* occurs just where the Tay leaves the Borough. A little further up the river we get the freshwater limpet, *Ancylus fluviatilis*, as well as *Valvata piscinalis* and *Physa fontinalis*. The genera *Limnæa* and *Planorbis* are respresented by three or four of the commoner forms. Altogether, there cannot be many towns of the size of Perth which yield such an interesting Molluscan Fauna.

In the following list, for the sake of uniformity, I have adhered rigidly to the classification and nomenclature adopted in Roebuck's Census of June, 1921, as being the latest authoritative system. But, as many of the newer names are still unfamiliar to conchologists, like myself, of the older generation, I have added in these cases the synonyms with which we used to be better acquainted, although they did not always conform to the " Law of Priority." In every case, both in regard to the records in the Census of June, 1921, and those that I have added in the present List, the specimens have been examined and authenticated by the Recorder and Referees of the Conchological Society. I have included three doubtful vice-comital records, namely, *Testacella scutulum, Hyalinia helvetica*, and *Limnæa glabra*, all in the vice-county 87, Perth West and Clackmannan, but these are all indicated as doubtful in the usual way, by being enclosed in square brackets. On the other hand, I have removed *Helicella virgata* from the category of the "doubtfuls," because its identification is beyond all question, and the locality, Kincardine-on-Forth, actually was in Perthshire at the date when Dr. Buchanan White discovered it there.

All new records, not in the 1921 Census, are indicated in the list by **heavier type.** The list shows, after the name and synonym, (1) the number of vice-counties in Great Britain and Ireland from which the species has been recorded; (2) the same in Scotland; (3) whether it is represented in the Perthshire Natural History Museum, or "Wanted to Complete;" (4) its occurrence in or absence from each of the three Perthshire vice-counties—87, Perth West and Clackmannan, 88, Perth Mid., and 89, Perth East—(5) a brief statement of the habitat it frequents, and (6) a short account of its distribution in the county, with historical and bibliographical references. The following abbreviations are used:—

P.S.N.S. = Perthshire Society of Natural Science.
E.S.U.N.S. = East of Scotland Union of Naturalists' Societies.
S.N.H.A.S. = Stirling Natural History and Archæological Society.
R.P.S. = Royal Physical Society [of Edinburgh].
C.S.G.B.I. = Conchological Society of Great Britain and Ireland.
P.N.H. Mus. = Perthshire Natural History Museum.
S.N. = Scottish Naturalist.
A.S.N.H. = Annals of Scottish Natural History.
J.C. = Journal of Conchology.
Taylor, Mono. = Taylor's Monograph of the Land and Freshwater Mollusca of the British Isles.

It now only remains to record my thanks to those Conchologists, both in the district and at a distance, who have assisted me in making these notes as complete and trustworthy as possible. Some of these are with us still; others, alas! are no more. Place of honour must be given to Mr. John W. Taylor, M.Sc., F.L.S., of Leeds, who has spent a lifetime in compiling the monumental "Monograph of the Land and Freshwater Mollusca of the British Isles," which, begun in 1894, has now reached its fourth volume. Mr. Taylor has not only assisted me in identifying specimens from time to time, but has also most kindly revised the proofs of the present paper, while Mr. William Evans, of Edinburgh, has kindly done the same. To the late Mr. W. Denison Roebuck, M.Sc., F.L.S., also of Leeds, with whom I corresponded for many years, I owe much in the way of encouragement and assistance. The present Recorder of the Conchological Society, Prof. A. E. Boycott,

F.R.S., of London University, has been unfailing in his courtesy in answering enquiries regarding the Society's Census Records, and also in getting specimens authenticated for me by the Referees. He, also, has revised the proofs of the present paper. I have already referred to the assistance I have received from Messrs. Oldham, Stelfox, and Phillips in working out the *Pisidia.* Coming nearer home, I have to express my sincere thanks to Mr. E. Crapper, a comparatively recent recruit to the study, who has done a good deal of collecting around Perth, and in Perth East, and has placed all his records at my disposal. Lastly I have to thank my friend Mr. James Menzies, of Perth, who, within the last few years, has given special attention to the slugs of the district—*Limacidae* and *Arionidae*—a group which I have not worked up so thoroughly myself as I have some of the other families. Mr. Menzies, also, has allowed me to make full use of his notes.

II.—List of Species.

TESTACELLIDAE.

Testacella scutulum, Sow. (=*T. haliotidea,* Drap., var. *scutulum,* Moq.-Tand).

Brit., 47.	Scot., 5.	P.N.H.Mus.
[**Perth West.**	Perth Mid.	O.

Habitat.—Chiefly found in gardens, where it sometimes burrows deeply into the soil.

Local Distribution.—Found at the Gardens, Dunbarney House, Bridge of Earn, Perth Mid., by Mr. Davie, gardener, in April, 1917 (Scot. Nat., 1917, p. 142. Note by H. Coates. Also Jl. of Con., XVI. 101. Note by W. D. Roebuck). It was probably introduced into the gardens with plants from England, or elsewhere.

It was also found at Airthrey Gardens, near Bridge of Allan, in Perth West, by the late Mr. Gilbert M'Dougall, of Stirling, in February, 1896 (Taylor, Mono., II. 263), but the specimens were not examined and confirmed by the Referees of the Conchological Society. I have, therefore, retained the record for Perth West, but only within square brackets.

LIMACIDAE.

Limax maximus, Linné.

Brit., 144.	Scot., 36.	P.N.H.Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—In damp places, both in town and country, such as cellars, outhouses, gardens, woods, hedgerows, etc. It is found under old logs and stones, and in crevices of walls.

Local Distribution.—This handsome and finely-marked slug is fairly abundant in all parts of the county, including the district around Perth. The var. *fasciata* was taken by Mr. W. Evans at Bridge of Cally, in July, 1890; by myself at Annat Lodge, Perth (Taylor, Mono., II, 42); and by the late Mr. C. McIntosh at Inver, near Dunkeld, in September, 1904 (id., p. 266). The var. *cellaria*, sub-var. *maculata*, was got by Mr. W. Evans at Blairgowrie, in July, 1890 (id., p. 45).

L. cinereoniger, Wolf.

Brit., 64.	Scot., 13.	Wanted, P.N.H.Mus.
Perth West.	Perth Mid.	O.

Habitat.—The "Grey-black" slug frequents shady places in woods, hiding under the bark of dead trees, or among decaying leaves.

Local Distribution.—In Perth West, it was taken at Loch Ard by the late Mr. G. McDougall in April, 1897; and in Perth Mid. on Drummond Hill, near Kenmore, by Mr. W. Evans, in May, 1892 (Taylor, Mono., II, 69). It has not been recorded from Perth East, nor from any place near Perth. The var. *cinereoniger*, sub-var. *razoumowskii*, was got by the Rev. R. Godfrey at Balquhidder, in July, 1904 (id., p. 269).

L. tenellus, Müll.

Brit., 23.	Scot., 6.	Wanted, P.N.H.Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—Practically confined to woods, where it lives among decaying pine needles, etc. It is partial to fungoid growths.

Local Distribution.—This slug was lost sight of as a British species until August, 1904, when specimens found in the Forest of Rothiemurchus by the Rev. R. Godfrey were identified by the late Mr. W. D. Roebuck, then our leading authority on this group. In the following month, September, 1904, it was found in two localities in our own county, namely, at Inver, near Dunkeld, in Perth Mid., by the late Mr. C. McIntosh; and in the Clackmannan Pine Forest, Perth West, by Mr. W. Evans. (Taylor, Mono., II. 270). See also J.C., XI., 106; A.S.N.H., XIII., 221; Proc., P.S.N.S., IV., p. LI.; and A.S.N.H., XX., 123.)

In Octber, 1910, Mr. Chas. Oldham found it in abundance at Pitlochry, in Perth East, feeding on Fungi in a birch wood (J.C., XIII., 148). Most of the specimens belonged to the var. *cincta*, but a few were referable to the var. *cerea*. The specimens taken by Mr. McIntosh at Inver also included examples of the var. *cerea*. Mr. James Menzies has recently taken *L. tenellus* on fungi in Kinfauns Wood, near Perth. (Perth East.)

The known range of this species, both in the British Isles and in Europe generally, is still very limited.

L. arborum, Bouch.—Chant. (=*L. marginatus,* Müll.)

Brit., 137.	Scot., 37.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—As its name implies, this is essentially an arboreal species, being found especially on trees where there is an abundance of fungoid growths, such as the beech, ash, rowan, alder, willow, etc. It is frequently found at considerable altitudes, living on bare rocks or walls.

Local Distribution.—The tree slug has been taken in all three divisions of the county, but not in the immediate neighbourhood of Perth. In Perth West it is recorded from Bridge of Allan, Aberfoyle and Callander. In Perth Mid., it was got by myself in Glentilt, by Dr. Buchanan White on Ben Lawers, at an elevation of 3,000 feet (S.N. II., 164), and by Mr. C. McIntosh at Inver. The var. *alpestris,* was taken by Mr. W. Evans at Blairgowrie, Perth East, in July, 1890 (Taylor, Mono., II, 100).

Agriolimax agrestis (Linné). (=*Limax agrestis,* Linné.)

Brit., 153.	Scot., 41.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—In fields, gardens, hedgerows, and waste places everywhere.

Local Distribution.—This, the common field slug, is one of the few species of Mollusca which is found in every county and vice-county of England, Wales, Scotland and Ireland. There is probably hardly a field in the British Isles where it does not abound.

The var. *sylvatica* was taken by the Rev. J .E. Somerville on Loch Tay side (Proc., R.P.S., X., 448).

A. lævis (Müll.) (=*Limax lævis,* Müll.)

Brit., 105.	Scot., 28.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This, the smallest of our slugs, is found in similar situations to the last species and also in marshy places, but it is much more restricted in its range, and less abundant. It is also much more active in its habits.

Local Distribution.—In Perth West, it has been taken at the Port of Menteith, at Dollar, at Wharry Glen, near Bridge of Allan, and at Callander, by Mr. W. Evans. In Perth East Mr. Evans took it at Lawers and Fearnan, on Loch Tay side, while the Rev. R. Gordon took it in Glen Ogle, near Lochearnhead. Mr. James Menzies has taken it in more than one locality near Perth, on both sides of the Tay.

Milax sowerbyi (Férussac). (=*Limax sowerbii,* Fér., =*L. marginatus,* Jeff.)

Brit., 94.	Scot., 9.	Wanted, P.N.H. Mus.
Perth West.	O.	O.

Habitat.—This slug is of a retiring habit, passing most of its time in holes in the ground, or crevices of old walls, where many individuals congregate together. It also hides under stones and dead leaves.

Local Distribution.—This slug, which is by no means common, was taken at Inchmahome, Lake of Menteith, Perth West, by the late Mr. G. McDougall, in October, 1895 (Trans., S.N.H.A.S., 1894-95, p. 25). It has not yet been recorded from Perth Mid. or Perth East.

M. gagates (Drap.). (=*Limax gagates,* Drap., = *Amalia gagates,* Moquin Tandon.)

Brit., 87	Scot., 10.	Wanted, P.N.H. Mus.
Perth West.	O.	O.

Habitat.—Like *M. sowerbyi,* this is a shy species, hiding under the ground, except after heavy rain. It is found under decaying vegetation in gardens, at the foot of old walls and hedgerows, etc.

Local Distribution.—This slug, like the last, has been recorded from Perth West, but not from Perth Mid or East. It was found by the late Mr. G. McDougall on the south side of the Abbey Craig, Bridge of Allan, in March, 1897 (Trans., S.N.H.A.S., 1897-98, p. 138). The var. *rava* was found in a garden at Callander by Mr. W. Evans, in September, 1906 (A.S.N.H., 1906, p. 241).

ZONITIDAE.

Vitrina pellucida (Müll.)

Brit., 148.	Scot., 39.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—To be found everywhere, in damp places, under stones and leaves, among decaying vegetable matter, moss, etc.

Local Distribution.—This is one of the most abundant, as well as one of the most beautiful, of our land shells. It is found in every part of the county, and in nearly every county of Scotland. It reaches a height of 1,750 feet in Glen Tilt, and 3,000 feet on Craig Calleagh. Mr. Frank F. Laidlaw reports that it has been found at heights of from 2,500 to 3,800 feet on Ben Lawers (J.C., XII., 192).

Hyalinia crystallina (Müll.) (=*Zonites crystallinus,* Gray.)

Brit., 147.	Scot., 38.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This is a shy species, keeping out of sight, under stones and among roots of mosses, in moist and sheltered situations.

Local Distribution.—This beautiful little shell, which well merits its specific name, is found in practically every part of the county. The var. *contracta* has been taken by Mr. W. Evans in the Pass of Leny, near Callander, Perth West (Taylor, Mono., III., 114).

Dr. Buchanan White found this species in Glen Tilt at an altitude of 1,750 feet, in 1878.

Hyalinia lucida (Drap.). (=*H. draparnaldi,* Weinland.)

Brit., 56.	Scot., 9.	P.N.H. Mus.
O.	Perth Mid.	Perth East.

Habitat.—Generally found in colonies, in moist and sheltered situations, in gardens, woods and waste grounds. During the heat of the day, and in dry weather, it hides under stones, or in crevices of rocks and walls.

Local Distribution.—This species was not recognised as one of our local mollusks until April, 1909, when it was taken by Mr. Fred. Smith, Jun., in Messrs. Dickson and Turnbull's Nurseries, Perth, in Perth East. In August of the same year it was taken by Mr. Jas. Leslie at Aberfeldy, in Perth Mid. (Proc., P.S.NS., vol. V. pp. XXI. and LIX.). It has also been taken by Mr. Jas. Menzies at Perth Harbour, on the right bank of the Tay, in Perth Mid.

It is possible that this shell, which is the handsomest of the *Zonitidae,* may previously have been mistaken for *H. cellaria,* which it resembles in some respects. It should be looked for in other districts of the county.

H. cellaria (Müll.). (=*Zonites cellarius,* Jeff.)

Brit., 152.	Scot., 40.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This mollusk, as its specific name implies, has a partiality for cellars, and damp dark outhouses, but it is also found under stones and logs in hedgerows, banks, and waste places generally.

Local Distribution.—This species, which is the most widely distributed of our *Zonitidae,* is found not only in every part of our county, but in every county and vice-county of Great Britain and Ireland, with the exception of Sutherland West (No. 108). The largest specimens I have taken in Perthshire were under stones on a grassy bank between the Lade and the River Tay above Stormontfield, where the ground is always kept more or less moist by the two streams.

The vars. *compacta* and *complanata* were taken by the late Dr. Buchanan White near Perth (S.N., 1873, II., 165).

[*H. helvetica*, Blum. (=*Zonites glabra*, Jeff.)]

Brit., 69.	Scot., 10.	Wanted, P.N.H. Mus.
[Perth West.]	O.	O.

Habitat.—" Inhabits, by preference, very shady and almost gloomy woods and thickets " (Taylor, Mono., II., 49).

Local Distribution.—This rare Hyalinia was recorded for Perth West by the late Mr. G. McDougall, under the following circumstances. Mr. Scott, of the High School, Stirling, discovered nine specimens amongst some *Sphagnum* which was covering a flower pot in the school. On enquiry it was found that the janitor had got the *Sphagnum* from a friend in Alva, who had gathered it in the wood at Brucefield, near Dollar, in Perth West. (Trans., S.N.H.A.S., 1895-96, p. 141.) On this somewhat slender evidence, Mr. Taylor admits the vice-comital record in his " Monograph," but it is not included in Roebuck's Census of June, 1921. As the record seems of doubtful value, I have only retained it in the present list within square brackets.

Hyalinia alliaria (Miller). (=*Zonites alliarius*, Miller.)

Brit., 148.	Scot., 41.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—Under stones, on banks, and in shady places.

Local Distribution.—This species, the " Garlic Snail," is widely distributed, but not so abundant as *H. cellaria*. It is found in all parts of the county, but more commonly in the Highland than in the Lowland districts.

The var. *viridula* was taken on Abbey Craig, Bridge of Allan, Perth West, by the late Mr. G. McDougall (Trans., S.N.H.A.S., 1895-96, p. 141).

H. nitidula (Drap.). (=*Zonites nitidulus*, Gray.)

Brit., 147.	Scot., 36.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—Under stones and logs, in moist and shady places. Also among moss and decaying leaves in woods and hedgerows.

Local Distribution.—This species is widely distributed in the county, and occurs nearly everywhere, if a suitable habitat is to be found.

Dr. Buchanan White found the var. *nitens* " more common than the type, and frequenting drier places " (S.N., II., 165).

R. Rimmer states that the Rev. J. McMurtrie had informed him that in Perthshire he had found specimens of *H. nitidula* which emitted a strong smell of garlic (L. and F.-W. Shells of the British Isles, p. 102).

H. pura (Ald.). (=*Zonites purus*, Moq.-Tand.)

Brit., 137.	Scot., 33.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—In moist shady places, beneath decaying trees, among moss, leaves, etc.

Local Distribution.—Widely distributed in both the Highland and Lowland districts of the county.

This species occurs both of a pale horn colour, and of a pearly white. J. Gwynn Jeffreys considered the former to be the type, and named the white form var. *margaritacea*. J. W. Taylor, on the other hand, considers the white form to be the type, and the horn-coloured form a variation. On the whole, I prefer to adhere to Jeffrey's view. Dr. Buchanan White says, "The var. *margaritacea* seems to be commoner than the typical form" (S.N., II., 165). In my experience the same is true as regards Perthshire. I have taken the white form in several localities both in Perth Mid. and Perth East. The late Mr. G. McDougall took it on Abbey Craig, Bridge of Allan, in Perth East (Trans., S.N.H.A.S., 1895-96, p. 141).

H. radiatula (Alder). (=*Zonites radiatulus*, Gray.)

Brit., 142.	Scot., 35.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This is a moisture-loving species. It is found in damp pastures and woods, among moss and grass, and under stones and decaying logs.

Local Distribution.—It is widely distributed, but by no means common in the county. I have taken it in the immediate neighbourhood of Perth, on Kinnoull Hill, at Stormontfield, and Pitlochry, in Perth East; and at Birnam and Forgandenny, in Perth Mid. In Perth West it was got at Callander, Bridge of Allan, Pass of Leny, and Braendam.

The var. *viridula* was got by the Rev. R. Godfrey at Crieff, Perth Mid., in June, 1904; and the var. *viridula*, sub-var. *viridicenti-alba*, at Strathyre, Perth West, by Mr. W. Evans (Taylor Mono., III., 94).

Euconulus fulvus (Müll.). (=*Zonites fulvus*, Müll.)

Brit., 143.	Scot., 39.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—In damp shady woods and moist pastures, under rotten branches and logs, or amongst moss. Under stones in quarries, hedgerows, etc.

Local Distribution.—Widely distributed in suitable localities throughout the county. I have taken it in each of the three vice-counties, and have also taken the var. *mortoni* on Kinnoull Hill, Perth East.

Zonitoides nitidus (Müll.). (=*Zonites nitidus,* Müll.)

Brit., 112.	Scot., 15.	Wanted, P.N.H. Mus.
Perth West.	O	Perth East.

Habitat.—In wet shady places, under stones, and at the roots of grass and other herbage. It is especially partial to the roots of aquatic grasses at the margins of ponds and watercourses.

Local Distribution.—This is nowhere a common species, and in Perthshire it is rare. It has been taken by Mr. W. Evans at Butterstone Loch, near Dunkeld, Perth East (Proc., R.P.S., X., 438). This is just the sort of place where it would be likely to be found. It was also gathered by the late Mr. G. McDougall about ditches at Cornton, in Perth West (Trans., S.N.H.A.S., 1894-95, p. 26).

Z. excavatus (Bean). (=*Zonites excavatus,* Bean.)

Brit., 67.	Scot., 15.	Wanted, P.N.H. Mus.
Perth West.	Perth Mid.	o.

Habitat.—In damp shady woods, under stones and decaying timber. Unlike most species of land mollusca, it is not specially partial to calcareous soils.

Local Distribution.—This is one of the rarer species of the *Zonitidae,* and is very limited in its range of distribution. In Perthshire it has been taken in three localities only. In Perth West it was got by Mr. W. Evans at Strathyre, near Callander, and by the late Mr. G. McDougall at the foot of Loch Ard, in April, 1897 (Trans., S.N.H.A.S., 1897-98, p. 138). In Perth West it was also taken by Mr. W. Evans at Achtoo, near Balquhidder, in 1902 (Taylor, Mono., III., 139). In Perth Mid. it was got by Mr. W. Evans at Fearnan in April, 1892. It has not yet been recorded from Perth East.

I have not taken either this or the preceding species myself, and there is no representative of either in the Perthshire Natural History Museum.

ARIONIDAE.

Arion ater (Linné).

Brit., 151.	Scot., 41.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—The common Black Slug is very widely distributed, in both wild and cultivated places, such as kitchen gardens, damp and shady woods, thickets, road-side hedges, wells, etc. Except on very dull days, it usually hides under cover during the day, only showing itself after a heavy shower of rain, or at dusk or night. It attains a higher altitude than any of the other slugs, being found near the summit of some of our highest mountains.

Local Distribution.—Found in every part of the county, and at all elevations. The late Dr. Buchanan White took it on Ben Lawers at an altitude of about 3,000 feet (M.S. note in his interleaved copy of Lovell Reeve's " Mollusca "). In dry seasons it keeps out of sight, but after a shower of rain it comes out in abundance, when numbers may be seen crossing the wet country roads.

The var. *aterrima* was taken by Mr. W. Evans, in September, 1902, on the summit of Ben Vorlich, Perth West (3224 feet); and also by Mr. A. Somerville at Callander, in the same vice-county, in April, 1888 (Taylor, Mono., II., 176). The var. *pallescens* was found by the late Mr. G. McDougall, beside his own house near Stirling, in Perth West (Trans., S.N.H.A.S., 1894-95, p. 25).

A. subfuscus (Drap.). (=*A. flavus,* Pollon.)

Brit., 132.	Scot., 35.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This is a widely distributed slug, but it is never very abundant. It is particularly partial to fungi, such as *Rusula fuscata* and *Agaricus muscarius,* and is thus generally to be found in woods where these and similar fungi occur.

Local Distribution.—This slug is widely distributed throughout the county, especially in woods where fungi are plentiful in autumn. It is found in waste places, both in the Highland and Lowland districts, but not often in gardens. It is fairly common around Perth, on both sides of the Tay.

The var. *cinereo-fusca* was got in Glen Ogle, Lochearnhead, Perth Mid., by the Rev. R. Godfrey, in June, 1904; and by the side of the Dunkeld Road, Perth, Perth Mid., by Mr. W. Evans, in September, 1904 (Taylor, Mono., II., 207). He also got the var. *fuliginea,* sub-var. *brunnea* in the same locality (id., p. 199). The vars. *succinea* and *fuliginea* were got at Pitlochry, Perth East, in 1910, by Mr. Chas. Oldham (J.C., XIII., 148).

A. minimus, Simroth. (=*A. intermedius,* Normand.)

Brit., 133.	Scot., 33.	Wanted, P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This is not a garden slug. It seems to prefer open country to cultivated ground. It is a fungivorous species and is found in damp woods, hedgebanks, etc. It is widely distributed, and is said to be common everywhere.

Local Distribution.—This small slug is widely distributed in the county, but does not appear to be very plentiful. Possibly it has been overlooked in many localities, or mistaken for the young of other species. It has been recorded from Callander, Aberfoyle, Dollar, and Bridge of Allan, in Perth, West, and from Ben Lawers and Glen Ogle, in Perth Mid. (Taylor, Mono., II., 248). In Perth East, Mr. W. Evans found it at Persie Inn, Glenshee (Proc., R.P.S., X., 445). Mr. Menzies has not taken it in the neighbourhood of Perth.

A. hortensis, Férussac.

Brit., 150.	Scot., 38.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This, as its name implies, is essentially a garden slug, although it is sometimes found in wild places, such as damp hedgerows, woods, and meadows. It prefers a heavy soil, and is found beneath logs and stones. It is widely distributed, and by no means uncommon.

Local Distribution.—The Garden Arion is found in most parts of the county. It has been recorded from Callander, Dollar, Abbey Craig (Bridge of Allan), and Balquhidder, in Perth West; from Glen Tilt, Glen Ogle, and Inver, in Perth Mid., and from Glen Shee, in Perth East (Taylor, Mono., II., 224).

This slug, which is easily identified by the yellow sole of the foot, is fairly common around Perth, on both sides of the Tay.

A. circumscriptus, Johnston. (=*A. bourguignati,* Mabille.)

Brit., 145.	Scot., 41.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This slug is widely distributed, being found like *A. ater,* in every vice-county of Scotland, and nearly every vice-county of England and Ireland. It is not a garden species, but is found more generally in woods, open fields, and cultivated grounds, on decaying tree trunks, under fallen leaves, and in the stem and cap of large mushrooms and other fungi.

Local Distribution.—This slug is common in most parts of the county, in woods, and waste places generally. It is abundant around Perth, on both sides of the river. It has been recorded from all three divisions of the county, both in their Highland and their Lowland areas.

HELICIDAE.

Punctum pygmæum (Drap.). (=*Helix pygmaea,* Drap.)

Brit., 127.	Scot., 30.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This tiny shell is found in moist and shady woods and other damp situtations, hiding under stones, amongst decaying leaves and moss, or at the roots of grass and rushes.

Local Distribution.—It is widely distributed throughout the county, but not very abundant. In Perth West it was got by Mr. W. Evans, in the Pass of Leny, near Callander (Proc., R.P.S., X., 473). I have taken it at several localities in Perth Mid. and Perth East, especially in the Highland districts. It may be collected in the same way as recommended for *Acanthinula lamellata* below.

Pyramidula rupestris (Drap.). (=*Helix rupestris,* Drap.)

Brit., 84.	Scot., 4.	P.N.H. Mus.
O.	**Perth Mid.**	Perth East.

Habitat.—This little snail, as its name implies, is to be found on old walls, ruins, or rocks, frequently in bare and bleak situations, exposed to the sun. It reaches considerable elevations on mountain slopes, where it may be found among the debris of the rocks.

Local Distribution.—I have taken this interesting little shell on Kinnoull Hill, in Perth East. It has also been taken in two localities in Perth Mid., although these were not recorded in Roebuck's Census of June, 1921. In June, 1908, Mr. Fred. Smith, Jun., took it on some rocks by the Edinburgh Road, near Perth, and in August, 1909, Mr. Jas. Leslie got it near Aberfeldy. The specimens have now been authenticated by the Recorder and Referees of the Conchological Society. It had previously been taken on Moncreiffe Hill, also in Perth Mid., by the late Mr. J. Dawson (Proc., P.S.N.S., 1869-70, p. 18).

P. rotundata (Müll.). (=*Helix rotundata,* Müll.)

Brit., 151.	Scot., 40.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This is the most abundant of all the Helicidae, and is practically ubiquitous as regards its habitat. It is found in damp places everywhere, under stones and logs, under the bark of old trees, and on rocks and walls.

Local Distribution.—This little snail is abundant everywhere in the county. I have taken it in all three vice-counties, and found it equally abundant in the Highlands and in the Lowlands. I have taken the var. *alba* near Clunie Bridge, Pitlochry, in Perth Mid., and the var. *pyramidalis* in Quarry Mill Den, near Perth, in Perth East. The var. *alba* was also got by the late Mr. G. McDougall at Cornton, near Bridge of Allan, in Perth West, in May, 1897 (Trans., S.N.H.A.S., 1897-98, p. 138).

Helicella virgata (Da Costa). (=*Helix virgata,* Mont.)

Brit., 94.	Scot., 3.	P.N.H. Mus.
Perth West.	O.	O.

Habitat.—This is essentially a maritime species, never found far from the sea coast. It is very gregarious, and is frequently found in large numbers on grassy downs, heaths, and sand-dunes.

Local Distribution.—The claim of this mollusk to be regarded as a Perthshire species rests on a somewhat slender basis. One specimen was found by the late Dr. Buchanan White near Kincardine-on-Forth, in August, 1890. The locality was, at that date, in Perthshire, but it was shortly afterwards transferred to Fifeshire by the Boundary Commissioners. The specimen is now preserved in the Perthshire Natural History Museum. (See S.N., XI., 126.)

In June, 1901, Mr. W. Evans found some more specimens of *H. virgata* on some old ballast heaps near the same locality (A.S.N.H., X., 183). By this time, however, the boundary had been changed, so that Fifeshire now claims this more recent discovery. The position is surely a unique one, with two Faunal Counties each claiming the same species, got in the same locality, but at different dates!

Ashfordia granulata (Alder). (=*Helix sericea,* Jeffreys.)

Brit., 74.	Scot., 18.	Wanted, P.N.H. Mus.
O.	O.	Perth East.

Habitat.—This is essentially a moisture-loving snail, being found on damp mossy banks, moist woods, and banks of streams.

Local Distribution.—This species is fairly common in many parts of England, but is rare in Scotland. Only a single specimen has been taken in Perthshire, that one having been taken by Mrs. Carphin at Dunkeld, in Perth East, about 1892 (A.S.N.H., II., 167). After Mrs. Carphin's death, her collection of shells was acquired by the governing body of University College, Dundee, for their Natural History Museum, but I do not know whether this specimen was amongst them.

Hygromia fusca (Mont.). (=*Helix fusca*, Mont.)

Brit., 86.	Scot., 26.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This fragile shell is more partial to the northern than to the southern portion of the United Kingdom. It loves deep shady glens, such as are to be found in our Highlands, where there is an abundance of moisture. There it may be found crawling amongst the rank vegetation, such as grasses, rushes, nettles, brambles, ferns, etc. It may frequently be captured by sweeping such herbaceous growths with an entomologist's net.

Local Distribution.—This species is decidedly local in the county, and nowhere abundant. I have taken it at Ardoch, in Perth West, and Pitlochry, in Perth Mid. Mr. Fred. Smith, Jun., found it at Kinfauns, and Pitroddie Den, in Perth East. Mr. Evans collected it in two localities near Callander, and in Wharry Glen.

H. hispida (Linné). (=*Helix hispida*, Linné.)

Brit., 137.	Scot., 26.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This, the Hairy Snail, is another abundant and nearly ubiquitous species, except in the North of Scotland, beyond the Grampians. It is found in both wild and cultivated places, under stones and logs, among moss and decaying vegation, in woods, gardens, hedges, and rural places generally.

Local Distribution.—This species, which now includes the *Helix concinna* of Jeffreys, is abundant everywhere, in each division of the county, and in the Highlands equally with the Lowlands. I have taken the var. *albida* at Perth, and the var. *subglobosa* at Pitlochry. The var. *subrufa* was got by the late Dr. Buchanan White on Kinnoull Hill. The vars. *albo-cincta, hispidosa, nitidula* and *albida* were got by the late Mr. G. McDougall near Bridge of Allan (Trans., S.N.H.A.S., 1895-96).

H. striolata (C. Pfr.). (=*Helix rufescens,* Mont.)

Brit., 123.	Scot., 15.	P.N.H. Mus.
Perth West.	**Perth Mid.**	Perth East.

Habitat.—This species, which is common in England, but rare in Scotland, frequents the same kind of haunts as the preceding species, to which it is closely allied. It is also found among rank grass, nettles and brambles.

Local Distribution.—This snail was unknown as a Perthshire species until 1894, when the late Mr. G. McDougall discovered it in two or three localities around Bridge of Allan, in Perth West (Trans., S.N.H.A.S., 1894-95, p. 26). In January, 1907, the late Mr. W. Wyllie, Jun., discovered it in his father's garden, which runs down to the River Tay, in Commercial Street, Bridgend, Perth (Perth East). In October of the following year it was found by Mr. Fred. Smith, Jun., in Kinnoull School Quarry, Perth (Perth East). Finally, in August, 1910, it was taken by another young collecter, Mr. Jas. Leslie, at Aberfeldy, in Perth Mid., thus completing the records for the three vice-counties. (See Proc., P.S.N.S., vol. V., pp. VII. and X.) This last find, in Perth Mid., was not recorded in Roebuck's Census of June, 1921, but the specimen has now been authenticated by the Recorder and Referees of the Conchological Society.

In passing, it may be mentioned that some of the best work in investigating the Mollusca of the county has been done by some of our enthusiastic junior naturalists.

Acanthinula aculeata (Müll.). (=*Helix aculeata,* Müll.)

Brit., 120.	Scot., 24.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This beautiful little shell, which is distinguished by its crown of spines, is found among small stones and dead leaves in moist woods, hedge-banks, and waste places generally.

Local Distribution.—This species is fairly plentiful in the county, in suitable situations. I have taken it on Kinnoull Hill, in Perth East, and at Pitlochry, in Perth Mid., as well as other localities. In Perth West, it was taken by Mr. W. Evans in the vicinity of Bridge of Allan (A.S.N.H., III., 156).

A. lamellata (Jeffreys). (=*Helix lamellata,* Jeffr.)

Brit., 56.	Scot., 19.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This is a northern and rather local species. The best description of its habitat I have seen is that by the late Dr. Buchanan White in the "Scottish Naturalist," vol. II., p. 167, written just fifty years ago—"In wooded Highland glens, where I have found it at an elevation of 1,200 feet. It inhabits woods, especially of birch, living amongst dead leaves, especially the decaying fronds of the softer ferns, such as *Aspidium oreopteris,* and the Lady Fern.

In the same article he recommends, as the best method of collecting this and similar small species, to gather a quantity of the dead and decaying fronds of such ferns, as well as dead leaves generally, take them home in a bag, and spread them out on sheets of paper on the floor. When the leaves, etc., are quite dry, a rich harvest of minute shells may sometimes be reaped.

Local Distribution.—This beautiful little shell was first taken in the county by the late Dr. Buchanan White, who discovered it on Birnam Hill, Perth Mid., in May, 1870. (Proc., P.S.N.S., for 1869-70, p. 99.) I have since taken it in the same locality, and also at Craighall, near Blairgowrie, in Perth East. In Perth Mid. it was also taken at Aberfeldy, by Mr. Jas. Leslie, and at Drummond Hill, near Kenmore, by Mr. W. Evans (A.S.N.H., I., 235). In Perth West it was got by the late Mr. G. McDougall, near Bridge of Allan (Trans., S.N.H.A.S., 1897-98, p. 138), and by Mr. W. Evans in Keltie Ravine, near Callander, in April, 1892. In the county it is decidedly local.

Vallonia pulchella (Müller). (=*Helix pulchella,* Müll.)

Brit., 134.	Scot., 18.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This little shell, which is well named "Beautiful," is generally found in open exposed waste places, rather than in woods. It takes refuge under stones and logs of wood, in old walls, and among the roots of grass and other herbage.

Local Distribution.—This is another very local species. I have taken it on Kinnoull Hill, in Perth East, and it has also been taken by Mr. Fred. Smith, Jun., at Callerfountain, near Perth, in Perth Mid. In Perth West it was found by the late Mr. G. McDougall among boulders on Abbey Craig, near Bridge of Allan (Trans., S.N.H.A.S., 1894-95, p. 26).

V. costata (Müll.). (=*Helix pulchella,* Müll., *var. costata.)*

Brit., 88.	Scot., 9.	P.N.H. Mus.
O.	Perth Mid.	Perth East.

Habitat.—The same as for *V. pulchella*, with which it is probably equally widely distributed, although it has not been differentiated for a sufficent length of time for the distribution to be fully recorded.

Local Distribution.—Until quite recently, this species was regarded as a variety of *V. pulchella,* distinguished by the transverse raised ridges on the shell. Even yet its position is not determined beyond all doubt. I have taken it on Kinnoull Hill, in Perth East, and also at Birnam, in Perth Mid.

Arianta arbustorum (Linné). (=*Helix arbustorum,* L.)

Brit., 113.	Scot., 39.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This handsome snail is, as its name implies, partial to copses and shady thickets. It is found at higher altitudes than any other of our larger species, reaching almost to the snow-line in the Alps. In our own country it occurs at all elevations, from sea level up to about 4,000 feet, or the limit of maximum glaciation in central Scotland.

Local Distribution.—This snail is not so widely distributed in the county as *Helix nemoralis,* but it is fairly abundant where it does occur, especially in the Highland districts. I have taken it in all three vice-counties. It reaches considerable elevations on our mountains. I have taken it on the shoulders of Ben Vrackie, above Pitlochry; Dr. Buchanan White found it abundant in Glen Tilt, on limestone rocks, up to a height of 1,600 feet (J.C., III., pp. 241 and 302); the late Mr. A. M. Rodger found it on Ben Lui at 2,000 feet; and Mr. Frank F. Laidlaw took it on Ben Lawers at heights varying from 2,500 to 3,800 feet (J.C., XII., 192—"Shells at High Altitudes in Scotland").

Four varieties of this species have been taken in the county. The dwarf or alpine form, var. *alpicola,* formerly known as *alpestris,*—is the one most commonly met with at high altitudes. In June, 1875, I found it abundant on the banks of the Craigeour Burn, above Moulin, Pitlochry (Perth East), at 500-600 feet (S.N. III., 160). It is also common in Glen Tilt, where it occurs in company with the var. *flavescens,* of a pale yellow colour (Proc., P.S.N.S., 1881-86, p. 215). The var. *flavescens* was also taken at Kenmore, Perth Mid., by Mr. T. Scott, F.L.S. (Proc., R.P.S., X., 466). The var. *picea,* sub-var. *fusca,* was found on Ben More, in Perth West, by Rev. W. C. Hey (Taylor, Mono., III., 432). Lastly, the var. *rudis* was got at Pitroddie Den, in Perth East, by Mr. Fred. Smith, Jun., (id., p. 431.)

Helix aspersa, Müller.

Brit., 138.	Scot., 30.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This, the " Common Garden Snail "of the South of England, is by no means common in Scotland, where it is seldom met with in gardens. In Scotland, indeed, it is chiefly confined to the vicinity of the sea coast, although it sometimes occurs at inland stations. It frequents woods, hedges, waste spaces, and cultivated ground around houses, and is especially partial to old ivy-covered walls and rocks.

Local Distribution.—This, the largest of the Scottish *Helicidae,* occurs only very sparingly in Perthshire. I have taken it on Kinnoull Hill, and also on the ivy-hung rocks by the Dundee Road, near Barnhill, where it has been long established It has also been taken at more than one spot at Craigie, another suburb of Perth on the opposite side of the river Tay (Proc., P.S.N.S., vol. V., p. LIX.) Other localities from which it has been reported are Methven and Madderty, in Perth Mid., where it was got by Mr. Jas. Leslie; Longforgan and Invergowrie, in Perth East, where the late Dr. Buchanan White found it (S.N., VIII., 40); Blairgowrie, also in Perth East, where it was taken by Mr. W. Evans (Proc., R.P.S., X., 462); and Remony, near Loch Tay, where it was got by the late Mr. Duncan Dewar (Proc., P.S.N.S., 1881-86, p. 216). In Perth West it was taken by the late Mr. G. McDougall near Bridge of Allan (Trans., S.N.H.A.S., 1895-96, p. 142).

None of the varieties of *H. aspersa* have been recorded from Perthshire, although as a rule it is a very variable species.

H. nemoralis, Linné.

Brit., 138.	Scot., 28.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This beautiful banded snail derives its specific name from its partiality to groves and woodlands. It has a wide distribution, being found in gardens, woods, hedgebanks, fields, cliffs, quarries, etc., throughout Britain, except in the extreme North of Scotland. Like the last species, it is fond of ivy-covered walls and rocks.

Local Distribution.—This snail, with its conspicuous shell, is widely distributed and fairly abundant in all parts of the county. It is one of the most variable of the *Helicidae*, both as regards the shape and size of the shell, and its colouring and ornamentation. A number of these variations have been recorded from the county, and others could no doubt be added to the list, were a more careful search made with this object in view. The following are some of the more noticeable forms:—

Var. *minor*. This small form was got at Balgowan by the late Dr. Buchanan White, who remarked that it seemed to pass gradually into *hortensis* (S.N., 1873, II., 166). In these days, however, the distinction between the two species was not so well understood as it is now. The same variety was also taken at Bridgeton, near Almondbank, by the late Mr. H. Wilkie.

Var. *fasciata*, sub-var. *cincta*, is a common form. It has been taken in the vicinity of Perth, at Balgowan, Almondbank, and other places.

Var. *libellula*, sub-var. *flava* (yellow, self-coloured), is also fairly common. It has been taken at the same localities as the last variety, as well as several localities in Perth West.

Var. *castanea*. This variety, which is of a chestnut self-colour, is not quite so common as the last. It has been taken in the same localities.

Var. *rubella*. This beautiful rose-coloured variety has been recorded from Balgowan, Blairgowrie, Dunkeld, and Birnam (Taylor, Mono., III., 305); also from the Pass of Leny, near Callander, and Drummond Hill, near Kenmore (A.S.N.H., I., 236).

Var. *hyalozonata*. This somewhat rare variety, with translucent bandings, was got by the late Mr. J. Dawson at Balgowan, in 1869.

Var. *olivacea*. This is also a rare variety, of a deep olive brown tint, with a shade of violet inside. One specimen was got by the late Mr. G. McDougall at Parkhead, Airthrey, near Bridge of Allan, in Perth West, in 1895. In the district around Bridge of Allan Mr. McDougall also got the varieties *rubella, castanea,* and *libellula* (Trans., S.N.H.A.S., 1895-96, p. 141).

[For further remarks on the banding of *H. nemoralis* and *H. hortensis* in Perthshire, see a paper on this subject by the present writer in the Proceedings of the P.S.N.S., 1881-86, p. 145.]

H. hortensis, Müller. (=*H. nemoralis, L.,* var. *hortensis.*)

Brit., 126.	Scot., 36.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This, the "Garden Snail" proper, was formerly looked upon as a variety of the last species, which it closely resembles, but more careful anatomical examination has revealed specific differences, in addition to the colour of the lip. It is a more northern species, extending into the Orkney and Shetland Islands. Its habitat is similar to that of *H. nemoralis.* Both species are gregarious, being generally found in considerable colonies.

Local Distribution.—This species, like the last, is found in all parts of the county, but it is rather more abundant in the Highland than in the Lowland districts, whereas the reverse is the case with regard to *H. nemoralis.* The two species are subject to nearly the same variations of size, shape, colour, and banding. The following are the principal varieties of *hortensis* recorded for the county :—

Var. *minor*, a small form, got at Inchture and Balgowan.

Var. *alba,* with a white shell. This rather scarce variety was found by the side of the Edinburgh Road, Perth (Perth Mid.), in April, 1909, by Mr. Fred. Smith, Jun.

Var. *lutea*—yellow, self-coloured. This form is fairly common. It has been taken at Balgowan and Almondbank; also in Glen Tilt, where Dr. Buchanan White found it at an elevation of 1,600 feet. It was also found in abundance on Abbey Craig, Bridge of Allan, by Mr. G. McDougall (Trans., S.N.H.A.S., 1895-96, p. 141).

Var. *trochoidea*, sub-var. *conica.* This variety, which, as its name implies, has the spire raised more than usual, was taken by Mr. John Mason at Inchture, Perth East, in 1901.

Var. *arenicola (=hyalozonata),* with translucent banding. This rather scarce variety was found by Mr. Fred. Smith, Jun., by the side of the Edinburgh Road, Perth, in company with the var. *alba,* already referred to.

Var. *roseozonata (vinosofasciata,* Coates), shell with rose-coloured bands. I took this beautiful variety at Balgowan, Perth Mid., in 1884 (Taylor Mono., III., 353).

BULIMINIDAE.

Ena obscura (Müll.). (=*Bulimus obscurus*, Müll.).

Brit., 99.	Scot., 16.	P.N.H. Mus.
O.	Perth Mid.	Perth East.

Habitat.—This species is somewhat restricted in its distribution, but not uncommon where it does occur, in Scotland. It is confined to the Eastern Counties, as far north as the Moray Firth. It is found in moist and shady places, among heaps of stones, on rocks, old walls, trunks of trees, etc.

Local Distribution.—This interesting little mollusk is fairly abundant in East and Mid. Perth, especially in the Highland districts, but it has not yet been recorded from Perth West. I in Quarry Mill Den, and around Pitlochry. Dr. Buchanan White have found it fairly plentiful on Kinnoull and Moncreiffe Hills, took it at Forest Lodge, Glen Tilt, at an elevation of 1,000 feet.

STENOGYRIDAE.

Cochlicopa lubrica (Müll.). (=*Zua lubrica,* Müll.).

Brit., 153.	Scot., 41.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This species is almost ubiquitous, being found in both wet and dry places, under stones, and among decaying leaves and moss, and the roots of grass, in woods, fields, hedges, gardens, etc.

Local Distribution.—This is one of the commonest and most widely distributed mollusks in our county. I have taken it in all three vice-counties. The var. *lubricoides* was said by Dr. Buchanan White to be not uncommon near Perth (S.N., II., 169). It was also taken by the Rev. J. E. Somerville at Kenmore (Proc., R.P.S., X., 482). The var. *hyalina* was got by Mr. Ponsonby near Loch Rannoch (R. Rimmer, L. and F.-W Shells of the Brit. Isles, 1880, p. 182).

Azeca tridens (Pult.).

Brit., 52.	Scot., 1.	Wanted, P.N.H. Mus.
Perth West.	O.	O.

Habitat.—A very local species, found in damp woods and hedgerows, among moss and dead leaves.

Local Distribution.—Perthshire boasts the only Scottish station for this rare mollusk. This is a spot near Bridge of Allan, in Perth West, where it was first found by Mr. Foulis in 1868, as recorded by Mr. John Young, of the Hunterian Museum, Glasgow, in the Proceedings of the Natural History Society of Glasgow, 1869, vol. I., p. 240. It was then lost sight of for a number of years, but was re-discovered by Mr. McLellan, of Stirling, in April, 1896, in Wharry Glen, Bridge of Allan,which is possibly a slightly different locality from Mr. Foulis' original station. The specimens were authenticated by the Recorder of the Conchological Society. (See Trans., S.N.H.A.S., 1895-96, p. 140.) Then, in February, 1898, it was again got on a mossy bank near Bridge of Allan in some numbers by Mr. W. Evans, who states that he hunted it up independently (A.S.N.H., 1898, vol. VII., p. 186).

The specimens got by Mr. Foulis in 1868 were said to belong to the variety *nouletiana*. Of the specimens got by Mr. McLellan in 1896, one was found to belong to the variety *crystallina*.

The Scottish record of *Azeca tridens* was inadvertantly omitted from W. D. Roebuck's Census of June, 1921. This omission was rectified by Prof. A. E. Boycott, the Recorder of the Conchological Society, in the Journal of Conchology, vol. XVI., p. 274.

PUPIDAE.

Pupa umbilicata, Drap. (=*P. cylindracea*, Da Costa.)

Brit., 151.	Scot., 40.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This little mollusk is just about as widely distributed and as common as *Cochlicopa lubrica*, and is found in similar situations. It is especially fond of hiding in crevices of rocks, among the moss on old walls, and under the bark of trees.

Local Distribution.—This is the most abundant of the *Pupidae* in the county. I have taken it in all three vice-counties. The var. *albina*, which has a whitish shell, was found by Mr. McDougall on the front of Abbey Craig, Bridge of Allan, in 1894 (Trans., S.N.H.A.S., 1894-95, p. 26). The var. *edentula*, I took on Kinnoull Hill in 1880.

[The late Dr. Buchanan White informed me that he had taken *P. marginata*, Drap. (=*P. muscorum*, Linné) on Kinnoull Hill, in Perth East (Proc., P.S.N.S., 1881-86, p. 75); but as the specimens do not seem to have been preserved I have not included it in the present list.]

Pupa anglica, Férussac. (=*P. ringens*, Jeffreys.)

Brit., 78.	Scot., 21.	Wanted, P.N.H. Mus.
Perth West.	Perth Mid.	O.

Habitat.—This species is always found in damp situations, frequently by the side of streams, or in marshes. It lives under stones and among moss and dead leaves. It is by no means common, although fairly widely distributed.

Local Distribution.—This rare and local Pupa was got by Mr. W. Evans on Drummond Hill, near Kenmore, Perth Mid., in May, 1892 (A.S.N.H., I., 237). It has also been recorded from Perth West, where it was got by Mr. W. Evans at Achtoo, near Balquhidder, in September, 1902 (Census Books). It has not yet been got in Perth East.

Vertigo antivertigo (Drap.).

Brit. 89.	Scot., 12.	P.N.H. Mus.
Perth West.	O.	Perth East.

Habitat.—This is another marsh-loving species It is restricted in its distribution, and is by no means common. It may sometimes be found on water flags and other aquatic plants, in marshes and by the side of streams.

Local Distribution.—This rather rare shell was first taken by Dr. Buchanan White in Quarry Mill Den in 1870 (Proc., P.S.N.S., 1869-70, p. 77). Ten years later I found it still flourishing in the same locality, and in the following year I took it on Kinnoull Hill. Then, in April, 1896, Mr. W. Evans found a good many in the Pass of Aberfoyle, Perth West (A.S.N.H., 1898, VII., 185). This last discovery was not recorded in Roebuck's Census of June, 1921, but Prof. Boycott, F.R.S., the Recorder of the Conchological Society writes to me under date February, 17, 1922, that the record is presumably correct. Mr. Evans informs me, however, that the specimens were verified by Mr. J. W. Taylor at the time.

V. substriata (Jeffreys).

Brit., 71.	Scot., 18.	Wanted, P.N.H. Mus.
Perth West.	Perth Mid.	O.

Habitat.—This species also frequents moist places, under stones, among decaying leaves and ferns, and at the roots of grass and rushes. It is met with in Highland glens, where it may sometimes be captured by sweeping the rank herbage with a butterfly net.

Local Distribution.—This rather scarce species is recorded from two localities in Perth West—in April, 1892, it was found on the banks of the Keltie, near Callander, by Mr. W. Evans (A.S.N.H., II., 166) and also at Aberfoyle; and in 1894 it was got by Mr. G. McDougall on Abbey Craig, Bridge of Allan (Trans., S.N.H.A.S., 1894-95, p. 26). In Perth Mid. it was taken by Mr. R. Standen on Birnam Hill, in 1886. In 1869 it was recorded by Dr. Buchanan White from "Near Perth" (Jeffreys, Brit. Con., vol. V. Supplement, 1869, p. 160), but he does not state on which side of the river he found it. There is, therefore, no definite record for Perth East. I have not taken this species myself.

V. pygmæa Drap.).

Brit., 125.	Scot., 27.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This small species frequents moist or dry places indifferently. It is found under stones and logs of wood, and at the roots of grass, sometimes in dry and elevated situations on hillsides.

Local Distribution.—This very small shell has been detected in all three divisions of the county, but it is by no means common. In Perth West it was taken on the front of Abbey Craig, Bridge of Allan, in 1894, by Mr. G. McDougall (A.S.N.H., 1895, vol. IV., p. 150); and by Mr. W. Evans at Aberfoyle in 1896. In Perth Mid. it was taken in Glen Turret, near Crieff, in April, 1903, by the Rev. R. Godfrey (Census Books). In Perth East it was found by Mr. W. Evans on grass by the side of Loch Moraig, near Fenderbridge, at the foot of Glen Tilt, in 1899 (A.S.N.H., vol. VIII., p. 117).

In 1880 I took the var. *pallida* in Quarry Mill Den, in Perth East. This variety was also taken by the Rev. R. Godfrey in Glen Turret.

V. pusilla, (Müll.).

Brit., 27.	Scot., 4.	Wanted, P.N.H. Mus.
Perth West.	O.	O.

Habitat.—This species is rare, and local in its distribution. It lives among damp moss and dead leaves, on old walls and banks, and under stones.

Local Distribution.—This rare little shell was found by the late Mr. McDougall in two localities near Bridge of Allan, Perth West, in 1894, the one being on the front of Abbey Craig, and the other at the foot of the hill west of Blairlogie (A.S.N.H., 1895, vol. IV., p. 150). These are, so far as I am aware, the only places where it has been detected in Perthshire. The only other counties in Scotland where it has been found are Dumfries, Kirkcudbright and Ayr.

Sphyradium edentulum (Drap.). (=*Vertigo edentula,* Drap.)

Brit., 115.	Scot., 32.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This species is widely distributed over the British Isles, and is not uncommon. It is found both in wild and cultivated places, under stones, among moss and decaying fronds of ferns, such as the Male Fern. It is also found in woods, on the trunks of trees.

Local Distribution.—This is the commonest of the Vertigo group, and is found in all districts of the county, both Highland and Lowland. I have taken it in Birnam Glen, Perth Mid., and on Kinnoull Hill, in Perth East. In Perth West it has been recorded from several localities, around Callander and Bridge of Allan (A.S.N.H., I., 236; II., 167; III., 156).

I have taken the var. *columella* in Quarry Mill Den, Perth East.

S. minutissimum (Hartmann). (=*Vertigo minutissima,* Hart.)

Brit., 11.	Scot., 3.	P.N.H. Mus.
O.	O.	**Perth East.**

Habitat.—This is one of the rarest of the *Pupidae,* as well as the smallest. It has only been recorded from seven stations in England, three in Scotland, and one in Ireland. It is found under stones in shady places on hillsides.

Local Distribution.—This very rare mollusk is now recorded as a Perthshire species for the first time. In August, 1910, Mr. Fred. Smith, Jun., found one specimen on Kinnoull Hill, in Perth East, but, for some reason or other, the discovery was omitted to be reported either to the Perthshire Society of Natural Science or the Conchological Society, and thus it was not recorded in any of the journals. Probably the reason was that Mr. Smith left Perth about that time, to take up his residence in London. The specimen has recently been authenticated by the Recorder and Referees of the Conchological Society, and is now in the Perthshire Natural History Museum.

The only other stations in Scotland from which *S. minutissimum* has been recorded are Arthur's Seat, Edinburgh (v.-c. 83), and North Berwick Law, Haddingtonshire (v.-c. 82). [J.C., 1889, vol. VI., p. 5.]

CLAUSILIIDAE.

Balea perversa (Linné).

Brit., 129.	Scot., 32.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This pretty reversed spiral shell is widely distributed, but not very abundant. It is found in comparatively dry places, on mossy rocks and old walls, on the trunks of trees, and amongst loose stones. In dry weather it shelters under the loose bark of trees, or in crevices of the lichen-covered rocks and walls.

Local Distribution.—This shell occurs in several localities in each of the divisions of the county. I have taken it on Kinnoull Hill and at Stobhall, in Perth East, and at Bridge of Allan, in Perth West. In Perth Mid., it was taken at Aberfeldy by Mr. James Leslie.

The late Dr. Buchanan White said that he found the Perthshire specimens of *B. perversa*, which he collected at Dunkeld, in Perth East, to be rather larger than average English specimens (J. G. Jeffreys, Brit. Con., vol. V., Supplement, 1869, p. 161).

Clausilia laminata (Mont.)

Brit., 61.	Scot., 3.	P.N.H. Mus.
O.	O.	Perth East.

Habitat.—This species, which is very restricted in its distribution, is chiefly confined to woods, especially of beech, where it is found both on and under the bark of trees. It is also found on mossy rocks.

Local Distribution.—This very handsome *Clausilia* was first discovered on the face of Kinnoull Hill by Dr. Buchanan White in 1869 (Jeffreys, Brit. Con., vol. V., Suppt., 1869, p. 161). In his List of Scot. L. and F.W. Mollusca, published in the Scot. Nat. in 1873 (vol. II., p. 169), Dr. White describes the habitat thus—"Among ivy on a shaded rock near Perth, where I discovered it some years ago." In October, 1880, Dr. White and I again visited the spot, and found the small colony was still flourishing. We found them living among the débris of the screes at the foot of the perpendicular cliffs, where the volcanic soil is kept moist and shaded by the fairly thick growth of trees. In August, 1920, the spot was again visited by Mr. E. Crapper, who found that they were still fairly abundant, especially under the decaying bark of fallen tree trunks, and amongst dead leaves, twigs, and other rubbish. It is very satisfactory to know that this little detached colony of a species once thought to be confined to the southern half of the kingdom is not dying out.

For many years after 1869, Kinnoull Hill was the only known Scottish station for this species, but in April, 1901, it was discovered by Mr. W. Evans near Oakley, in Fifeshire, so that it is recorded in Roebuck's Census of June, 1921, from Fife and Kinross, v.-c. 85 (see A.S.N.H., 1901, p. 183). It has also been found at Muchalls, in Kincardineshire, No. 91, by Mr. N. G. Hadden (recorded in Census Books, July, 1910).

C. bidentata (Ström.). (=*C. rugosa,* Drap., =*C. perversa* Pult.)

Brit., 146.	Scot., 36.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This in one of our commonest and most widely distributed species. It is found in all sorts of situations—on both wild and cultivated land, in crevices of walls and rocks, on the bark of trees, under stones, among moss, and at the roots of grass.

Local Distribution.—This pretty spindle-shaped shell is abundant in all parts of the county, and ranges to considerable elevations. Dr. Buchanan White found it on Ben Lawers at an altitude of 2,400 feet (S.N., II., 169). Mr. Frank F. Laidlaw found it on the same mountain, in company with *Helix arbustorum,* at an elevation of about 3,000 feet (J.C., XII., 129, " Shells at High Altitudes in Scotland.")

This shell varies considerably, both in size and shape. I have taken the varieties *tumidula* and *everetti* in more than one locality both in the Lowland and Highland districts. The var. *gracilior* was taken by Mr. J. Ray Hardy at the head of Loch Tummel, in Perth Mid. (Proc., R.P.S., X., 480).

SUCCINEIDAE.

Succinea putris (Linné).

Brit., 136.	Scot., 29.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This mollusk, like the next, is almost amphibious in its habits, although it is seldom found actually under water. It lives in marshy places, by the sides of ditches, and along the margins of streams. It may frequently be found on the leaves of water plants, or crawling over the wet mud.

Local Distribution.—This species is fairly common in wet places both in Perth East and Perth Mid. In Perth West, it was taken by Mr. W. Evans at Dollar, in April, 1897, but this was omitted to be recorded in the Census of June, 1921.

Mr. Fred. Smith, Jun., took the var. *subglobosa* at Friarton, near Perth, Perth Mid., in July, 1908.

S. elegans, Risso.

Brit. 123.	Scot., 19.	Wanted, P.N.H. Mus.
Perth West.	O.	Perth East.

Habitat.—This species is found in the same situations as the last. Indeed, they are frequently met with in company with each other.

Local Distribution.—This rather rare mollusk has been found at two localities in Perth East, and two in Perth West, but it has not yet been recorded from Perth Mid. In Perth East, Mr. Evans took it at Loch Clunie (Proc., R.P.S., X., 451); and also in the neighbourhood of Fenderbridge, near the foot of Glen Tilt, in September, 1898 (A.S.N.H., VIII., 117). In Perth West, Mr. Evans found it at Callander, in May, 1894 (id., IV., 150); and Mr. McDougall got it along the edges of streams in Cornton, near Bridge of Allan (Trans., S.N.H.A.S., 1894-95, p. 26).

Succinea oblonga, Drap.

Brit., 22.	Scot., 3.	P.N.H. Mus.
Perth West.	O.	O.

Habitat.—This very rare species is almost entirely confined to situations near the sea, where it is found on plants in sandy places, and sometimes in marshes.

Local Distribution.—This is one of the rarest of our Perthshire mollusks, being confined to one locality in the western division. It was found by Mr. (now Dr.) R. Kidston, in 1893, near Thornhill, at a spot two or three miles north of the River Forth. (Trans., S.N.H.A.S., 1895-96, p. 140; recorded by Mr. G. McDougall. See also A.S.N.H. 1894, vol. III., p. 155.) It was also found by Mr. W. Evans, in 1914, on the north bank of the Forth opposite Craigforth, above Stirling, which is not very far from Dr. Kidston's original locality. (S.N., 1914, p. 120).

Amongst the specimens which Dr. Kidston found was a sinistral example, which was exhibited at a meeting of the Conchological Society at Leeds in February, 1894 (J.C., VII., 367). Mr. J. W. Taylor, commenting on this specimen in the same number of the Journal (p. 367), says that it is new to science, and names it S. *oblonga* m. *sinistrosum.* He says it was picked out by him from amongst a few typical forms which had been sent to him by Mr. McLellan. These specimens, he says, were found "in an old road-side quarry in South Perthshire during the autumn of 1893, by a conchological friend of Mr. McLellan's."

It is difficult to account for the presence of these two isolated colonies of a more or less maritime species in a position now so far removed from the sea coast, unless, indeed, they are survivals from the comparatively recent geological period when the Valley of the Forth was an arm of the sea. This explanation may account also for the presence of another maritime species, *Helix virgata,* at Kincardine-on-Forth, a little further down the river.

The only other Scottish stations for *S. oblonga* are in Ayrshire (v.-c. 75) and Linlithgowshire (v.-c. 84).

AURICULIDAE.

Carychium minimum, Müll.

Brit., 141.	Scot., 34.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This very pretty little shell is almost ubiquitous throughout the British Isles. It is found under stones and logs of wood and among wet moss and dead leaves, in moist woods and other damp and shady places.

Local Distribution.—This little mollusk is found in suitable situations in all parts of the county, both Highland and Lowland.

ANCYLIDAE.

Ancylus fluviatilis, Müll.

Brit., 137.	Scot., 37.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—Abundant on stones, rocks, wooden piles, etc., in shallow parts of quickly flowing streams and rivers. Sometimes found adhering to the shells of freshwater mussels.

Local Distribution.—This, the common freshwater limpet, is found in running water in all parts of the county, both Highland and Lowland.

A. lacustris (Linné). (=*A. oblongus,* Lightfoot).

Brit., 86.	Scot., 11.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This rather local freshwater limpet inhabits ponds, lakes, canals, sluggish streams and rivers, where it is found adhering to the under sides of the leaves and the stems of water lilies, and other aquatic plants.

Local Distribution.—This species is found in several localities throughout the county, but is by no means common. I have taken it in Dupplin Loch, in the Deadwaters of the Earn, near Forgandenny, and in the Tay by the Woody Island, above Perth. In Perth West, Mrs. Carphin found it at Bridge of Allan. The var. *albida* is not uncommon. Indeed, Dr. Buchanan White went so far as to say that all the Perthshire specimens appeared to belong to this variety (S.N., 1883, vol. II., p. 208), but with this I can hardly agree.

LIMNÆIDAE.

Limnæa peregra (Müll.).

Brit., 153.	Scot., 41.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This species, which is the commonest of the fresh-water snails, is ubiquitous, being found in every vice-county of the United Kingdom, and over the whole of the Eastern Hemisphere. It is found also at all elevations. It inhabits both stagnant and running water, in ponds, ditches, marshes, and sluggish streams.

Local Distribution.—This very common and very variable species occurs everywhere throughout the county. It was taken in a tarn at an elevation of 1,500 feet on Ben-y-Vrackie, by Mr. T. M. McGregor, F.E.S., in July, 1898. In August 1909, Mr. Jas. Leslie found it on Farragon, at an elevation of 2,000 feet.

The following varieties have been recorded from the county:—

Var. *decollata,* in a cold spring at Glenalmond, Perth Mid., by Dr. Buchanan White (S.N., 1873, vol. II., p. 207).

Var. *lacustris,* in the River Tay, at Perth (Perth Mid. and East), by Mr. A. K. Lawson (J.C., XVI., 269); Loch Clunie, Perth East, by Mr. W. Evans (Proc., R.P.S. X., 490); North Inch Pond, Perth, Perth Mid., by Mr. Fred Smith, Jun.; and Lake of Mentieth, Perth West, by Mr. G. McDougall (A.S.N.H., IV., 150).

Var. *oblonga,* Muir of Durdie, near Perth, Perth East, by Mr. F. Smith, Jun., August, 1908.

Var. *ovata,* Forgandenny, Perth Mid., and Pitlochry, Perth East, in 1880, by H. Coates; and Loch Dochart, Perth Mid., by Mr. A. Somerville (Proc., R.P.S., X., 490).

Var. *succineæformis*, Forgandenny, Perth Mid., 1880, by H. Coates.

Var. *albinos,* Lake of Menteith, Perth West, by Mr. G. McDougall (A.S.N.H., IV., 150).

L. burnetti, Ald. (=*L. peregra* [Müll.], var. *burnetti* [Ald.].)

Brit., 5.	Scot., 2.	P.N.H. Mus.
O.	O.	Perth East.

Habitat.—This very rare and local species is found in mountain lakes or tarns.

Local Distribution.—This species was taken by Dr. Buchanan White in the Loch of the Lowes, Perth East, in 1882. The specimen was authenticated by the Referees of the Conchological Society, and is now in the Perthshire Natural History Museum.

The only other Scottish station for *L. burnetti* is Loch Skene, in Dumfries-shire (v.-c. 72), where it has been known for many years. Mr. E. Crapper visited the loch as recently as September, 1921, and found the colony still flourishing.

L. palustris (Müll.).

Brit., 127.	Scot., 21.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—Found in shallow, muddy ponds, and sluggish streams, and along the margins of ditches.

Local Distribution.—This species is widely distributed in the county, but not very common. Dr. Buchanan White found the var. *elongata* near Perth, and the var. *decollatum* near Dunkeld, in 1892.

L. truncatula (Müll.)

Brit., 145.	Scot., 37.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This small species is found in muddy ponds and ditches, and in marshes and slow running streams. Dr. Buchanan White said that he frequently found it adhering to stones and aquatic plants out of the water. It is also found on rocks kept moist by the spray from waterfalls. It reaches considerable elevations.

Local Distribution.—This small freshwater snail is widely distributed and abundant in the county. It may be found adhering to the stones in streams and ditches in most places.

L. glabra (Müll.)

Brit., 34.	Scot., 4.	P.N.H. Mus.
[**Perth West.**]	O.	Perth East.

Habitat.—This very scarce and local species is found on the banks of ponds, ditches, shallow pools, and marshes.

Local Distribution.—This rare mollusk was first found in Perthshire in October, 1870, by the late Dr. Buchanan White, in some small marshy pools on the Muir of Durdie, about 3 miles E.N.E. of Perth Bridge, in Perth East (S.N., I., 26). These pools contained a thick growth of grasses, rushes, *Sphagnum* and *Potamogeton*. In November, 1881, I visited the pools, and found the colony still flourishing, but in November, 1917, when I visited the spot again, there was not a trace of them to be seen. It is possible, however, that they were in hiding amongst the roots of the water plants.

Most of the specimens got by Dr. Buchanan White had the three apical segments eroded, and to this form he gave the name *decollata*, B.W. (See Dr. White's " List of the Scottish L. and F.-W. Moll.," S.N. 1873, vol. II., p. 208; also "*Limnæa glabra* as a Scottish Mollusk," by W. Denison Roebuck, Scot. Nat., 1918, p. 113.)

In the paper referred to above, Mr. Roebuck mentioned that in April, 1896, Mr. W. Evans had found a single immature specimen of *L. glabra* in a pool on the north side of Duchray Water, near Aberfoyle, in Perth West. As there seems, however, to have been some doubt regarding the authentication of the specimen, although it was confirmed by Mr. J. W. Taylor, I have retained the record, but only within square brackets. This record for Perth West was not included in Roebuck's Census of June, 1921.

PLANORBIDAE.

Planorbis albus, Müll.

Brit., 128.	Scot., 24.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This widely distributed *Planorbis* is found on water plants in weedy pools and slow-running streams.

Local Distribution.—This species is found abundantly in all parts of the county. I have taken it in all three vice-counties.

P. glaber, Jeff. (=*P. parvus,* Say.)

Brit., 52.	Scot., 13.	Wanted, P.N.H. Mus.
Perth West.	O.	O.

Habitat.—This rare and local species is found on water plants in ponds and marshes.

Local Distribution.—This rare little mollusk has only been recorded from the Western division of the county, where it was found by Mr. G. McDougall in the Lake of Menteith (A.S.N.H., IV., 150). I have never come across it myself.

P. nautileus (Linné).

Brit., 113.	Scot., 25.	P.N.H. Mus.
Perth West.	**Perth Mid.**	Perth East.

Habitat.—This species is found in similar positions to *P. albus,* but it is by no means so common, nor so widely distributed.

Local Distribution.—This beautiful little shell has been taken in all three divisions of the county. It had not been recorded from Perth Mid. in Roebuck's Census of June, 1921, but I recently sent to Prof. Boycott, the Recorder of the Conchological Society, specimens which I took in Dupplin Loch in May, 1915, and these have now been confirmed by the Referees as *P. nautileus,* var. *lævigata.* The var. *crista* (or *imbricata)* appears to be nearly, if not quite, as common as the type. It was got by the late Mrs. Carphin at Bridge of Allan, Perth West (A.S.N.H., II., 166), and by Dr. Buchanan White in Loch Marlee, Perth East.

P. leucostoma, Millet. (=*P. spirorbis* [Linné].)

Brit., 125.	Scot., 20.	P.N.H. Mus.
Perth West.	O.	Perth East.

Habitat.—Found on water plants in shallow stagnant pools and sluggish streams. It is even found in pools which may be dried up in summer.

Local Distribution.—This pretty little flat-coiled shell was first taken in a pond at Errol, Perth East, by Dr. Buchanan White, about 1872. It was unfortunately wrongly identified as *P. vortex,* and as such was recorded in my "Notes on the Mollusca of Perthshire," published in the Proceedings of the Perth. Soc. Nat. Sc., for 1881-86, p. 72. Mr. Fred. Smith, Jun., revisited the pond at Errol in June, 1908, and found the colony still flourishing there at that date.

In Perth West it was taken in a ditch at Cornton, near Bridge of Allan, by Mr. G. McDougall (A.S.N.H., IV., 150), and also at Dollar, in April, 1897, by Mr. W. Evans. It is said to have been taken also at Dunning, in Perth Mid., but as I can find no confirmation of this record, I have not included it in the present list.

Amongst the Errol specimens was a curiously malformed or semi-scaliform shell, a portion of the last whorl being turned up at right angles to the plane of the rest of the shell (Proc., P.S.N.S., 1881-86, p. 195). Malformations of this kind are not uncommon with *P. leucostoma.*

Bathyomphalus contortus (Linné). (=*Planorbis contortus* [Linné].)

Brit., 120.	Scot., 28.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This species is as common and as widely distributed as *P. albus,* and is found in similar situations.

Local Distribution.—Found in streams, ponds and ditches in every part of the county.

Hippeutis fontanus (Lightfoot). (=*Planorbis nitidus,* Müll.)

Brit., 97.	Scot., 13.	P.N.H. Mus.
Perth West.	Perth Mid.	O.

Habitat.—This very local species is found on aquatic plants in ditches, marshes and streams. It is generally found amongst the mud at the bottom of the water.

Local Distribution.—This rather rare little mollusk was got by Mr. W. Evans at the foot of Loch Ard, in Perth West, in July, 1905 (A.S.N.H., XIV., 247). In May, 1915, I got it in Dupplin Loch, in company with *P. nautileus* (Proc., P.S.NS., vol. VI., p. CI.). It was also got by Dr. Buchanan White, in 1869, in the Lower Moncreiffe Pond. These two last localities are both in Perth Mid. It has not yet recorded form Perth East.

PHYSIDAE.

Physa fontinalis (Linné).

Brit., 119.	Scot., 19.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—On water lilies and other aquatic plants in weedy ponds, ditches and streams.

Local Distribution.—This beautiful glossy little shell is fairly common throughout the county. I have taken it in all the three vice-counties. Dr. Buchanan White said that the var. *curta* was the only form that occurred in Perthshire. He found it at an elevation of at least 1,000 feet (S.N., II., 207).

Aplexa hypnorum (Linné). (=*Physa hypnorum* [Linné].)

Brit., 97.	Scot., 8.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This rather local species, although very restricted in its range, has been recorded from all the three divisions of the county. In Perth West it was found in at ditch at Cornton, near Bridge of Allan, by Mr. G. McDougall (A.S.N.H., IV., 150). In May, 1895, Mr. T. M. McGregor, F.E.S., found it in a small pond at the mouth of the Almond, in Perth Mid. In July, 1908, Mr. Fred. Smith, Jun., visited the same pond, and found the colony still holding its ground. In Perth East it was found at Errol, in 1869, by Mr. J. MacFarlane, now the only surviving founder of the Perthshire Society of Natural Science (Proc., P.S.NS., 1869-70, p. 75). I have never taken it myself.

PALUDESTRINIDAE.

Paludestrina jenkinsi (Smith) [*Paludestrina*=*Hydrobia.*]

Brit., 69.	Scot., 2.	P.N.H. Mus.
O.	Perth Mid.	**Perth East.**

Habitat.—This little mollusk, which is supposed to have been introduced into this country with timber from the Baltic, was at first confined to the brackish water at the mouths of rivers. Within recent years, however, it has spread rapidly to the fresh-water upper reaches of these rivers, and also into their tributary streams, and canals. It is found chiefly on stones at the edges of the stream.

Local Distribution.—This interesting species was first detected in Perthshire—and, indeed, in Scotland—by Mr. William Barclay, of Perth, while botanising by the side of the River Tay, at a point a little above Elcho, on the South or right bank of the river, in Perth Mid. The date was in August, 1906, and the mollusks were found adhering to stones near the edge of the river, at a point about two miles below Perth Harbour, where the stream is under the influence of the tides. (See Proc., P.S.N.S., vol. V. p. LXIX.)

In April, 1921, Mr. E. Crapper discovered another station for this species, in a small stream which flows into the Tay near Kinfauns, on the North or left bank of the river and therefore in Perth East. A little later, in July of the same year, he found it in yet another locality, further down the river, but still on the left bank. This was in Huntly Burn, near Longforgan. In these two last cases, the mollusks were confined to the portions of the burns which are under the influence of the tides. (See "*Paludestrina jenkinsi* in Scotland," by E. Crapper, Jl. of Con., 1922, XVI., 275; "Census Authentications," by W. D. Roebuck, *id.*, 1920, XV., 101; "*Paludestrina jenkinsi* in Scotland," by W. D. Roebuck, Scot. Nat., 1918, p. 142; and "Additions to the Census of June, 1921," by Prof. A. E. Boycott, Jl. of Con., 1922, XVI., 274.)

In February, 1922, specimens of *P. jenkinsi* were found adhering to the bill of a Scaup Duck which was feeding just below the Old Harbour at Perth (Perth Mid.). The specimens, which were quite fresh, were removed from the bill by Mr. John Ritchie, Jun., Curator of the Perthshire Natural History Museum. This incident has an interesting bearing on some of the problems connected with the Dispersal of the Mollusca.

VALVATIDAE.

Valvata piscinalis (Müll.).

Brit., 121.	Scot., 20.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—Found adhering to submerged stones and sticks in lakes, ponds, and sluggish streams, in most parts of the British Isles.

Local Distribution.— This species is widely distributed and common in standing waters and slow-running streams in most parts of the county. I have taken it in several localities in Perth Mid. and Perth East, both in the Highland and Lowland portions. In Perth West it was got by Mr. G. McDougall in the Lake of Menteith (A.S.N.H., IV., 150).

V. cristata, Müll.

Brit., 95.	Scot., 12.	P.N.H. Mus.
O.	**Perth Mid.**	O.

Habitat.—Found in similar situations to the last, but much more restricted in its distribution. Dr. Buchanan White said he found it adhering to the roots of aquatic plants.

Local Distribution.—This rare and beautiful little shell was not recorded from any of the three vice-counties of Perthshire in Roebuck's Census of June, 1921, but recently (Feb., 1922), in overhauling the Conchological Collections of the Perthshire Natural History Museum, I came across some specimens which had been got at the Old Harbour, Perth (Perth Mid.), in July, 1908, by Mr. Fred. Smith, Jun. I at once sent the specimens up to Prof. Boycott, the Recorder of the Conchological Society, and he had them confirmed by the Referees. It is difficult to know why this discovery was not recorded at the time, but it must have been overlooked.

DREISSENIDAE.

Dreissensia polymorpha (Pallas).

Brit., 38.	Scot., 5.	P.N.H. Mus.
O.	Perth Mid.	O.

Habitat.—This freshwater mussel is another species which is supposed to have been introduced into this country with timber from Russia, about 1824. It inhabits canals, slow-running rivers, docks, water-pipes, etc. Its distribution is still restricted, but it is firmly established in a number of localities, where large and flourishing colonies are to be found.

Local Distribution.—This interesting species was discovered by the late Mr. W. Herd at the Old Harbour, Perth (Perth Mid.), about 1869. As a considerable trade was carried on between Perth and the Baltic Ports in the early part of last century, it is not difficult to understand how they came to find their way to the Harbour. For nearly forty years they were lost sight of, but in July, 1908, Mr. Fred. Smith, Jun., rediscovered them at the same spot. The specimens are all of small size.

UNIONIDAE.

Margaritana margaritifera (Linné). (=*Unio margaritifer*, Linné.)

Brit., 60.	Scot., 21.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This species, the Freshwater Pearl Mussel, is chiefly confined to the swiftly-flowing rivers of the more mountainous districts of Great Britain. It seems to prefer soft-water streams, rather than those of which the water is hard.

Local Distribution.—This handsome bivalve is one of the notable mollusks of the county. Nowhere else in the British Isles does it find a more congenial habitat than in the swift-flowing mountain-fed streams of Perthshire. It is found throughout the whole course of the River Tay, from Loch Tay to where the water ceases to be fresh. It is also found in all the larger tributaries, including the Tilt, the Garry, the Tummel, the Braan, the Lyon, the Almond, the Earn, the Isla, the Farg, and possibly others. It is also found in the River Forth and its tributaries, in Perth West. It is not confined to these rivers, however, but is also found in many of the larger Highland lochs, including Loch Tay, Loch Rannoch, Loch Tummel, Loch Earn and Loch Katrine.

Mr. James Abernethy, of Coupar-Angus, who made a special study of the habits and distribution of this species sends me the following notes:—

Regarding the tributaries of the Tay in which *M. margaritifera* has been found, I have taken it in the following:—

In the River Earn I have taken it from the confluence with the Tay up to Highlandman Station. It was fairly abundant in 1906.

In the River Isla it occurs from the confluence with the Tay up to the confluence of the Isla and the Dean. It was abundant in 1903.

In the Lunan Burn, a tributary of the Isla, it was present up to near Loch Ordie, in 1907, but in small numbers.

In the River Tummel it is quite common, up to Loch Tummel. Above this loch, up to Dunalastair, it is very abundant. From thence to Loch Rannoch it is common. In the River Gauer it is abundant up to Loch Lydoch. In the River Ba it is common up to Loch Ba. Above that it is very abundant. These observations in the Tummel and its tributaries were made in 1908.

In the River Lyon it was abundant, in 1906, from the confluence with the Tay up to Meggernie Castle, and is said to be found still further up.

In the River Dochart it was abundant, in 1906, from the mouth up to Luib.

With regard to the River Tay itself, I have found them from the mouth of the Earn up to Loch Tay, very abundant in parts. There is one very noticeable characteristic in all these various waters, and that is that in "thin" or shallow waters, where pearl fishers have been operating, the remaining specimens are of much more vigorous growth than in the deeper and less accessible water, where specimens are numerous. This extra healthy growth is also very observable in all tidal waters. No doubt this is due to the relative abundance or scarcity of food.*

With regard to the further incidence of this species in Perthshire, I have found it in the following tributaries of the Forth:—

In the River Allan it is quite common, from Dunblane up to Greenloaning.

In the River Teith it occurs from the confluence with the Forth up to Callander, and is abundant in parts.

In the River Balvaig it is very abundant from Loch Lubnaig to Loch Voile.

I have also taken it in the following lochs:—Loch Rannoch, Loch Tummel, Loch Lubnaig, Loch Vennacher, and Loch Achray, as well as the water connecting these last two lochs, also Loch Doine.

JAS. ABERNETHY.

The vars. *roissyi* and *sinuata* are not uncommon in the Tay and the Earn.

What gives this species special importance is, of course, its economic value as the source of the Pearl Fishing Industry in Great Britain, which has been in existence from the time of the Roman occupation, if not earlier. It still remains a source of revenue to a number of fishers up and down the valleys of the Tay and its tributaries, during the summer months, when the waters are low. The mussels are not so abundant as they used to be, but pearls are still occasionally got, valued at from one to twenty pounds.

[References:—H. Coates, "The Pearl Mussel of the Tay," Proc., P.S.N.S., 1881-86, pp. 11, 24. William Japp, "The Pearl Mussel in the Isla," S.N., 1885, vol. VIII., pp. 62, 113.

* Mr. John Ritchie, of the Perth Museum, is of the opinion that the more robust condition of the specimens in shallow portions of the river may also be accounted for by the fact that the water in these portions would be more thoroughly oxygenated, and fresher, than the water in deeper pools.

J. R. B. Masefield, M.A., "The Economic Uses of some British Mollusca," J.C., 1898, IX., 153. J. Stewart, "The Pearl Mussel and its Fishery," Proc., P.S.N.S., 1909, V. 17. All these Papers contain references to the Pearl Fisheries of the Tay.]

Anodonta cygnea (Linné).

Brit., 86.	Scot., 12.	P.N.H. Mus.
O.	Perth Mid.	Perth East.

Habitat.—This mussel, unlike the last one, lives in sluggish rivers, canals, lakes and ponds, where it lies amongst the mud at the bottom.

Local Distribution.—This large bivalve, the "Swan Mussel," was first recorded as a native of the county in November, 1869, when a number of the shells were exhibited at a meeting of the Perthshire Society of Natural Science by the late Mr. W. Herd, who had got them in the River Earn, near the Railway Bridge at Hilton, in company with *M. margaritifera* (Proc., P.S.N.S., 1869-70, p. 15).

Four years later, in 1873, Mr., afterwards the Rev. Fred. Smith found it in Dupplin Loch, which, like the previous locality, is in Perth Mid. In May, 1915, I visited Dupplin Loch, and found it still abundant there (Proc., P.S.N.S., vol. VI., p. CI.). In 1890 it was got by Dr. Buchanan White in Auchtertyre Loch, near Crieff, in the same vice-county. In Perth East it has been got in Scone Curling Pond by myself and others. It has not yet been recorded from Perth West, although it seems reasonable to expect that it will yet be found there. Indeed, the late Mr. McDougall stated that it was reported to occur in the bed of the River Forth, below the mouth of the Allan, although he had not seen it there himself (Trans., S.N.H.A.S., 1897-98, p. 138).

The var. *incrassata* is not uncommon in the Earn, and also in the "Deadwaters" of the same river. The var. *ponderosa* was got by Mr. Fred. Smith, Jun., in Scone Curling Pond, in May, 1909.

CYRENIDAE.

Sphærium corneum (Linné). (= *Cyclas cornea*, L.)

Brit., 131.	Scot., 25.	P.N.H. Mus.
Perth West.	Perth Mid.	Perth East.

Habitat.—This bivalve is found in nearly every part of the British Isles, in both stagnant and flowing water. It inhabits ponds, streams, ditches, canals and rivers, frequently at the roots of water-lilies and other aquatic plants.

Local Distribution.—This species is widely distributed in the county, especially in standing waters. I have taken it in the Upper Moncreiffe Pond and North Inch Pond, both in Perth Mid., and in Balruddery Pond, in Perth East. In Perth West it was got in the Lake of Menteith by Mr. G. McDougall (A.S.N.H., IV., 150).

S. lacustre (Müll.). (=*Cyclas lacustre,* Müll.)

Brit., 93.	Scot., 10.	P.N.H. Mus.
O.	Perth Mid.	O.

Habitat.—This species is found in similar situations to the last, but is much more local. It is frequently found in marshes, and in ponds which dry up in summer.

Local Distribution.—This rather rare bivalve was found in the Town's Lade, opposite Tulloch, near Perth (Perth Mid.), by Mr. Fred. Smith, Jun., in July, 1908 (Proc., P.S.N.S., vol. V., pp. VII., X.). This is the only record for the county.

Pisidium amnicum (Müll.).

Brit., 95.	Scot., 6.	P.N.H. Mus.
Perth West.	Perth Mid.	O.

Habitat.—In slow running rivers, gently flowing streams, lakes, ponds and canals.

Local Distribution.—This rather rare bivalve, which is by far the largest of the *Pisidia,* was first taken in Perthshire by the Rev. Fred. Smith, who discovered it in the Town's Lade at the North Inch, Perth (Perth Mid.), in 1888. Just twenty years later, in 1908, it was again found a little further up the same Lade, opposite Tulloch, by Mr. Fred. Smith, Jun., who was unaware of the previous record by his namesake, for practically the same locality! (See Proc., P.S.N.S., vol. V., p. LIX.).

In Perth West it was found by the late Mrs. Carphin in the River Allan, at Dunblane (Proc., R.P.S., X., 459). It has not yet been recorded from Perth East.

P. casertanum (Poli).

Brit., 114.	Scot., 16.	P.N.H. Mus.
Perth West.	Perth Mid.	**Perth East.**

Habitat.—Widely distributed, in gently-flowing streams and ponds.

Local Distribution.—This is probably the most abundant of the smaller *Pisidia* in the county, as well as throughout Britain. It occurs in several localities around Perth, such as Craigie Mill Dam, the Burghmuir, and the North Inch Pond, all in Perth Mid. Mr. W. Evans has taken it at Fearnan, Loch Tay side, also in Perth Mid. In Perth East, I found it in the marshy pools on the Muir of Durdie, along with *Limnæa glabra,* and Mr. E. Crapper took it in Huntly Burn, Longforgan. In Perth West, Mr. W. Evans got it at Callander and Loch Lubnaig, in April, 1892.

The records for Perth West and Perth Mid. are entered in Roebuck's Census of June, 1921, but that for Perth East is new.

P. hibernicum, Westld.

Brit., 69.	Scot., 4.	P.N.H. Mus.
O.	**Perth Mid.**	O.

Habitat.—Rare in Britain. Found in lakes, ponds, streams, etc.

Local Distribution.—This rare *Pisidium,* which was formerly supposed to be confined to Ireland, has been taken in two localities in Perth Mid., not very far from each other. These are, Lower Moncreiffe Pond, where Dr. Buchanan White got it in 1869; and Dupplin Loch, where Mr. E. Crapper found it in October, 1921. Although the specimens from the former locality were got more than fifty years ago, they constitute a new record for the county, as they have only now been authenticated by the Referees.

P. lilljeborgii, Clessin.

Brit., 27.	Scot., 5.	P.N.H. Mus.
O.	Perth Mid.	**Perth East.**

Habitat.—A rare species, found especially in mountain lakes and tarns.

Local Distribution.—This species has been taken in Perth Mid. at Dupplin Loch, by Mr. Crapper and myself; and also at the Old Harbour, Perth, by Mr. Fred. Smith, Jun. In the same vice-county it was found by Dr. F. F. Laidlaw in Lochan a' Chait, a mountain tarn, at an elevation of 2,250 feet (B. B. Woodward, Cat. of Brit. Pisidia, p. 115). In Perth East, it was found in Marlee and Fingask Lochs by Dr. Buchanan White in September, 1882, constituting a new record for the vice-county.

P. milium, Held. (=*P. roseum,* Scholtz.)

Brit., 102.	Scot., 8.	P.N.H. Mus.
O.	**Perth Mid.**	**Perth East.**

Habitat.—Fairly widely distributed, in ponds, ditches, marshes, canals, and stagnant waters.

Local Distribution.—This species is by no means rare, but it is now recorded for the county for the first time. In Perth Mid., I have taken it in the Upper Moncreiffe Pond, in Dupplin Loch, and in the Deadwaters of the Earn at Forgandenny. It was also taken at the Old Harbour, Perth, by Mr. Fred. Smith, Jun., and at the Woody Island by Mr. Crapper. In Perth East, I have taken it at the Muir of Durdie, and Dr. Buchanan White took it at Fingask Loch.

P. nitidum, Jenyns.

Brit., 110.	Scot., 10.	P.N.H. Mus.
O.	**Perth Mid.**	**Perth East.**

Habitat.—Fairly abundant in lakes, ponds, ditches, and stagnant waters generally.

Local Distribution.—This is another new record for the county, although not a rare shell. In Perth Mid., I have taken it at Dupplin Loch, and Forgandenny, while Mr. Crapper has taken it at the Woody Island. In Perth East, Dr. Buchanan White got it in Fingask Loch, and Mr. Crapper found it in Huntly Burn, Longforgan.

P. obtusale, Jenyns.

Brit., 92.	Scot., 8.	P.N.H. Mus.
O.	**Perth Mid.**	**Perth East.**

Habitat.—In shallow ponds, pools, swamps, and stagnant waters generally.

Local Distribution.—This is another fairly common species, but a new county record. In Perth Mid., I have taken it at Laggan Hill Pond, near Crieff, and at Methven Bog; while Mr. T. M. McGregor took it in the small pond at the mouth of the Almond. In East Perth, along with the Rev. F. Smith, I took it at Corsiehill Quarry, and also at the Muir of Durdie, while Dr. Buchanan White found it at Dunkeld.

P. personatum, Malm.

Brit., 90.	Scot., 13.	P.N.H. Mus.
Perth West.	**Perth Mid.**	**Perth East.**

Habitat.—In ponds, pools, and stagnant waters.

Local Distribution.—This is a new record for Perth Mid., and Perth East, but not for Perth West. In Perth Mid., it was taken at the North Inch Pond, Perth, by the late Dr. Howard Bendall, and at the Mill Dam, Craigie, by Dr. Buchanan White. In Perth East, I took it at Corsiehill Quarry, and at the Muir of Durdie; while Dr. Buchanan White took it in Quarrymill Den. In Perth West it was got by Mr. W. Evans at Callander and Loch Lubnaig, in April, 1892.

It was also found by Mr. W. E. Evans in a tarn at an altitude of about 3,000 feet on Cru-y-Ben, Tarmachans, near Killin, in Perth Mid., in July, 1909 (S.N. 1918, p. 71), although the record was not included in the Census of June, 1921.

P. pulchellum, Jenyns.

Brit., 51.	Scot., 4.	P.N.H. Mus.
O.	**Perth Mid.**	**Perth East.**

Habitat.—A rather scarce species, found in ponds, sluggish streams, canals, ditches, etc., either buried in the mud, or hidden among the roots of aquatic plants.

Local Distribution.—This rare *Pisidium* has been taken at one locality in Perth Mid., and one in Perth East, and constitutes a new county record. In Perth Mid., it was got at the Old Harbour, Perth, by Mr. Fred. Smith, Jun., in July, 1908. In Perth East, it was got by Dr. Buchanan White in Fingask Loch, in Sept., 1882.

P. subtruncatum, Malm. (=*P. fontinale,* Pfeiffer).

Brit., 114.	Scot., 10.	P.N.H. Mus.
O.	**Perth Mid.**	**Perth East.**

Habitat.—This is one of the commonest species of the genus. It is found amongst the mud of ponds, stagnant pools, canals, ditches, and sluggish streams.

A good way of collecting this and other small species inhabiting similar situations is to gather a quantity of the mud, and take it home in a tin canister, for examination at leisure in a shallow vessel of water.

Local Distribution.—This is another new county record, but, like the last, it has not yet been recorded from Perth West. Strangely enough, although it is a common species, it was not found amongst any of the older lots, collected during the latter half of the last century, which were recently sent to the Referees for authentication. The question therefore arises—Is this a comparatively recent introduction into the district?

There are only two records of this species for the county, and these have both been obtained by Mr. E. Crapper within the past year. In April, 1921, he found it at the Woody Island, near the junction of the Almond and the Tay, in Perth Mid.; and in July, 1921, he got it in Huntly Burn, Longforgan, in Perth East.

Another record, of somewhat doubtful value, has been made more recently. Some specimens of this species were found amongst the mollusks which were adhering to the bill of the Scaup Duck caught at the bank of the River Tay below the Old Harbour, Perth (Perth Mid.), in February, 1922, as already described under *Paludestrina jenkinsi* (see p. 217). This incident of the Scaup's bill may possibly supply an answer to the question asked above regarding the introduction of *P. subtruncatum* into the district within comparatively recent years.

III.—Bibliography.

1853. Prof. Edward Forbes, F.R.S., and **Sylvanus Hanley, B.A., F.L.S.**

A History of British Mollusca and their Shells. 4 vols.

Unio margaritiferus in Scotland. The Tay, the seat of a pearl fishery, extending from Perth to Loch Tay. Vol. II., p. 152. [This is the sole allusion to Perthshire.]

1866. Ralph Tate, F.G.S., F.A.S.L.

A Plain and Easy Account of the Land and Freshwater Mollusks of Great Britain.

The Pearl Fisheries of the Tay, p. 30.

1868. John Dawson [of Perth.]

British Mollusks. Proc., Alloa Soc. of Nat. Sc. and Arch., p. 43.

On the Life History and Habits of Snails.

1869. J. Gwyn Jeffreys, F.R.S., F.G.S.

British Conchology. Vol. V., Supplement. [Vol. I., published in 1862, contains no references to Perthshire.]

Zonites excavatus in Perthshire, F. Buchanan White [this should have been Ross-shire, *fide* F.B.W.], p. 157, *Helix rotundata* var. *alba,* in Perthshire, F.B.W., p. 159. *Vertigo substriata* at Perth, F.B.W., p. 160. *Balia perversa* in Perthshire, F.B.W., specimens rather larger than English specimens, p. 161. *Clausilia laminata* at Perth, F.B.W., p. 161.

1869. John Young, Hunterian Museum, Glasgow.

Azeca tridens, var. *nouletiana,* found near Bridge of Allan. Proc., Nat. Hist. Soc. of Glasgow, vol. I., p. 240.

1869. W. Herd.

Anodonta cygnea, with var. *incrassata,* found in the River Earn, along with *Unio margaritifer,* Proc., P.S.N.S., 1869-70, p. 15.

1869. John Dawson.

Shells of the Genus *Helix* found in Perthshire. (11 species) Proc., P.S.N.S., 1869-70, p. 15.

1870. F. Buchanan White.

Species [of Mollusca] added to the Local Lists during the Session 1869-70. Proc., P.S.N.S, 1869-70, p. 75.

Physa hypnorum, Ancylus lacustris, with var. *albida, Pupa muscorum, Planorbis nautileus, P. nitidus, Pisidium nitidum Anodonta cygnea,* with var. *incrassata;* and *Helix nemoralis,* var. *alpestris.*

1870. J. McFarlane.

The Mollusca of the Ponds of the District. (17 species) Proc., P.S.N.S., 1869-70, p. 84.

1870. F. Buchanan White.

Mollusca got during an Excursion to Methven. Proc., P.S.N.S., 1869-70, p. 98.

Including the following species :—*Zonites cellarius, Z. nitidulus, Z. crystallinus, Z. fulvus, Helix nemoralis*, var. *hortensis, H. hispida, H. rotundata, Bulimus obscurus, Clausilia perversa, Balea perversa, Planorbis albus, P. contortus*, and *Lymnæa peregra*.

1870. F. Buchanan White.

An Addition to the Perthshire List of Land and Freshwater Mollusca. Proc., P.S.N.S., 1869-70, p. 99.

Helix lamellata on Birnam Hill, and other species accompanying it.

1870. F. Buchanan White.

Report on *Vertigo antivertigo* and *Helix aculeata* found in Quarrymill Den. Proc., P.S.N.S., 1869, p. 77.

1871. F. Buchanan White.

Report on *Limnæa glabra* got at Muir of Durdie, near Perth. Scot. Nat., I., 26.

1873. F. Buchanan White, M.D., F.L.S.

A List of the Scottish Land and Fresh-Water Mollusca, with hints on Collecting. Scot. Nat., vol. II., pp. 163 and 205.

Perthshire references :—*Limax marginatus* on Ben Lawers, at an elevation of 3,000 feet; *Zonites cellarius*, vars. *complanatus* and *compacta; Z. crystallinus; Helix arbustorum*, var. *alpestris, H. nemoralis*, vars. *minor* and *hortensis, H. hispida*, var. *albida, H. fusca, H. pulchella*, var. *costata, H. rotundata*, var. *alba, Cochlicopa lubrica*, var. *lubricoides, Azeca tridens, Clausilia laminata, C. perversa* on Ben Lawers at an altitude of 2,400 feet, *C. perversa*, vars. *everetti* and *tumidula, Vertigo antivertigo, Planorbis nautileus, P. vortex* [should have been *spirorbis*, H.C.], *Physa fontinalis*, var. *curta, P. hypnorum, Limnæa peregra*, var. *decollata, L. glabra*, and var. *decollata, Ancylus lacustris*, var, albida, *Anodonta cygnea*, var. *incrassata, Unio margaritifer*, vars. *sinuata* and *roissyi*.

1875. Henry Coates.

Captures of Helicidae at Moulin, near Pitlochry, Perthshire. (17 species.) Scot. Nat., III., 160.

1878. F. Buchanan White. M.D., F.L.S.

Glen Tilt: Its Fauna and Flora. (16 species of Mollusca.) Scot. Nat., IV., 244.

1879. J. W. Taylor.

Note on *Cochlicopa tridens*. Jl. of Con., II., 220.

Occurrence of var. *nouletiana* at Bridge of Allan noted.

1880. John W. Taylor.

Additional Notes on *Helix arbustorum*. Jl. of Con., III., 302.

Occurrence of var. *alpestris* at Pitlochry, at an elevation of 500 to 600 feet, noted.

1880. Richard Rimmer, F.L.S.

The Land and Freshwater Shells of the British Isles.

Perthshire References:—Pearl Fisheries in Perthshire, p. 16. *Unio margaritifer*, vars., *sinuata* and *roissyi*, p. 16. *Anodonta cygnea*, and var. *incrassata*, in the R. Earn, p. 17. *Physa fontinalis*, var. *curta*, p. 53. *Lymnæa glabra;* near Perth, p. 67. *Zonites nitidulus* emitting a strong smell of garlic, p. 102. *Helix lamellata* in wooded highland glens, at an elevation of 1,200 feet, p. 111. *Helix rotundata*, var. *alba*, p. 139. *Clausilia rugosa*, vars. *everetti* and *tumidula*, at Perth, p. 173. *C. laminata*, near Perth, p. 177. *Cochlicopa tridens*, near Bridge of Allan, p. 179. *C. lubrica*, var. *hyalina*, near Loch Rannoch, p. 182.

1881. John W. Taylor.

Life Histories of British Helices. Jl. of Con., vol. III., pp. 241-259 and 302-305.

P. 247, *Helix (Arianta) arbustorum*. L., var. *alpestris*, Zeigl. In Scotland it occurs but rarely, in several parts of Perthshire and Aberdeenshire. Dr. Buchanan White found it abundantly in Glen Tilt, but strictly confined to limestone. P. 258, H. Coates found it on the Old Red Sandstone Series at elevations of 50 to 300 feet, and on the Highland Metamorphic Series at elevations of 100 to 300 feet. P. 304, var. *fusca*, Fer., on Ben More (Hey).

1881. Henry Coates.

The Pearl Mussel *(Unio margaritiferus)* of the Tay. Proc., P.S.N.S., 1881-86, p. 11.

1881. William Japp, Alyth.

Unio margaritiferus in the River Isla. Id., p. 24.

1882. Henry Coates.

Notes on the Mollusca of Perthshire. Id., p. 72.

51 species recorded [*Planorbis vortex* should be *P. spirorbis*].

1882. **A. H. Cooke, M.A., F.Z.S.**

On the McAndrews Collection of British Shells. Jl. of of Con., vol. III., pp. 340-390.

Description of *Unio margaritifer*, L., and Pearls, from the River Tay.

1882. **F. Buchanan White, M.D., F.L.S.**

Freshwater Mollusca got in the Blairgowrie Lochs. Proc., P.S.N.S., 1881-86, p. 81.

Species enumerated—*Limnæa limosa, Physa fontinalis, Planorbis albus, P. contortus, Valvata piscinalis,* and *Cyclas cornea.*

1882. **J. W. Taylor.**

Additional Notes on *Helix arbustorum.* Jl. of Con., III., 303.

Vars. *alpestris* and *fusca* in Perthshire, the former at an elevation of 500 to 600 feet.

1883. **J. W. Taylor** and **W. D. Roebuck.**

The Present State of Knowledge of the Distribution of Land and Freshwater Mollusca in Britain. Id., IV., 174.

The three Perthshire vice-counties all blank—no authenticated records.

1883. **F. Buchanan White.**

Helix fusca in Kincardine Glen, and *Physa fontinalis* in Loch Ordie. Proc., P.S.N.S., 1881-86, pp. 114 and 115.

1884. **Henry Coates.**

Helix lamellata at Craighall; and *H. aspersa,* varieties of *H. nemoralis,* and *H. hispida,* in Kingoodie Quarry, Longforgan. Scot. Nat., VIII., 40.

1884. **Henry Coates, F.R.P.S.**

The Life History of a Garden Snail. Proc., P.S.N.S., 1881-86, p. 140.

1884. **Henry Coates.**

Variations in Banding of *Helix nemoralis.* Id., p. 145.

1884. **Henry Coates.**

Preliminary Report on the Land and Freshwater Mollusca of the East of Scotland. Report of the East of Scotland Union of Naturalists' Societies, 1884, p. 33.

1885. **Henry Coates.**

Report on the Bibliography of the Land and Freshwater Mollusca of the Counties of Aberdeen, Kincardine, Forfar, Fife, Kinross and Perth. Report E.S.U.N.S., 1885, p. 26. (Also Scot. Nat., VIII., 218.)

1885. **Henry Coates.**

Helix arbustorum, vars, *alpestris* and *flavescens,* and *Limax (Lehmannia) arborum* in Glen Tilt. Proc., P.S.N.S., 1881-86, p. 215.

H. aspersa at Remony, Breadalbane. Id., p. 216.
Arion ater on Stuc a Chroin. Id., p. 217.

1885. **Henry Coates.**

Note on a Fractured and Mended Shell of *Helix nemoralis,* and on a malformed (semi-scalariform) Shell of *Planorbis vortex.* [Should be *P. spirorbis.*] Proc., P.S.N.S., 1881-86, p. 192. (Also Scot. Nat., VIII., 90.)

1885. **J. W. Taylor** and **W. Denison Roebuck.**

Census of the Authentic Distribution of British Land and Freshwater Mollusca. J.L. of Con., IV., pp. 319-336.

Authenticated records of 34 Perthshire species.

1885. **Dr. Buchanan White.**

Notice of *Helix aspersa, H. nemoralis* (several forms), and *H. hispida* at Longforgan and Invergowrie. Scot. Nat., VIII., 40. (Also Proc., P.S.N.S., 1881-86, p. 173.)

1885. **William Japp, F.S.A.**

Stray Notes on the Pearl Mussel. Id., pp. 62 and 113.

Special references to its occurrence in the River Isla.

1886. **Henry Coates.**

The Natural History of Kinnoull Hill,—VI., the Mollusca. Proc., P.S.N.S., 1881-86, pp. 247 and 255.

37 species enumerated.

1890. **William Denison Roebuck, F.L.S.**

Census of Scottish Land and Freshwater Mollusca. Proc., R. Phys. Soc., X., pp. 437-503.

References to all the Perthshire Records, then known, embracing 60 species. Table showing distribution of species, pp. 500-503.

1891. F. Buchanan White, M.D., F.L.S.

Note on the Occurrence of *Helix virgata* at Kincardine-on-Forth. Scot. Nat., XI., 126.

Reference to change of County Boundaries.

1892. William Denison Roebuck, F.L.S.

Additions to the Authenticated Comital Census of the Land and Freshwater Mollusca of Scotland. Ann. Scot., Nat. Hist., 1892, p. 235.

List of 34 new records for Perth West, and 29 for Perth Mid.

1893. Gilbert McDougall.

Notes on the Mollusca of Perthshire South and Clackmannan. Trans., Stirling Nat. Hist. and Arch. Soc., 1892-93, p. 49.

38 species enumerated.

1893. William Denison Roebuck, F.L.S.

Additions to the Authenticated Comital Census of the Land and Freshwater Mollusca of Scotland. Ann. Scot. Nat. Hist., 1893, p. 164.

3 new records for Perth West; 2 for Perth Mid.; and 3 for Perth East.

1893. Henry Coates, F.R.S.E.

The Natural History of the Banks of the Tay: The Mollusca. Trans., P.S.N.S., II., 60.

31 species enumerated.

1894. William Denison Roebuck, F.L.S.

Additions to the Authenticated Comital Census of the Land and Freshwater Mollusca of Scotland. Ann. Scot. Nat. Hist., 1894, p. 153.

Four new records for Perth West, including *Succinea oblonga* type and monst. *sinistrorsum,* and two new records for Perth Mid.

1894. Thomas Scott, F.L.S.

Valvata piscinalis in Loch Tay, Perthshire. Id., p. 116.

1895. William Denison Roebuck, F.L.S.

Additions to the Authenticated Comital Census of the Land and Freshwater Mollusca of Scotland. Ann. Scot. Nat. Hist., 1894, p. 149.

13 new records for Perth West, including *Succinea elegans;* also a list of 10 species from Killin, at the head of Loch Tay. (Perth Mid.).

1895. Gilbert McDougall.

Second Note on the Conchology of Perth (South) and Clackmannan. Stirling Nat. Hist. and Arch. Soc., Trans., 1894-95, p. 23.

Records of 21 new species, making, with the 38 recorded in 1893, a total for the vice-county of 59 species.

1895. Gilbert McDougall, Stirling.

Notes on Mollusca collected in South Perthshire and Clackmannan. Ann. Scot. Nat. Hist., 1895, p. 255.

1896. Gilbert McDougall.

Third Report on the Land and Freshwater Shells of Perth South and Clackmannan. Trans., Stirling Nat. Hist. and Arch. Soc., 1895-96, p. 140.

Records of 12 additional species, including *Helix virgata, Azeca tridens, Succinea oblonga* and *Hyalinia glabra.*

1896. Lionel Ernest Adams, B.A.

The Collector's Manual of British Land and Freshwater Shells. Second Edition.

Perthshire references :—*Clausilia laminata* at Perth, p. 108; *Azeca tridens,* var. *nouletiana,* at Bridge of Allan, p. 109; *Valvata piscinalis,* as far north as Perth, p. 146; *Unio margaritifer,* Pearls found in the Tay, p. 149; Distribution Tables, pp. 202-205, Perth West and Clackmannan, 58 species, Perth Mid., 45 species, Perth East, 51 species.

1898. Gilbert McDougall.

Comparative Statement of the Land and Freshwater Shells of the Vice-County of Stirling (collected by Mr. Andrew McLellan), and the Vice-County of Perth (South) and Clackmannan (collected by Mr. Gilbert McDougall). Trans., Stirling Nat. Hist. and Arch. Soc., 1897-98, p. 136.

Total records of 68 species and 19 varieties for Perth South, as compared with 62 species and 11 varieties for Stirling.

1898. Gilbert McDougall.

Land and Freshwater Shells of Perth (South) and Clackmannan. Trans., Stirling Nat. Hist. and Arch. Soc., 1897-98, p. 138.

Mr. McDougalls' Fourth and Final Report, adding one new record, and bringing up the total for the vice-county to 68 species and 19 varieties.

1898. William Evans.

Records of Scottish Land and Freshwater Mollusca. Ann. Scot. Nat. Hist., 1898, p. 185.

Vertigo antivertigo at Aberfoyle, and *Succinea putris* at Dollar, April, 1897. Independent discovery of *Azeca tridens* on a mossy bank near Bridge of Allan.

1898. J. R. B. Masefield.

The Economic Uses of some British Mollusca. Jl. of Con., IX., 153.

The Pearl Fishery of the Tay described.

1899. William Evans.

Vertigo pygmæa and other Molluscs in "Perth East." Ann. Scot. Nat. Hist., 1899, p. 117.

V. pygmæa got by the side of Loch Moraig. 29 other species recorded from the neighbourhood of Fenderbridge, near the foot of Glen Tilt.

1899. Thomas Scott, F.L.S.

The Invertebrate Fauna of the Inland Waters of Scotland,—Report on Special Investigations. 17th Annual Report of the Fishery Board for Scotland, Part III., p. 132.

Investigations carried on in connection with the Survey of the Scottish Freshwater Lakes. Also Appendix, with Lists of all species previously recorded, p. 185. In these lists the following species are recorded from Loch Achray, in Perth West,—*Pisidium pusillum, Planorbis albus, P. contortus* and *Limnæa peregra.*

1901. William Evans.

Clausilia laminata and *Helix virgata* in the Forth Area. Ann. Scot. Nat. Hist., 1901, p. 183

Records of *C. laminata* from a ravine near Oakley, Fife, and independent discovery of *H. virgata,* on an old ballast heap near Kincardine-on-Forth.

1902. Lionel E. Adams, B.A.

The Census of the British Land and Freshwater Mollusca. Jl. of Con. X., 217.

Also published separately, by Dulau & Co., London, in the same year, by Authority of the Conchological Society of Great Britain and Ireland.

Recording 58 species for Perth West, 45 for Perth Mid., and 49 for Perth East.

1904. W. Denison Roebuck.

Re-establishment of *Limax tenellus* as a British species. Jl. of Con., XI., 106.

Record of the finding of *L. tenellus*, var, *cerea*, by Mr. Charles McIntosh at Inver, near Dunkeld, in Perth Mid. [See also Note by W. D. Roebuck in Ann. Scot. Nat. Hist., 1904, p. 221; and Note by Rev. G. A. Frank Knight, Proc., P.S.N.S., vol. IV., p. LI.]

1904. William Evans.

Note on *Limax tenellus* (Müll), with exhibition of living examples from the Forth area. Proc., R. Phys. Soc., XVI., p. 22.

1905. William Evans.

Note on *Planorbis fontanus* (Light.) in South-West Perthshire. Ann. Scot. Nat. Hist., 1905, p. 247.

Found at the foot of Loch Ard, Perth West, in July, 1905.

1905-1906. Alex. M. Rodger.

Illustrated Hand-book to the Perthshire Natural History Museum, and Brief Guide to the Animals, Plants and Rocks of the County.

First Edition published 1905; Second Edition published 1906. References to Perthshire Mollusca, p. 69.

1906. William Evans.

Note on *Milax (Amalia) gagates*, var. *rava*, in South-West Perthshire. Ann. Scot. Nat. Hist., 1906, p. 241.

Found in a garden at Callander, September, 1906.

1907. John W. Taylor.

Monograph of the Land and Freshwater Mollusca of the British Isles. Vol. II., Testacellidae, Limacidae and Arionidae. Perthshire References :—

Limax maximus, var. *fasciata,* in Perth East, p. 42 ; var. *cellaria,* sub-var. *maculata,* in Perth East, p. 45.
L. maximus in Perth West and Perth Mid., p. 50.
L. cinereo-niger in Perth West and Perth Mid., p. 69.
L. flavus in Perth West, p. 86.
L. arborum in Perth West, Perth Mid., and Perth East, p. 100.
Agriolimax lævis in Perth West, Perth Mid., and Perth East, p. 130.
Milax gagates in Perth West, p. 148.
Arion ater var. *aterrima,* in Perth West, p. 176.
A. subfuscus, var. *fuliginea,* in Perth West, p. 199 ; var. *cinereofusca,* in Perth Mid., p. 201.
A. subfuscus in Perth West, Perth Mid., and Perth East, p. 207.
A. hortensis in Perth West, Perth Mid., and Perth East, p. 224.
A. circumscriptus in Perth West, Perth Mid., and Perth East, p. 237.
Testacella scutulum in Perth West, p. 263 [Appendix].
Limax maximus in Perth West, p. 264; var. *fasciata* in Perth Mid., p. 266.
L. cinereo-niger in Perth Mid., p. 269; var. *cinereo-niger,* sub-var. *razoumowskii,* in Perth West, p. 269.
L. tenellus, var. *cerea,* in Perth West and Perth Mid., p. 270.
Agriolimax lævis in Perth Mid., p. 280.
Milax gagates, var. *rava,* in Perth West, p. 282.
Arion intermedius in Perth East, p. 291.

1908. Frank F. Laidlaw.

Shells at High Altitudes in Scotland. Jl. of Con., XII., 192.

Records of three species on Ben Lawers at 3,000 to 3,800 feet.

1908. Alex. M. Rodger and **William Barclay.**

Note on Two Shells new to Perthshire. Proc., P.S.N.S., vol. V., pp. VII. and X.

Helix rufescens and *Sphærium lacustre,* got by Mr. Fred. Smith, Jun., and Mr. Wm. Wylie, Jun.

1908. Alex. M. Rodger.

Note on *Hyalinia lucida,* Drap., new to Perthshire. Id., p. XXI.

Got at Perth by Mr. Fred. Smith, Jun.

1908. Alex. M. Rodger.

Notes on New Records of Mollusca. Id., p. LIX.

Pisidium amnicum, Hyalinia lucida, and *Helix aspersa,* got by Mr. Fred. Smith, Jun., and Mr. Jas. Leslie.

1909. J. Stewart.

The Pearl Mussel and its Fishery. Trans., P.S.N.S., V., 17.

Records of *Unio margaritifer* throughout the Tay Basin, in all tributaries of sufficient size.

1910. Alex. M. Rodger.

Note on *Paludestrina jenkinsi,* Smith, new to Perthshire. Id., p. LXIX.

Got by Mr. Wm. Barclay in the Tay, near Elcho, in 1906.

1910. Charles Oldham.

Note on *Limax tenellus* in Perth East. Jl. of Con., XIII., 148. (See also Ann. Scot. Nat. Hist., 1911, p. 123.)

Found it feeding in a birch wood at Pitlochry, also vars. *cincta* and *cerea.* In the same place he also found *Arion ater, A. intermedius,* and *A. subfuscus,* vars. *succinea* and *fuliginea.*

1910. William Denison Roebuck.

Report on the Acceleration of the Census, in 1909. Jl. of Con., XIII., 28.

Total species recorded to date, Perth West, 62; Perth Mid., 48; Perth East, 48.

1910. William Denison Roebuck.

Further Report on the Acceleration of the Census, in 1910. Id., p. 156.

v.-c. 87,	Perth West,	additions in 1910,	4,	total, 66.
v.-c. 88,	Perth Mid.,	do.	17,	do. 65.
v.-c. 89,	Perth East,	do.	19,	do. 67.

1913. B. B. Woodward, F.L.S.

Catalogue of the British Species of *Pisidium* (Recent and Fossil) in the Collections of the British Museum (Natural History). Published by Authority of the Trustees of the Museum.

References to Perthshire species:—*P. amnicum* in Perth Mid., and *P. lilljeborgii* in Perth Mid.

1914. William Evans.

An additional locality for *Succinea oblonga* in Forth Area. Scot. Nat. 1914, p. 120.

Record of the independent discovery of *S. oblonga* on the North bank of the Forth, opposite Craigforth, above Stirling, in Perth West.

1914. John W. Taylor.

Monograph of the Land and Freshwater Mollusca of the British Isles. Vol. III., Zonitidae, Endodontidae and Helicidae.

Perthshire References:—

Hyalinia cellaria, var. *compacta,* in Perth Mid., p. 37; var. *complanata,* in Perth Mid., p. 38.

H. helvetica in Perth West, p. 55.

H. alliaria, var. *viridula,* in Perth West, p. 63.

H. radiatula, var. *viridula,* in Perth Mid., p. 94; *H. radiatula,* in Perth West and Perth Mid., p. 104.

H. crystallina, var. *contracta*, in Perth West, p. 114.
Zonitoides excavatus in Perth West and Perth Mid., p. 139.
Punctum pygmæum in Perth West, Perth Mid., and Perth East, p. 166.
Pyramidula rupestris in Perth Mid. and Perth East, p. 177.
P. rotundata, var. *scalaris*, in Perth East, p. 187; var. *alba*, in Perth Mid. and Perth East, p. 190.
Helix nemoralis, var. *minor*, in Perth Mid., p. 290; var. *rubella*, in Perth Mid. and Perth East, p. 305.
H. hortensis, var. *minor*, in Perth Mid. and Perth East, p. 343; var. *roseozonata* (*vinosofasciata*, Coates) in Perth Mid., p. 353; var. *roseolabiata* in Perth East, p. 358; var. *fuscolabris* in Perth Mid., p. 359.
Helicigona arbustorum, var. *rudis*, in Perth East, p. 431; var. *picea*, sub-var. *fusca*, in Perth West, p. 432; var. *alpicola* [=*alpestris*] in Perth Mid. and Perth East, p. 436.
Punctum pygmæum in Perth Mid., p. 473 [Appendix].

1915. Henry Coates, F.S.A. Scot.

Note on Freshwater Mollusca taken at Dupplin Loch. Proc., P.S.N.S., Vol. VI., p. CI. (see also p. CVII.).

Record of 7 species taken during an Excursion of the Society on May, 24, 1915, namely:—*Anodonta cygnæa*, *Acroloxus lacustris*, *Planorbis albus*, *P. crista*, *P. contortus*, *P. fontanus*, and *Pisidium nitidum*.

1916. John W. Taylor, F.L.S., M.Sc.

Monograph of the Land and Freshwater Mollusca of the British Isles. Vol. IV., Part 22. Helicidae (continued).

Perthshire References:—
Hygromia striolata in Perth East, p. 14.
H. hispida, var. *albocincta*, in Perthshire. [Near Bridge of Allan, in Perth West; see Trans., Stirling Nat. His. and Arch. Soc., 1895-96, p. 141.]

1917. Henry Coates, F.S.A. Scot.

Note on the Occurrence of *Testacella scutulum* in Perthshire. Scot. Nat., 1917, p. 142.

Record of the finding of *T. scutulum* at the Gardens, Dunbarney House, Bridge of Earn, in Perth Mid., in April, 1917.

1917. W. D. Roebuck, F.L.S.

Census Authentications. Jl. of Con., XV., 190.

Record of *Balea perversa* got at Braco, Perth West, in August, 1908, by Mr. Fred. Smith, Jun.

1917. W. D. Roebuck, F.L.S.

Census Authentications. Id., p. 223.

Record of *Pisidium nitidum* got at Loch Dochart, Perth West, by Rev. G. A. Frank Knight.

1918. William Evans, F.R.S.E.

Note on *Pisidium personatum,* Malm., in Mid. Perth. Scot. Nat., 1918, p. 71.

Found in a Tarn at an altitude of about 3,000 feet on Cru-y-Ben, Tarmachans, near Killin, in July, 1909.

1918. W. Denison Roebuck, M.Sc., F.L.S.

Limnæa glabra as a Scottish Mollusca. Id., p. 113.

Records of its occurrence in Perth West and Perth East.

1918. W. Denison Roebuck, M.Sc., F.L.S.

Paludestrina jenkinsi in Scotland. Id., p. 142.

Record of its occurrence in Perth Mid.

1920. The late W. Denison Roebuck, M.Sc., F.L.S.

[died February, 15, 1919.]

Census Authentications. Jl. of Con., XVI., 101.

Records of *Paludestrina jenkinsi* in the Tay near Elcho by Wm. Barclay, August, 1906, and *Testacella scutulum* at Dunbarney House, near Bridge of Earn, by H. Coates, April, 1917.

1921. The late W. Denison Roebuck, M.Sc., F.L.S.

Census of the Distribution of British Land and Freshwater Mollusca. Jl. of Con., XVI., pp. 165-212. Published June, 1921, as the **Roebuck Memorial Number** of the Journal, with five Plates of Distribution Maps.

This Census contains the names of 163 species, of which 115 have been authenticated for Scotland, 66 for Perth West and Clackmannan (v.-c. 87), 65 for Perth Mid. (v.-c. 88), 64 for Perth East (v.-c. 89), and 83 for Perthshire as a whole.

1922. A. K. Lawson.

Note on *Limnæa peregra,* var. *lacustris,* from the River Tay, Perth; and *Ancylus fluviatilis,* from Millbrook, Perth.* Jl. of Con., XVI., 269.

1922. Prof. A. E. Boycott, F.R.S.

Additions to the Census of June, 1921. Id. 274.

Additional Record, *Paludestrina jenkinsi* in Perth East, per E. Crapper and H. Coates. *Azeca tridens* in Perth West, omitted from the Census through an oversight.

1922. Ellis Crapper.

Paludestrina jenkinsi in Scotland. Id., p. 275.

Describing the Perthshire records.

* "Millbrook, Perth," should be Sawmill Stream, River Tay, Perth. H.C.

IV.—TABLE OF DISTRIBUTION OF PERTHSHIRE SPECIES.

No.	NAME.	SYNONYM.	Perth West. 87.	Perth Mid. 88.	Perth East. 89.	Brit. Vice-Counties. 153.	Scot. Vice-Counties. 41.	Perth Nat. Hist. Mus.
	TESTACELLIDAE.							
1	Testacella scutulum,	[=T. haliotidea, var. scutulum.]	[87]	88	—	47	5	Mus.
	LIMACIDAE.							
2	Limax maximus,	———	87	88	89	144	36	Mus.
3	L. cinereoniger,	———	87	88	—	64	13	—
4	L. tenellus,	———	87	88	89	23	6	—
5	L. arborum,	L. marginatus.	87	88	89	137	37	Mus.
6	Agriolimax agrestis,	L. agrestis.	87	88	89	153	41	Mus.
7	A. lævis,	L. lævis.	87	88	89	105	28	Mus.
8	Milax sowerbyi,	L. sowerbii	87	—	—	94	9	—
9	M. gagates,	L. gagates.	87	—	—	87	10	—
	ZONITIDAE.							
10	Vitrina pellucida,	———	87	88	89	148	39	Mus.
11	Hyalinia crystallina,	Zonites crystallinus.	87	88	89	147	38	Mus.
12	H. lucida,	H. drapardnaldi.	—	88	89	56	9	Mus.
13	H. cellaria,	Zonites cellarius.	87	88	89	152	40	Mus.
14	H. helvetica,	Z. glaber.	[87]	—	—	69	10	—
15	H. alliaria,	Z. alliarius.	87	88	89	148	41	Mus.
16	H. nitidula,	Z. nitidulus.	87	88	89	147	36	Mus.
17	H. pura,	Z. purus.	87	88	89	137	33	Mus.
18	H. radiatula,	Z. radiatulus.	87	88	89	142	35	Mus.
19	Euconulus fulvus,	Z. fulvus.	87	88	89	143	39	Mus.
20	Zonitoides nitidus,	Z. nitidus.	87	—	89	112	15	—
21	Z. excavatus,	Z. excavatus.	87	88	—	67	15	—

No.	NAME.	SYNONYM.	Perth West. 87.	Perth Mid. 88.	Perth East. 89.	Brit. Vice-Counties. 153.	Scot. Vice-Counties. 41.	Perth Nat. Hist. Mus.
	ARIONIDAE.							
22	Arion ater,	———	87	88	89	151	41	Mus.
23	A. subfuscus,	A. flavus.	87	88	89	132	35	Mus.
24	A. minimus,	A. intermedius.	87	88	89	133	33	—
25	A. hortensis,	———	87	88	89	150	38	Mus.
26	A. circumscriptus,	A. bourguignati.	87	88	89	145	41	Mus.
	HELICIDAE.							
27	Punctum pygmæum,	Helix pygmæa.	87	88	89	127	30	Mus.
28	Pyramidula rupestris,	H. rupestris.	—	**88**	89	84	4	Mus.
29	P. rotundata,	H. rotundata.	87	88	89	151	40	Mus.
30	Helicella virgata,	H. virgata.	87	—	—	94	3	Mus.
31	Ashfordia granulata,	H. sericea.	—	—	89	74	18	—
32	Hygromia fusca,	H. fusca.	87	88	89	86	26	Mus.
33	H. hispida,	H. hispida [+ H. concinna].	87	88	89	137	26	Mus.
34	H. striolata,	H. rufescens.	87	**88**	89	123	15	Mus.
35	Acanthinula aculeata,	H. aculeata.	87	88	89	120	24	Mus.
36	A. lamellata,	H. lamellata.	87	88	89	56	19	Mus.
37	Vallonia costata,	H. pulchella, var. costata.	—	88	89	88	9	Mus.
38	V. pulchella,	H. pulchella.	87	88	89	134	18	Mus.
39	Arianta arbustorum,	H. arbustorum.	87	88	89	113	39	Mus.
40	Helix aspersa,	———	87	88	89	138	30	Mus.
41	H. nemoralis,	———	87	88	89	138	28	Mus.
42	H. hortensis,	[= H. nemoralis, var. hortensis]	87	88	89	126	36	Mus.
	BULIMINIDAE.							
43	Ena obscura,	Bulimus obscurus.	—	88	89	99	16	Mus.

	STENOGYRIDAE.							
44	Cochlicopa lubrica,	Zua lubrica.	87	88	89	153	41	Mus.
45	Azeca tridens,	———	**87**	—	—	52	1	—
	PUPIDAE.							
46	Pupa umbilicata,	P. cylindracea.	87	88	89	151	40	Mus.
47	P. anglica,	P. ringens.	87	88	—	78	21	—
48	Vertigo antivertigo,	———	**87**	—	89	89	12	Mus.
49	V. substriata,	———	87	88	—	71	18	—
50	V. pygmæa,	———	87	88	89	125	27	Mus.
51	V. pusilla,	———	87	—	—	27	4	—
52	Sphyradium edentulum,	Vertigo edentula.	87	88	89	115	32	Mus.
53	S. minutissimum,	V. minutissima.	—	—	**89**	11	3	Mus.
	CLAUSILLIIDAE.							
54	Balea perversa,	———	87	88	89	129	32	Mus.
55	Clausilia laminata,	———	—	—	89	61	3	Mus.
56	C. bidentata,	C. rugosa [=C. perversa].	87	88	89	146	36	Mus.
	SUCCINEIDAE.							
57	Succinea putris,	———	**87**	88	89	136	29	Mus.
58	S. elegans,	———	87	—	89	123	19	—
59	S. oblonga,	———	87	—	—	22	3	Mus.
	AURICULIDAE.							
60	Carichium minimum,	———	87	88	89	141	34	Mus.
	ANCYLIDAE.							
61	Ancylus fluviatilis,	———	87	88	89	137	37	Mus.
62	A. lacustris,	A. oblongus.	87	88	89	86	11	Mus.

No.	NAME.	SYNONYM.	Perth West. 87.	Perth Mid. 88.	Perth East. 89.	Brit. Vice-Counties. **153.**	Scot. Vice-Counties. **41.**	Perth Nat. Hist. Mus.
	LIMNAEIDAE.							
63	Limnæa peregra,	———	87	88	89	153	41	Mus.
64	L. burnetti,	[= L. peregra, var. burnetti].	—	—	89	5	2	Mus.
65	L. palustris,	———	87	88	89	127	21	Mus.
66	L. truncatula,	———	87	88	89	145	37	Mus.
67	L. glabra,	———	[**87**]	—	89	34	4	Mus.
	PLANORBIDAE.							
68	Planorbis albus,	———	87	88	89	128	24	Mus.
69	P. glaber,	P. parvus.	87	—	—	52	13	—
70	P. nautileus,	———	87	**88**	89	113	25	Mus.
71	P. leucostoma,	P. spirorbis.	87	—	89	125	20	Mus.
72	Bathyomphalus contortus,	P. contortus.	87	88	89	120	28	Mus.
73	Hippeutis fontanus,	P. nitidus.	87	88	—	97	13	Mus.
	PHYSIDAE.							
74	Physa fontinalis,	———	87	88	89	119	19	Mus.
75	Aplexa hypnorum,	Physa hypnorum.	87	88	89	97	8	Mus.
	PALUDESTRINIDAE.							
76	Paludestrina jenkinsi,	[Paludestrina = Hydrobia]	—	88	**89**	69	2	Mus.
	VALVATIDAE.							
77	Valvata piscinalis,	———	87	88	89	121	20	Mus.
78	V. cristata,	———	—	**88**	—	95	12	Mus.

	DREISSENIDAE.								
79	Dreissensia polymorpha,	——	—	88	—	38	5	Mus.	
	UNIONIDAE.								
80	Margaritana margaritifera,	Unio margaritifer.	87	88	89	60	21	Mus.	
81	Anodonta cygnea,	——	—	88	89	86	12	Mus.	
	CYRENIDAE.								
82	Sphærium corneum,	Cyclas cornea.	87	88	89	131	25	Mus.	
83	S. lacustre,	C. lacustris.	—	88	—	93	10	Mus.	
84	Pisidium amnicum,	——	87	88	—	95	6	Mus.	
85	P. casertanum,	——	87	88	**89**	114	16	Mus.	
86	P. hibernicum,	——	—	**88**	—	69	4	Mus.	
87	P. lilljeborgii,	——	—	88	**89**	27	5	Mus.	
88	P. milium,	P. roseum.	—	**88**	**89**	102	8	Mus.	
89	P. nitidum,	——	—	**88**	**89**	110	10	Mus.	
90	P. obtusale,	——	—	**88**	**89**	92	8	Mus.	
91	P. personatum,	——	87	**88**	**89**	90	13	Mus.	
92	P. pulchellum,	——	—	**88**	**89**	51	4	Mus.	
93	P. subtruncatum,	P. fontinale.	—	**88**	**89**	114	10	Mus.	
	Species, Total Records for each Vice-county, - - -		73	76	74	—	—	—	
	Species, Total British and Scottish Records, - - - -		—	—	—	163	121	—	
	Species, Total Perthshire Records, - - - - - - -		—	—	—	—	—	—	93
	Species, Total Species represented in Perth Nat. Hist. Mus.,		—	—	—	—	—	78	
	Species, Total "Wanted to Complete" in do. do.		—	—	—	—	—	15	

Records already in W. D. Roebuck's Census of June, 1921, are given in Ordinary Type.

New Records, not in the Census, are given in Heavy Type.

PERTH, *March, 1922.*

HENRY COATES.

XVII.—*Geological Deductions from the Strata passed through in the Artesian Boring at the Water House, Perth, August, 1917.*

By Henry Coates, F.R.S.E.

(Read 8th February, 1918.)

Although the boring carried out at the Perth Water House last summer was not successful from an economic point of view, it has yielded some exceedingly interesting geological results. It so happens that the point where the bore is situated is one where several stratigraphical problems of considerable complexity present themselves, and never before, on the actual site of Perth itself, have we been able to see, as it were, into the solid crust of the earth, to a depth of 450 feet. As this depth is equivalent to more than the height of Craigie Wood Hill, which rises to the south west, it is evident that it very considerably enlarges our range of vision. When we come to examine the contents of the bore, we shall find that they contain examples of the three phases of geological activity represented in the deposits of Strathmore and the lower reaches of the Tay valley,—phases widely separated from each other in point of geological time. Before making a detailed examination of the bore, however, let us make a general survey of the stratigraphical framework which surrounds it.

The Water House, inside which the bore was drilled, is situated at the corner of Tay Street and Marshall Place, with the north-east corner of the South Inch opposite to it on the south, and the River Tay opposite to it on the east. The bore is 31 yards west from the river, and starts at an elevation of 18.2 feet above Ordnance Datum, the latter being very little below the mean level of the river at this point. Referring now to the geological map of the district, we find that this point lies in the middle of the alluvial deposits of the River Tay, which is here still flowing due south, although a mile further on it turns abruptly to the east. This alluvial plain, on which stand the City of Perth and its two Inches, is made up of the lower and upper haughlands of the river's most recent action. To the east it is flanked by the steeply rising western slope of Kinnoull Hill, composed entirely of a series of volcanic rocks—andesites, tuffs and agglomerates—of Old Red Sandstone age. To the west it is flanked by the much more gentle slope of the undulating hills which lie between the Almond and the Earn, and which are made up of massive beds of the Lower Old Red Sandstone. Both these sandstones to the west and the volcanic rocks to the east dip moderately steeply to the north-west, that is, towards the central axis of Strathmore, the horizon of the volcanic rocks being underneath that of the sandstones. The actual dip in the bore is about 8½ degrees.

So far, the geotectonic structure is comparatively simple. It is when we turn our eyes southwards that perplexities arise. Immediately to the south, just beyond the bend of the river at the south end of Moncreiffe Island, we encounter another barrier of volcanic formation, forming the range of hills lying between the Tay and the lower course of the Earn from Forgandenny downwards. This range, which is about five miles long, embraces Craigie Wood Hill, Kirton Hill, and Moncreiffe Hill. The beds of which it is made up are identical with those of Kinnoull Hill, which they underlie, and they dip in the same direction—towards the north-west—and at practically the same angle. They are, therefore, evidently a continuation of the same series, and form a south-western outlier of the Sidlaw range.

The very statement of these topographical facts brings us face to face with one of the local problems to which I have referred. Why has the River Tay, so to speak, dashed its head against this rocky barrier to the south, and then continued its course eastwards and seawards along the summit of what is really an anticlinal arch? Why did it not find an outlet to the sea along the trough of the Strathmore syncline to the north, or, at least, if it was determined to choose a channel between the Sidlaws and the Ochils, why did it not skirt round the western flank of the Moncreiffe Hill range? These questions cannot be answered in a sentence, but I think the solution may be summed up in the two terms, Fault and Dip. It may perhaps enable us to find the key to the puzzle more easily if we first examine the course of the lower Earn valley, from Forgandenny down to its junction with the Tay valley, and thence eastwards through the Carse of Gowrie, which, as we shall find presently, is the true continuation of the Earn valley, both topographically and geologically. The topographical unity is evident on any map of the district, where the general trend of the respective alluvial areas is seen to be continuous, the one with the other. Geologically, the homologous structure is seen when we trace the two parallel lines of fault which bound first the lower Earn valley, and then the Carse of Gowrie, on their northern and southern flanks respectively. The most northerly of these faults runs continuously along the foot of the southern escarpment of Moncreiffe Hill, from Craigend to Fingask, where it disappears under the alluvial deposits of the Tay, and under the River Tay itself. It reappears on the northern side of the Carse of Gowrie about Kinnaird, at the foot of the southern escarpment of the Sidlaws, and thence continues right down to Dundee. The line of fault on the southern boundary of the lower Earn valley commences at Glenearn, and passes by Dron, Abernethy, and Newburgh, at the foot of the northern escarpment of the Ochils, after which it is lost beneath the alluvial deposits of the Carse. We thus see that the River Earn and its continuation eastwards, the Tay below the junction, run continuously between these two lines of fault, whereas the River Tay, before its junction with the Earn, *cuts across* the northern fault. These two faults, however, are not merely the boundaries of what we may call, for want of a better name, the Earn-Gowrie valley—they are actually the cause of it. The reason of this is that they enclose what is called a Fault-trough, that is to say, the strata of solid rocks between them have sunk down in a wedge-like mass, while the strata to the north and south of them, outside of the trough, have been correspondingly forced up, during some great secular upheaval and fracturing of the earth's crust in this region, subsequent to the laying down of the Old Red Sandstone and Carboniferous formations. That it was subsequent to carboniferous times is evident from the fact that a small remnant of carboniferous strata has been preserved at Dron by being thrust down into the trough, and thus preserved from denudation and obliteration.

Now, we have accounted for the Tay choosing a course along the Carse of Gowrie, where, following the good example of the Earn, it takes the line of least resistance, along the channel prepared for it by the formation of the Fault-trough. We have not yet, however, brought it into the "Channel of Ease," that is to say, we have not yet accounted for the part of its course from the Water House down to its junction with the Earn. This course consists of three sections:—First, from the Water House to Easter Tarsappie, approximately south-east, or in line with the dip of the rocks; Second, from Easter Tarsappie to Sleepless Island, approximately north-east, or in line with the strike and outcrop of the rocks; and, Third, from Sleepless Island to the junction with the Earn, approximately south-east again, or again in line with the dip of the rocks. These changes of direction must not be confused with the windings of a stream athwart its alluvial plain, for we are here dealing with a river confined between ramparts of solid volcanic rock. The second section is the easiest to account for, because a stream can with comparative ease find its way along the plane of bedding of inclined strata, especially where, as at this point, a rather more friable series of beds crops out to the surface. Such are the beds of volcanic ash and agglomerate which here present themselves, interbedded between the more solid lavas.

We have now pushed our problem back to its furthest and also its hardest limit. How did the Tay hack its way through—to use a now familiar phrase—between the volcanic rocks which bound it on either hand in the region which the City of Perth now occupies?

What makes this the more difficult to explain is the fact that to do this it had actually to work against the slope of these hard rocks, which dip towards the north-west, and therefore rise towards the south-east. Here, again, I think we must look for a solution in the development of faults. On either side of the river channel at this point there are smaller subsidiary faults, running approximately from north-west to south-east, that is, at right angles to the great faults bounding the Earn-Gowrie valley, already described. These transverse faults, as they might be called, would doubtless produce local dislocations and displacements of the strata, which would induce runnels to be formed by the streamlets draining the hill itself, and these in time might easily cut their way down through the fractured rocks, until at length a channel was prepared for the mightier waters from the north. The two faults to which I have referred may be traced—the one running from Cleeve through Cherrybank and Kirton Hill to a point east of Hilton junction, and the other cutting across the extreme west corner of Kinnoull Hill, and losing itself under the alluvial deposits of Lairwell. It is probable that the third section of the winding course, from Sleepless Island to the junction with the Earn, is to be explained by a similar set of circumstances.*

I may appear to have digressed far from the boring in the Water House, but yet I think you will agree with me that the problems of local stratigraphy which I have endeavoured to bring before you are of sufficient importance to rouse our interest in what the bore has to reveal to us in regard to the strata existing at hitherto unknown depths. Let us now see what these strata are, and their relative vertical extension.

Taking the records kept by the water manager, Mr. Robert Stewart, and by the boring engineer, Mr. Robert Henderson, and collating them with what we know of the stratigraphical succession of the district, I make out the complete record to be as follows :—

*For these Faults, and the relation of the different sections of the Tay Valley to Strathearn and the Carse of Gowrie, see the Sketch Map of the Lower Basin of the Tay, on page 252.

I have to express my indebtedness to Mr. Thomas McLaren for valuable assistance in preparing the Diagrams which accompany this paper.

	FT.	IN.	FT.	IN.
MADE UP MATERIAL (Broken Bricks, Stones, etc.),	...	...	23	0
1. RECENT RIVER DEPOSITS (Fine Sand & Gravel),	...	...	22	0
2. ANCIENT RIVER DEPOSITS :				
Fine Soft Brown Clay, ...	40	0	...	...
Soft Brown Muddy Sand and Clay, ...	50	0	...	...
Hard Bound Sand, ...	3	0	...	...
Soft Brown Muddy Sand, ...	25	6	...	...
			118	6
3. BOULDER CLAY (Glacial), ...	...	...	57	6
4. OLD RED SANDSTONE SERIES :				
Broken Sandstone (Brash), ...	2	0	...	...
Sandstones proper, ...	12	0	...	...
Conglomerate and Grit, ...	56	0	...	...
			70	0
5. INTERBEDDED VOLCANIC SERIES (of old Red Sandstone Age) :				
Agglomerate and Tuff, ...	26	0	...	...
Andesite (Lava), ...	87	6	...	...
Tuff (Volcanic Ash), ...	1	6	...	...
Amygdaloidal Porphyrite (Vesicular Lava),	22	6	...	...
Tuff, ...	21	6	159	0
TOTAL DEPTH OF BORE, ...			450	0

Leaving out of account altogether the artificial made-up material, this record divides itself into two well-defined groups of strata, namely, 198 feet of detrital material above, and 229 feet of solid rocks below. The first of these groups may be further sub-divided into Recent River Deposits, Ancient River Deposits, and Boulder Clay; while the second group may be sub-divided into the series of Old Red Sandstone deposits, and the series of Volcanic Rocks of contemporaneous age. We may glance at each of these sub-divisions in turn, taking them in descending order, and see what geological lessons we can derive from each.

1. The Recent River Deposits, 22 feet. These consist of beds of fine sand and gravel. They are analogous to what we find in the upper and lower haughlands of the surrounding district, which have been built up by the river within recent times, and working at approximately its present level. The beds are roughly stratified, with some examples of false bedding. The depth is about what we should have anticipated, for these recent river deposits are invariably found spread over the alluvial area in a comparatively thin sheet.

2. The Ancient River Deposits, 118 feet 6 inches. These consist, for the most part, of soft clays and muddy sands of a brown colour. This result is highly suggestive, occurring at this

particular part of the Tay valley. It has to be borne in mind that these beds are intercalated between the Boulder Clay below and the Recent River Deposits above, which means that they were laid down after the close of the great Ice Age, and before the advent of present topographical conditions. In other words, they are the result of the work of the river after the Great Ice Sheet had receded from the Central Valley of Scotland, and before the river had settled down to its work under present-day conditions. Now, what do we find in this series of deposits? We find, not beds of sand and gravel, but tumultuous deposits of clay and muddy sand, scores of feet in thickness, showing that the river had great masses of detritus to deal with, which it was not able to carry with it to its lower reaches, and which it was not able to sift out into successive beds of finer and coarser deposits. The source from which it derived this vast store of material was doubtless the immense accumulation of clay and mud which the Ice Sheet left as a legacy on the plain of Strathmore as it gradually melted backwards towards the mountains, which, in turn, were the source from which much of it had come. A still more significant feature of this section of the bore, and one for which, I confess, I was not prepared, is the entire absence of the blue Carse Clays which are such a characteristic feature of the older deposits both of the Carse of Gowrie and the Earn Valley.

The great thickness of the Ancient River Deposits is to be accounted for not only by the fact that the river had more material to work upon then than now, but also that several changes of level took place during Post-glacial times. First, there was the great upheaval, when Scotland, in common with the rest of north-western Europe, was elevated some hundred feet or more, which would tend to increase the denuding activity of the river. Next came a period of corresponding subsidence, when the Earn Valley and the Carse of Gowrie became filled up with estuarine or fluvio-marine deposits. Lastly, there followed a minor elevation of the land, which forced the sea to retire once more and enabled the river to resume its normal functions. It was then that it began to build up the Recent River Deposits which we have already considered. To my mind, the absence of the blue Estuarine or Carse Clay from this portion of the Tay Valley, as revealed in the bore, seems to suggest two things—first, that the estuarine conditions did not extend across the barrier of Moncreiffe Hill into the portion of the Tay Valley to the west of Kinnoull Hill; and, second, that the Carse of Gowrie is, as I have already hinted, the true geological continuation of the Earn Valley, rather than of the Tay Valley. I would go further and venture the opinion that the waters of the Earn flowed down the Carse of Gowrie long before the waters of the Tay had eaten their way into that channel. We find further proof in this supposition in the fact that in the boring we find no trace of the Buried Forest Beds which are so frequently intercalated with the clays of the Earn Valley and Carse of Gowrie.

3. The Boulder Clay, 57 feet 6 inches. This deposit consists of a stiff unstratified clay, with boulders scattered through it, and represents the work of the Ice Sheet itself, in grinding down and transporting the rock material which it encountered in its progress from the mountains towards the sea. Running water has had no part in the building of this deposit. The feature to be noted about the Boulder Clay as represented in the bore is its very considerable depth. If a bed more than fifty feet thick still remained undenuded after the river had been acting upon it for untold years, we can have some conception as to the vast accumulations which must have covered the whole surface of the land immediately after the final melting of the ice. We have here also a hint as to the potency of the ice as an eroding agent, for it must have helped to carve out the valley at this point to a depth of nearly 200 feet.

4. The Old Red Sandstone Series, 70 feet. This series is represented by 14 feet of sandstone, of which the first two feet consist of the usual brash, or broken strata, while underneath are 56 feet of conglomerate, graduating into coarse grit. We naturally expect these rocks to appear first, for they overlie the volcanic rocks. Yet in the neighbouring slope of Kinnoull Hill, immediately to the east, they are entirely wanting, the volcanic rocks stretching down to the very edge of the alluvial plain. To the west, however, they crop out from beneath the edge of the alluvial deposits, although they are soon interrupted by the mass of volcanic strata forming Craigie Wood Hill. This mass, in turn, is abruptly cut off by the subsidiary transverse fault already referred to, which runs through Cherrybank. As this Craigie Wood Hill, although much higher than the sandstone areas on either side of it, actually consists of older and underlying rocks, it is evident that it must owe its origin to upheaval, fracturing, and faulting, and it is natural to infer that the adjoining river channel owes its origin, at least in part, to the same causes.

5. The Interbedded Volcanic Series, of Old Red Sandstone Age, 159 feet. This was the last series of rocks passed through before boring was stopped at a depth of 450 feet from the surface. It consists of the usual succession of lavas, agglomerates, and beds of volcanic ash, similar to those found in other parts of the Sidlaw range.* Some of the lavas are finer grained than others, while some are amygdaloidal in structure, with larger or smaller vescicles, or steam cavities, filled with secondary minerals. The successive beds of agglomerate and tuff occupy pretty much the

* See Proceedings, Vol. VI., Part V., p. ccxviii., for description of the microscopic structure of these rocks by Mr. G. F. Bates.

horizons we should expect, corresponding to the beds of these rocks which crop out at the foot of the escarpment of Kinnoull Hill to the south-east. The andesites also correspond to the massive beds which form the familiar cliffs overlooking the Tay. The amygdaloidal zone is probably that which is exposed at the entrance of Corsiehill Quarry, about a mile to the east.

In the foregoing summary of the contents of the bore, I have tried to correlate each division and sub-division to its corresponding horizon in the surrounding stratigraphical complex, and in doing so I have endeavoured to deduce some of the lessons which it has to teach us regarding the geological history and physiographical evolution of the district. In closing, it may be of interest to try to picture to ourselves some of the scenes which have been enacted in the long drama which that history embraces.

The opening scene, represented by the volcanic rocks at the bottom of the bore, reveals an ancient sea, stretching northwards towards the slopes of the distant mountains. That sea has already been in existence for many long years. Its floor is covered with vast deposits of brown sand, and its northern and southern margins with accumulations of pebbles, representing the ruins of a once lofty mountain range. In this sea, which is probably not very deep, live armour-clad fish and gigantic crustaceans. In the foreground, a range of low volcanic islands stretches away towards the east, from the vents of which there issue at intervals showers of rock fragments and volcanic dust, followed by streams of lava which flow far and wide over the islands, and under the shallow sea.

Scene two brings us to a period when the volcanoes have become quiescent, and when the placid sea again covers the foreground of the picture. The beds of ash, lava and volcanic fragments are now almost obliterated by fresh deposits of sand and gravel brought down by the rivers into the sea.

Our third scene brings us at a single bound from one of the most ancient to one of the most recent epochs in the earth's history. In our bore the Boulder Clay rests directly on the Old Red Sandstone, yet between the laying down of these two deposits whole eons of geological time have come and gone, leaving not a trace behind. The scene is now one of profound desolation. As far as the eye can reach, an unbroken plain of ice stretches away to the north-west, where a few isolated mountain peaks may be seen rising above the arctic expanse of glistening white. In the foreground a range of hills now rises where formerly the volcanic islands stood, but even that is entirely obliterated by the mantle of ice which is slowly pushing its way seawards over every obstacle, grinding the rocks to powder and smoothing the contours of the hills as it does so.

Scene four opens when the rigours of the Arctic night have

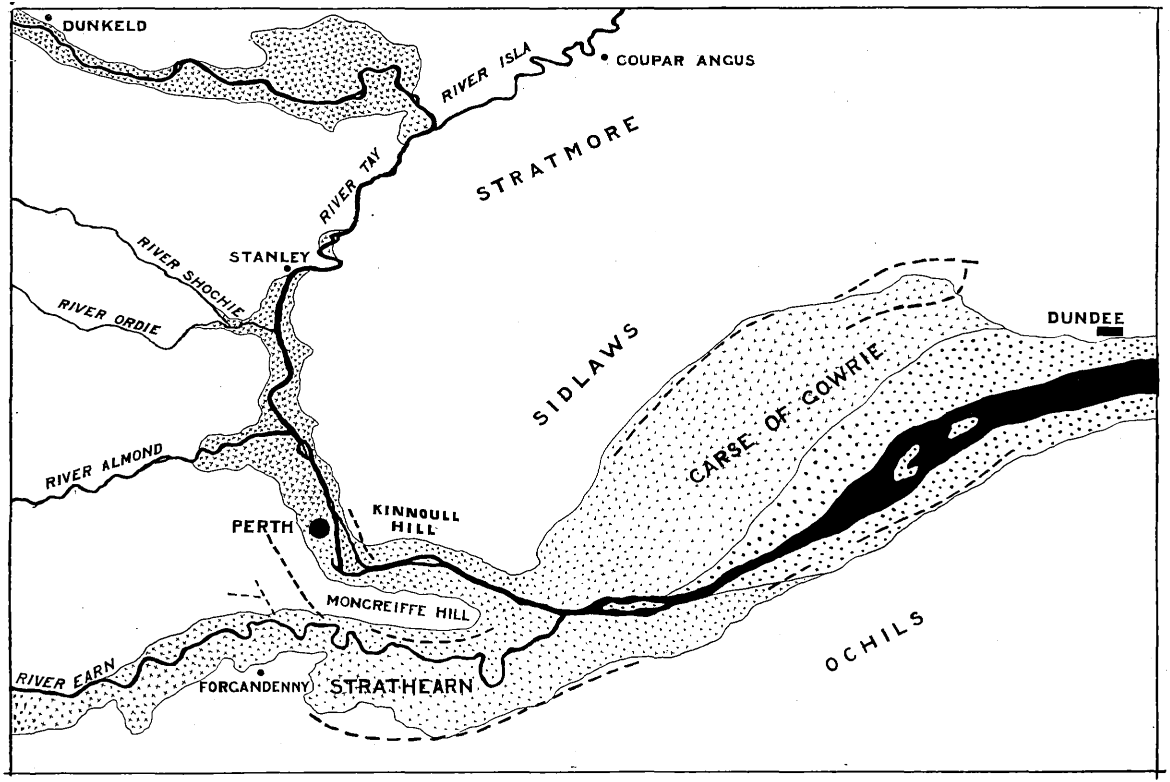


Plate 28.

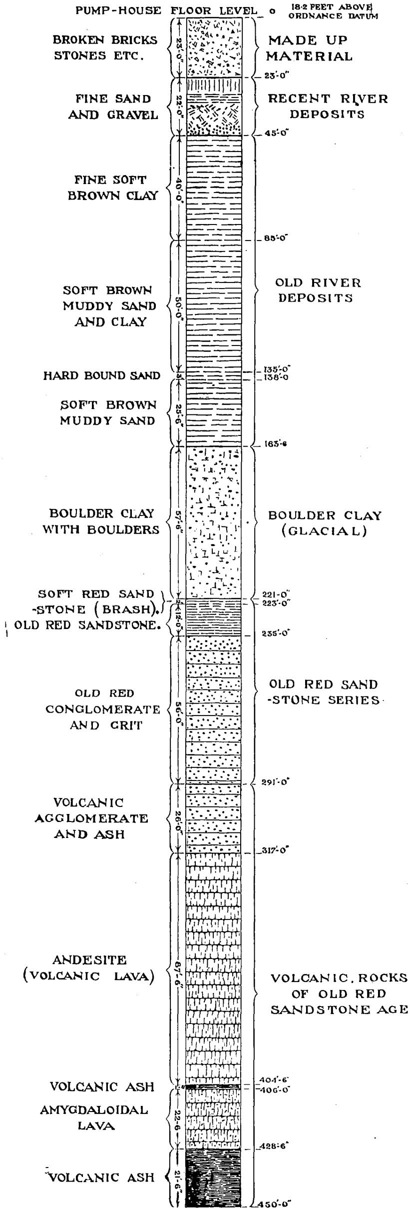
Sketch Map of the Lower Tay Basin. Showing the Relation of the Tay to the Sidlaws, and of Strathearn to the Carse of Gowrie.

The areas with the crosses are the Upper and Lower Haughlands of the River.

The areas with the dots are the Tidal Mud Banks of the Carse.

The Faults are indicated by broken lines.

SECTION OF STRATA IN ARTESIAN BORING AT PERTH WATER-WORKS.



AUGUST 1917.

Plate 29.

GEOLOGICAL SECTION THROUGH TAY VALLEY AT WATER WORKS.

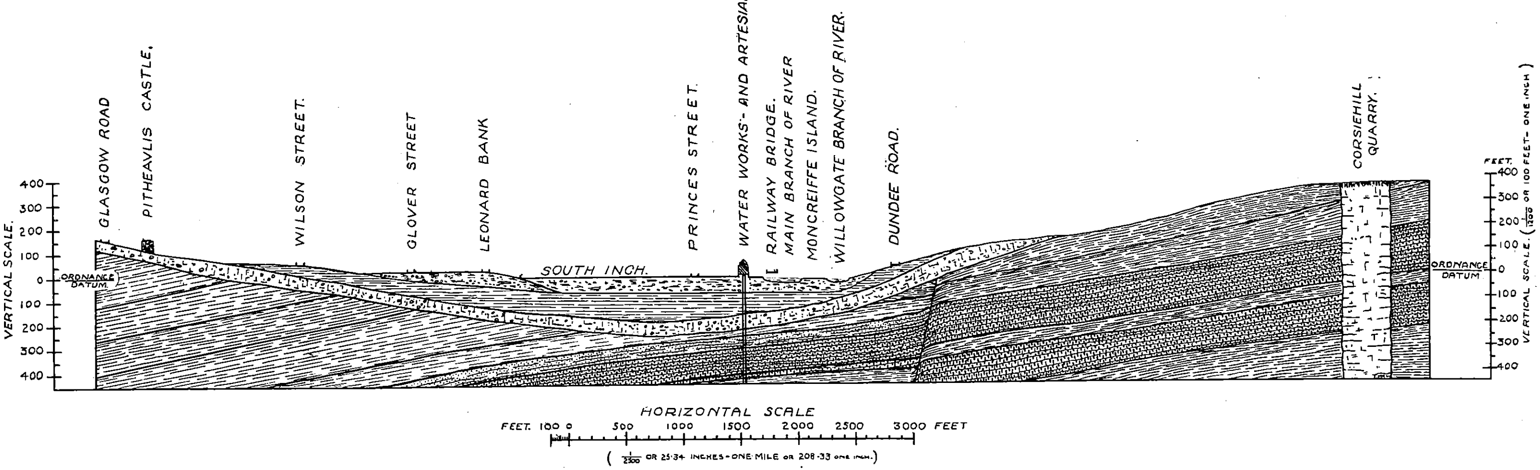


Plate 30.

passed away, and, with it, the ice-cap which had covered the land. In its place it has left a scene of inexpressible confusion. The plain of Strathmore, stretching between the nearer hills and the more distant mountains, is heaped up with vast mounds and hummocks of mud and clay, intersected by turbid streams, and dotted over with swamps and lakes.

Our final scene brings us a picture of order and beauty which has been evolved out of the chaos and ruin of the Ice Age through the beneficent agency of the river, which has smoothed out the wrinkles from the face of old Mother Earth, and prepared the valley floor for the transforming activities of plant and animal life.

Thus these five scenes, suggested by the contents of our bore, bring us down to present-day conditions on the earth's surface. What makes them the more impressive is the thought that the gaps unrepresented in the record are vastly greater than the periods actually represented, and yet all this orderly sequence of events took place long before any human intelligence was in existence to mark their progress. In face of such facts as these it is impossible not to believe that a higher Intelligence was at work, shaping the evolving forces of nature to a beneficent end.

XVIII.—*Louis Pasteur.*

1822—1895.

By GEORGE F. BATES, B.A., B.Sc.

(Read 9th March, 1923.)

Two days after Christmas, 1822, there was born at the little town of Dôle, in eastern France, one who was destined to play a great part on the stage of human life. This was Louis Pasteur, who, directly and indirectly, did more than any other worker to alleviate the sufferings of mankind and to save his fellow-mortals from premature and unnecessary death. On the 27th December, 1922, the bells of Dôle rang out in celebration of the centenary of Pasteur's birth, and were answered by the bells of all the neighbouring towns and villages. Paris and New York also kept the great man's birth in mind, and almost every newspaper of importance published an article on his life and work. From May to October, 1923, an exhibition will be held at Strasbourg, where for a time he occupied an important post; and a monument will be dedicated to his memory.

I propose this evening to discuss in an elementary manner the main features of Pasteur's scientific work. His personal life and character are full of interest, but time will only permit of the briefest allusions thereto.

Though born at Dôle, Pasteur spent his boyhood at the neighbouring town of Arbois, where his father, an old soldier of Napoleon's army, carried on the business of a tanner. Here Pasteur received his early education, but his great ambition was to become a "Normalien," *i.e.*, a student of the famous École Normale at Paris. With this end in view he was sent at the age of 16 to a preparatory school in the Quartier Latin. But he could not settle in his new surroundings—he longed for the smell of the tannery, and became so home-sick that his health broke down and he was obliged to return to Arbois. Later on he entered the Royal College at Besançon, where in 1840 and 1842 he obtained the preliminary degrees which entitled him to become a candidate for the Ecole Normale. But, as has happened so often, his genius was undeveloped or unrecognised, and the man who in a few years was to become famous as a chemist had been classed as "mediocre" in chemistry. A further year of study was necessary before he was finally admitted to the Ecole Normale.

Here he worked under the direction of two of the most famous scientific men of the day—Dumas (1800—1884), widely known for his investigations into several branches of chemical theory, and Biot (1774—1862), a physicist noted for his researches on polarised light, and the inventor of the polarimeter.

A lecture by Dumas at the Sorbonne gave the inspiration, and an appointment as laboratory assistant gave the opportunities for original work, and, curiously enough, his first investigation brought him into notice and established his position as a research worker of the highest type, winning the enthusiastic praise of his contemporaries, and particularly of the somewhat emotional Biot. I shall now endeavour to give a brief account of these early investigations, keeping myself free, as far as possible, from technical language.

Most people know that during the fermentation of grape juice to form wine, there is deposited in the vats a substance known as argol, which after purification becomes cream of tartar, familiar to every housewife. From cream of tartar the almost equally familiar tartaric acid can be readily obtained, and had, in fact, been isolated by the chemist Scheele as far back as 1769. Some fifty years later a substance closely resembling tartaric acid, but differing from it in certain respects, was found in the grape-vats at Thann in Alsace. Various investigators worked at it, one of whom gave it the name of Trauben-säure—acid of grapes, though in English it is commonly known as racemic acid, from Lat. *racemus*, a bunch of grapes. It was reserved for the Swedish chemist Berzelius (1779—1848) to prove that tartaric acid and racemic acid were identical in composition. This discovery was of the nature of a bomb-shell, for up to that time it was believed that no two different compounds could have the same composition—*i.e.*, be made up of the same elements combined in the same proportions. It is true that there had been more than one suggestion of such compounds, *e.g.*, the chemist Wöhler had shown in 1828 that the compounds Urea and Ammonium cyanate had the same composition, but at the time of which we speak it was generally believed that some error had been made in the analyses. At the present time a very large number of cases is known in which groups of two or more differing compounds has been proved to have the same composition, and such groups are known as isomers, or isomeric compounds. (It may be remarked here that racemic acid was somewhat of a mystery in more ways than one. It appeared almost invariably in the manufacture of tartaric acid from argol, but it was reserved for later investigators to reveal the conditions under which it was formed. These are now well known, and by avoiding them the appearance of racemic acid can be reduced to a minimum). Among the differences between tartaric acid and racemic acid, the physicist Biot, already mentioned as one of Pasteur's teachers, had found that if a ray of polarised light is passed through a solution of tartaric acid, the plane of polarisation is rotated to the right, while racemic acid under like conditions had no effect.

Pasteur, having undertaken researches on crystals, was led to examine the salts of the two acids—the tartrates and racemates. He knew that tartrates were usually hemihedral—that is, that the crystals showed only one half of the normal number of faces appropriate to the crystalline system; while the racemates were holohedral—that is, the crystals showed the full number of such faces. But on examining crystals of ammonium sodium racemate, Pasteur found that the crystals were hemihedral, and that they could be separated by hand into two groups, each group composed of crystals which resembled those in the other group in the same way as a right hand resembles a left, or as an object resembles its mirror-image. From the two forms the corresponding acids were prepared by processes well known to chemists, and it was then found that one acid was just the old familiar tartaric acid, and the other a new form of the same acid, differing from the original chiefly in the fact that its solution rotated the plane of polarisation of light to the left. By recombining the two forms the original racemic acid was obtained, and thus it was found that this acid is composed of two different forms of tartaric acid, and its optical inactivity is due to the fact that these properties of the components neutralise one another. The two forms of tartaric acid constitute the first known example of optical isomerism. To chemists to-day it appears fairly obvious that if two different substances contain the same components in the same proportions, the difference can only be due to a different arrangement in space of these components. The branch of chemistry which deals with such space arrangements is known as stereo-chemistry, and Pasteur must be regarded as the founder of stereo-chemistry, though the Dutch chemist, Van't Hoff (1852—1911) put the theory into its present form.

Let me try to give you an idea of the theory, which has led to the most important results in chemistry. Two points must be noted :—

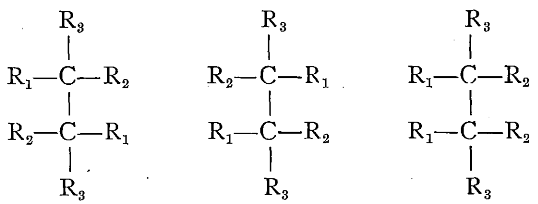
(i) The carbon atom is capable of uniting with four other atoms or groups of atoms.

(ii) The carbon atom and its associates are assumed to be grouped tetrahedrally—the carbon atom being at the centre and one other atom, or group, at each angle.

(Models were shown to illustrate these points.)

Now the atoms united with the carbon may be all alike, or unlike, in any proportions. In the extreme case they are all unlike, and the carbon atom is said to be asymmetrical. By a process of trial and error with models we may show that two, and two only, essentially different arrangements are possible in a molecule with one asymmetrical carbon atom, and these two arrangements are assumed to represent the two isomeric compounds which are possible under these condtions.

But if the molecules of the substances contain two asymmetrical carbon atoms the possibilities are enormously increased. In these cases it is assumed that the carbon atoms are united to one another and each of them to three other atoms (or groups). If we call the carbon atoms (a) and (b), the other atoms united to (a) may be all different, not only from one another, but from the atoms united to (b), and the case becomes exceedingly complicated. But if the atoms (or groups) united to (a) are the same as those united to (b), the matter is largely simplified, and luckily this is the case with tartaric acid. By trial and error with models we can find out that three essentially different arrangements are possible, which may be represented "on the flat" as below :—



(1) (2) (3)

It will be noted that formulae (1) and (2) are mirror-images of one another, and may be assumed to represent the two optically active forms of tartaric acid, which by union in equal proportions give rise to the inactive racemic acid. But what about formula (3)? If our theory is correct it should form a third form of tartaric acid, and judging by its internal arrangement it should be optically inactive. For note the sequence of the groups of atoms R_1, R_2, R_3. In fig. (1) the sequence is counter-clockwise, in fig. (2) clockwise, in both halves of the molecule, and this arrangement is associated with optical activity. But when equal and opposite sequences are combined, optical inactivity results, as in racemic acid. But an examination of fig. (3) will show that we have equal and opposite sequences within the molecule, hence the substance represented by (3) should be inactive. Is there such a substance? Yes, and it was discovered by Pasteur himself. It is known as meso-tartaric acid, and Pasteur's efforts to secure it led on to work which has rendered him even more famous than his chemical investigations did. During the process of his investigations Pasteur was led to the observation that under certain conditions racemic acid was acted on by the common mould *Penicillium glaucum,* and undergoes a kind of selective fermentation, the dextro-tartaric acid being decomposed first, so that by stopping at the right stage the laevo-acid can be isolated. This was the first of Pasteur's fermentation studies, which have had such momentous results.

In 1852 Pasteur was appointed Professor of Chemistry at the Faculté of Science at Strasbourg, and two years later became Professor of Chemistry and Dean of the Faculty of Sciences at Lille. At this town brewing was an important industry, and on one occasion he visited a brewery in which some beer had "gone wrong," and was led to investigate the cause. Finally he was led to the conclusion that all forms of fermentation, alcoholic or otherwise, are due to the presence in the fermenting medium of a specific organism—an organised ferment—each of which acts in a specific manner when the conditions of its activity—proper temperature, nutriment, etc.—are fulfilled. Thus, if you want true alcoholic fermentation you must take care to have present only the appropriate form of yeast, and so on. Thus the foundations of scientific brewing were laid, and the industry gradually ceased to be conducted by "rule of thumb." Of course, these organised ferments, of which yeast is the best known, had been recognised before Pasteur's day, but the view was taken that they were the *result*, not the *cause*, of fermentation. Berzelius regarded fermentation as a catalytic process; Liebig that yeast was an unstable substance which in its ready decomposition set in motion the molecules of the fermentive matter, but in Pasteur's words, "The chemical act of fermentation is essentially a correlative phenomenon of a vital act, beginning and ending with it." (This is not quite true, for the real cause of alcoholic fermentation is an "unorganised ferment," zymase, discovered in yeast by Buchner in 1897, though the possibility of its existence had been suggested by Berthelot in 1858).

It must be emphasised that processes like the souring of milk, decay of organic matter, are really fermentations, each due to a specific organism or group of organisms.

When Pasteur's results were made known, they quickly "set the heather on fire." Up till then it had been firmly believed by scientific men that low forms of life, such as Pasteur's organised ferments, were spontaneously generated in appropriate media and under suitable conditions. It was, and is, well known that jam will ferment, milk turn sour, meat go bad, etc., if these are simply exposed to air, without the actual addition of any organisms, though these organisms may be found abundantly in the fermenting or decaying substance. The old school believed that physical conditions produced the changes, and that the "germs" were spontaneously generated, but Pasteur proved to demonstration that if means be taken to exclude air-borne germs from a previously sterilised medium, no changes will take place in the latter, and no germs will appear, and thus the theory of spontaneous generation received its death-blow.

Two results, of supreme importance to mankind, have followed from this work of Pasteur, and depending upon the fact that the processes of fermentation, souring, and decay are all similar in principle, and only occur in the presence of the appropriate organism.

We place first the modern processes of food preservation. If we can, by any means, destroy any germs which may already exist in our food, and then prevent the access of fresh germs, the food will keep as long as the conditions are fulfilled. So closely is this process associated with the name of Pasteur, that the process of partial sterilisation, *e.g.*, of milk, with a view to prolonging its period of remaining sweet, is known as "Pasteurisation." The apparent failure in food preservation, which has often caused disastrous results, *e.g.*, in the Loch Maree Hotel case, is due either (1) to imperfect sterilisation, or (2) to imperfect sealing.

But perhaps of greater importance, from some points of view, is that triumph of modern science known as aseptic surgery, and in association with which the name of Lister is ever memorable. I shall quote before closing a passage which gives some idea of the present and past state of matters in this connection, but it will suffice to state here that in the memory of men still living, a surgical operation, even the slightest, was a thing to be dreaded, lest the wound should become infected by air-borne germs which might give rise to the most serious, or even fatal results. Lister saw the connection between Pasteur's work on ferments and his own surgical processes—keep out the germs, destroy any that may have gained access, and in normal cases the wound will heal in a healthy manner. It is not to be wondered at that the type of mind which opposed Pasteur also opposed Lister, and he had a long struggle before he overcame ancient prejudices. The Franco-Prussian war of 1870-71 afforded an object lesson on a grand scale, and it has been said that while Lister was pushing Pasteurism in Edinburgh, Pasteur was developing Listerism in the hospitals of Paris. It need hardly be said that Lister's principles have prevailed in every civilised country—aseptic surgery is the rule, no operation being carried out without the strictest precautions to prevent access to the wound of all those air-borne germs which formerly gave rise to the complications which took so heavy a toll of human life.

During the late war every precaution was taken to keep wounds aseptic from the first, and it cannot be questioned that, large as the loss of life was, it would have been enormously greater but for the work of Pasteur and Lister.

From 1865 to 1870, while continuing his work on Bacteria, and laying the foundations of the science of Bacteriology, Pasteur investigated, at the request of Dumas, the two diseases of the silk-worm, known as pébrine and flacherie, which were at that time threatening to destroy the silk industry of France. He found that the diseases were due to the presence in the insects at all stages—eggs, larva, imago—of a unicellular organism, sporozoon or bacterium. Neither Pasteur nor any one else has found a method of destroying the germ without at the same time destroying the insect, but the preventive methods introduced by Pasteur—destruction of infected insects, examination by the microscope of eggs with a view to destruction if found to be infected, fumigation with chlorine, combined with scrupulous cleanliness—keep the disease in check, and are estimated to save from 30 to 50 million francs per annum—a very conclusive answer to the people who can see no good in research work, and have no approval for any expenditure which does not bring an immediate return in hard cash. Who could have thought that when Pasteur was working at crystals of tartrates and racemates that he would be gradually led on till he became the saviour of one of the most important industries of his native land—and that perhaps one of the least important of his attainments, for he was destined to go on from strength to strength, conferring higher and higher benefits, not only on his beloved France, but upon all mankind.

His success with pébrine and flacherie led on to further investigations—this time into diseases affecting higher animals than silk-worms. From 1877 to 1881 he worked mainly at three diseases—anthrax, chicken cholera, and swine erysipelas. Sheep and cattle, poultry, and pigs were perishing in large numbers from these diseases, and the careful and thrifty French peasantry saw themselves faced with ruin. But Pasteur was enabled, not only to determine the cause of each disease, but to indicate the remedy. He proved conclusively that the cause in each case was the presence, in the tissues of the affected animal, of a specific organism, and following Koch, who in 1876 had established a method of making "pure cultures" of bacteria, etc., he was able to cultivate the germs in question on appropriate media outside the animal body, and to use these cultures as a means of protection against the disease, and to reduce the mortality from 10% to 1%. We shall discuss this point more fully in a few minutes, but note at this stage that, with the sole exception of vaccination for small-pox, introduced by Jenner, who died when Pasteur was a month old, every up-to-date process of inoculation and treatment of infectious disease by antitoxins has its foundations in the work and discoveries of Pasteur. For while Jenner's discovery was empirical, Pasteur's work was based upon that sure scientific basis which may give rise to a never-ending series of developments, continuing long after the original investigator is at rest from his labours. This has been pre-eminently the case with Pasteur, and, as has been well said, while Jenner made a discovery, Pasteur made discoverers.

The value of the live-stock saved for France was estimated by Huxley as being equal to the total amount of the indemnity paid by France to Germany after the Franco-Prussian war.

It is, however, by his researches on hydrophobia that Pasteur is best known; and to this subject he devoted his years between 1880 and 1885, when he began the process of inoculation for this disease. Very few people nowadays have ever seen a mad dog, and yet half-a-century ago or so the sight must have been not uncommon. Can we imagine the thrill of horror which would go through a community at the cry of "Mad Dog!"? How the timid would rush for a place of safety and the bolder spirits arm themselves with all sorts of weapons for the capture and destruction of the dangerous beast. For hydrophobia was a real terror—15% of those bitten by a mad dog contracted the disease, and the mortality was practically 100 per cent. Thanks to stringent regulations regarding importation of animals, rabies in dogs and hydrophobia in human beings are almost unknown in this country, though only the other day we read of a rabid cat in Ireland. But other countries are not so fortunate.

Strangely enough, neither Pasteur nor any of his successors has definitely succeeded in finding the actual germ of hydrophobia, and yet with the knowledge derived from his earlier investigations Pasteur was able to devise a remedy which reduced the mortality from 100% to 1%.

Leaving for a while the purely historical method which we have hitherto followed, let us digress for a moment to consider the general principles of protective medicine.

1. Infectious or contagious diseases are due to the development within the body of some definite germ, usually a humble form of plant life, known as a bacillus or bacterium, but in some cases of an animal nature. The germ never originates *de novo*, but gains admittance to the body from outside, in various ways. For many diseases the germ has actually been identified; in other cases its existence is strongly suspected.

2. The injury is not done directly by the mere presence of the germ, but by poisonous substances produced thereby. These poisons are known as toxins.
3. The body has two natural forms of protection: (a) the phagocytes (white blood corpuscles) have the power of ingesting and thus destroying the actual germs, and (b) the power of producing substances (antitoxins) which are capable of neutralising the action of the toxins. In the more deadly forms of infectious disease, if the toxins prevail the patient dies; if the phagocytes and antitoxins, he recovers.
4. Disease germs can as a rule be cultivated outside the body. They require proper temperature, moisture, and a suitable nutritive medium. Their life history can thus be studied in detail. The characteristic toxins are also produced.
5. The vigour of the germ and the consequent virulence of the toxin may be exalted or attenuated by appropriate modifications in the method of culture, or by other means.
6. A dose of the attenuated virus, or a succession of such doses, usually administered as a sub-cutaneous injection, carefully adjusted to the circumstances of the case, will, in some diseases, produce a mild attack and lead to a development of antitoxins, which, once developed, confer immunity from more serious attacks for a longer or shorter period.

These general principles were discovered by Pasteur in the course of his investigations on the diseases of domestic animals previously referred to, but it is in his treatment of hydrophobia that they receive their fullest illustration.

As has already been said, the actual germ of hydrophobia still awaits discovery. But Pasteur found that rabies in dogs was closely connected with the central nervous system, and that the cerebro-spinal fluid carried the infection. Thus, an injection of the cerebro-spinal fluid of a rabid dog into a healthy animal brings about the death of the latter in 12 or 14 days. If the virus be passed through a succession of monkeys, it becomes so weakened or attenuated that it is no longer capable of producing fatal results. On the other hand, if the monkey virus, or the original dog virus, be passed through a succession of rabbits, its virulence becomes so exalted that it will kill a healthy dog in 6 days. This was termed by Pasteur a "virus fixe" or standard virus, as it could be depended upon to produce a definite result. For treatment, rabbits are inoculated with standard virus, and their spinal cords are subsequently removed, cut into segments (held together by the dura mater, or tough outer covering of the cord) and suspended in sterile flasks over solid caustic potash. Thus they gradually dry, and at the same time the virulence falls, till about the 14th or 15th day it ceases to be lethal. By proceeding in this way it is possible to have "on hand" hydrophobia virus of varying strength, from a deadly quality which will kill in 6 days, to a feeble state which will not kill at all. These facts were established by experiments on lower animals, but in 1885 Pasteur applied his treatment to human beings. The patient receives first a sub-cutaneous dose of the weakest virus, prepared from a spinal cord which has been kept as noted above for about 13 or 14 days. Then for a period of 15 to 21 days he receives a daily injection of gradually increasing virulence, until he is able to tolerate a dose prepared from a cord of the third day. Fortunately the period of incubation of hydrophobia in the human subject is a long one, and the treatment above outlined gives a chance of obtaining for the patient complete acclimatisation or protection before the incubation period is complete and the attack develops.

The first "Institut Pasteur" was opened in Paris on the 14th November, 1888, for the treatment of persons bitten by rabid animals. Its beneficent work is still continued, although its first Director has been dead for nearly 18 years. Similar institutes have been established in other countries, notably in India, and the death rate over the whole world from hydrophobia is less than 1 per cent.

Had the fame of Pasteur depended solely upon his researches on hydrophobia, he would still have ranked as one of the foremost benefactors of the human race, but as we have seen, his pioneer work was of such a nature that it inevitably inspired further investigations. Disease germs unknown to Pasteur have now been discovered, and in some cases, at least, have shown themselves amenable to treatment similar to that discovered by Pasteur for hydrophobia.

A notable discovery was that which substituted the killed virus for the attenuated living substance; and at least four other diseases are now being treated by methods arising out of Pasteur's work. As an example we may note that anti-diphtheritic serum may be prepared as follows:—

1. Toxins may be isolated from the germs producing them.
2. Symptoms of disease may be produced by administration of these.
3. Animals, *e.g.*, horses, can be gradually acclimatised,
4. And are then capable of resisting attacks of actual germs.
5. Blood serum of an animal artificially immunised is itself antitoxic—preventive and curative.

In addition to diphtheria, typhoid, tetanus, and plague may be counteracted by antitoxin serums with a fair prospect of success, and the mortality from these diseases has been enormously reduced.

We can perhaps best estimate the value of Pasteur's work by comparing the state of matters now with what it was in pre-Pasteur days. For this purpose I cannot do better than give one or two quotations from articles which appeared in the "Times" at the time of the centenary in December last.

"Preventive medicine, with its auxiliary services of sanitation, water supply, food inspection, and hygiene remained as yet but a dream. Surgery was attended by dangers so great as to inspire in the general mind a horror unrelieved by any gleam of hope. Plagues and pestilences of many kinds swept at short intervals over Europe and the world, destroying vast numbers of human lives and taking, besides, a heavy toll of flocks and herds. Whole industries were not infrequently placed in jeopardy by unseen forces which defied the most scrupulous attempts to stay their havoc. It was an age of great intellectual activity, yet its negative outlook found many expressions, and none, perhaps, more significant than the doctrine of spontaneous generation of life.

Pasteur, in consequence of his studies of fermentation, attacked this doctrine with all the passion of his soul—he disproved it in a series of experiments, the authenticity of which has never been successfully assailed. In its stead he gave to the world his discovery of the kingdom of the infinitely small; those minute atoms of life, renewed from generation to generation, which by their ceaseless activity make and unmake our world.

Whatever the philosophical consequences of his labours may have been, their scientific results were instant and overwhelming.

Within the space of a few years bacteriology became an exact science. Disease after disease was conquered; the blight which threatened to destroy the silk industry of France; the fatal charbon, or anthrax, which was thinning out the flocks and herds of so many farmers; the fearful blood-poisoning which haunted surgeons and accoucheurs in every country, and rendered their work terrifying beyond exaggeration; finally, hydrophobia itself.

In this country the work of Lister, a direct outcome, as he freely acknowledged, of Pasteur's researches, created a new surgery. A new tropical medicine was soon on its way, for the kingdom of the infinitely small is as wide as the world."

And again:—

"Like a hero of romance this man of science came to a world vexed by dreadful unseen foes. Industries, the support of numberless poor folk, were sickening; plague took usurious toll of the herds and flocks of farmers and peasants. Man himself, though familiar with disease as with the changing seasons, went in fear of catastrophe. Year after year, thousands were stricken down in all lands by the fevers which followed so often even the most insignificant of wounds. A more terrible fever cast its ever-lengthening shadow on motherhood. Diphtheria and typhoid extinguished annually countless young lives, while the instant horror of the rabid dog haunted the minds of all."

Pasteur died at St. Cloud on 28th September, 1895, but in very truth, "His soul goes marching on." He was utterly unspoiled by the repeated successes which had entered so largely into his life. With regard to his scientific work it was the outcome of three notable characteristics—devotion to work, patient research, and quick and exact observation. In his own words, "These three things—will, work, success—share the whole of human existence. The will opens the doors to brilliant and fortunate careers; work steps through, and once arrived at the end of the journey, success comes to crown the labour."

In closing this brief account of the work of a truly great man, I quote a few sentences from his speech at the opening of the Pasteur Institute on the 14th November, 1888; words uttered nearly thirty-five years ago, but still, alas! terribly true:—"Two opposing laws seem to me now in contest. The one, a law of blood and death, opening out each day new modes of destruction, forces nations to be always ready for the battle. The other, a law of peace, work, and health, whose only aim is to deliver man from the calamities which beset him. The one seeks violent conquests, the other the relief of mankind. The one places a single life above all victories, the other sacrifices hundreds of thousands of lives to the ambition of a single individual. The law of which we are the instruments strives even through the carnage to cure the wounds due to the law of war. Treatment by our antiseptic methods may preserve the lives of thousands of soldiers. Which of these two laws will prevail, God only knows. But of this we may be sure, that Science, in obeying the law of humanity, will always labour to enlarge the frontiers of life."

XIX.—*Potamogetons of the Earn District of Perthshire.*

By J. R. Matthews, M.A., F.L.S.

(Read 13th April, 1923.)

Although Perthshire has long been systematically explored and its phanerogamic flora is exceptionally well known, it would be rash to say that nothing more remains to be done towards a study of the distribution of the flowering plants of the county. The more outlying parts require further exploration, while even the more accessible and better known districts frequently yield interesting additions to the local lists. This appears to be especially true in the case of aquatic species which, from the nature of their habitat, are often difficult to gather, if not entirely overlooked.

My own field-work on the water-plants of the county has been largely limited to the district of Lowland Earn. In 1912 some specimens of a Potamogeton obtained from the Whitemoss Loch which I considered to be *P. pusillus,* L., proved to be *P. trichoides,* Cham. & Schlecht. This constituted the first record for the plant in Scotland, and indicated a very considerable northern extension of its range in Britain. Again, in 1915, Mr. Barclay and I were fortunate in finding in the River Earn, *Potamogeton venustus,* Baagöe—a hybrid betweeen *P. crispus* and *P. alpinus.* This was another addition to the Scottish flora—a plant hitherto known, in fact, only from Denmark and possibly Bavaria, although I have since heard from Mr. A. Bennett that he has in his herbarium a specimen which is this hybrid collected in the year 1900 in the River Ythan, North Aberdeen, by the late Professor Trail. Three years ago I brought before the notice of the Society as an instance of recent dispersal the occurrence of *Zannichellia palustris* in Keltie Loch, and now I have to record the discovery of two Potamogetons whose names do not appear on the Perthshire List. These are *P. pectinatus,* L. and *P. panormitanus,* Biv. Bern. The plants made their appearance in a small ornamental pond constructed in 1910 on the Estate of Keltie, not far from the loch of that name. Numerous aquatic species established themselves in this artificial pond despite regular efforts to keep the unwelcome immigrants in check, and at various dates I made gatherings. We may refer to the locality as Keltie Pond, where in July, 1919, the two pond-weeds just mentioned were first noticed.

Potamogeton pectinatus, L. is widely distributed in the British Isles, being recorded (London Catalogue, 1908) for 90 Watsonian vice-counties from Cornwall to Orkney, while it occurs in 28 divisions in Ireland; yet in Perthshire it has not hitherto been noted beyond the record given in the " Flora " for Clackmannan, which Watson included under West Perth. The interesting feature in the present instance is its sudden appearance in a recently constructed pond in an area more or less isolated and remote from the chief lake centres of the county, where the plant may or may not occur. Whether or not it exists in the Whitemoss, the nearest loch to Keltie, I am at present unable to say.

Potamogeton panormitanus, described by Bivona Bernardi in 1838, has long been regarded as a variety of *P. pusillus,* if not actually considered the same as that species. Already there are indications that it is a wide-ranging species in Britain. It has been recorded from Surrey and from Orkney, besides several intermediate stations, and it doubtless occurs in the Perthshire lochs, but taken as a form of *pusillus.* The plant is restored to full specific rank by Dr. Hagstrom (1916), who gives a detailed account of it in his exhaustive work entitled " Critical Researches on the

Potamogetons," pp. 98--103. It differs from *P. pusillus* in its mode of growth, in having usually a yellowish tinge of colour to the leaves and in the possession of stipules which are connate and not convolute.

It is not unusual nowadays for a student of a particularly difficult genus to place an ever finer meaning on the conception of species, and the remarkable plasticity exhibited by Potamogeton and other aquatic genera offers ample opportunity for the creation of numerous varieties and forms based largely on vegetative features. Such studies are of real value if they lead ultimately to a better understanding of plant-structure, relationship, and behaviour. It is as a result of having examined my sheets of Potamogeton from Lowland Earn in the light of Hagstrom's researches that the following notes have been drawn up. Mr. Arthur Bennett, who has seen the specimens, has also kindly given me much help, and some of his observations are incorporated below.

Potamogeton polygonifolius, Pour., var. *cordifolius,* Cham. & Sch.

Hagstrom, discussing this species, says (*op. cit.* p. 177) that it has a tendency to lengthen the petioles, and only land-forms possess shorter petioles, although even in these they are generally as long as the blade. In my specimens from the Cow's Moss, Ochil Hills, south of Dunning, the upper leaves have petioles up to 130mm., while the leaf-blade is 50--60mm. x 30mm. They exhibit a cordate or subcordate base, and Mr. Bennett writes that the specimens agree well with var. *cordifolius,* Cham. & Schlech. The species itself is not given with the usual certainty for Lowland Earn in Dr. White's "Flora."

P. heterophyllus, Schreb.

Hagstrom discusses this species under its earlier name *P. gramineus,* L. (pp. 204--209), pointing out its great variability under different environmental conditions according to whether the plant grows in shallow, in deep, or in moving water. What is practically the typical form of the species occurs in Keltie Loch. A condition in which the upper floating leaves are small or almost entirely suppressed sometimes arises, and I have such an example from the Whitemoss. In the same loch the plant often exhibits somewhat elongated floating leaves with petioles twice the length of the lamina.

P. decipiens, Nolte.

This hybrid (*P. Lucens* x *perfoliatus*) is common in the River Earn. Hagstrom reviews the history of its systematic treatment and establishes, according to the size of the leaf, three series of forms—*latifolius, brevifolius,* and *longifolius*. The Earn specimens, with leaves about 105mm. × 26mm., come under var. *latifolius,* Hagst., but in connexion with varieties based on leaf dimensions some recent experimental work, to which reference will be made later, is of great interest.

P. perfoliatus, L.

Specimens from the Earn are robust, with a leaf-shape approaching var. *rotundifolius,* Wallr., while Whitemoss plants are much smaller, with shorter internodes and small leaves about 30mm. × 10--12mm. The species is one of the most variable as regards size and shape of leaves, and the numerous forms, according to Fryer (British Potamogetons, p. 41) "are probably nothing more than *states* produced by local and often temporary conditions."

P. crispus, L., var. *planifolius,* Meyer.

River Earn above Dalreoch Bridge. Leaves without the undulate margin, and with a very faint denticulation.

P. crispus x *alpinus* (x *P. venustus,* Baagöe).

Hagstrom gives an account of this hybrid (p. 144) from Danish material, the plant having been recorded only from Denmark at the time of his researches. He describes the anatomy, peduncles, and spikes as indicating clearly an affinity with *crispus,* while the leaf midrib has also the form of that of *crispus*. On the other hand, the leaf-margin is not serrate, and the venation of the leaf recalls *alpinus,* but with a reduction in the number of lateral veins. A reddish tinge in the leaf, more marked after drying, also points to the influence of *alpinus*. The leaves of the Earn specimens measure 75--90mm. × 7--9mm.

P. panormitanus, Biv. Bern.

The plant from Keltie pond, July, 1919, is slender, the leaves being not more than 1mm. broad.

P. pectinatus, L.

As already stated, this species is given within brackets in Dr. White's "Flora" as not having been found within the County boundary, thus—[*P. pectinatus,* Quarry at Clackmannan (J. Couper).]. Its discovery in Keltie Pond makes an addition to the county list. The plant appears as an unusually slender state.

P. filiformis, Nolte.

Very rare in Perthshire, being known only from the Whitemoss. The plant still occurs there.

To the foregoing list the following have to be added as occurring in the Earn districts :—*P. natans,* L., *P. alpinus,* Balb., *P. lucens,* L., *P. angustifolius,* Presl., *P. obtusifolius,* M. & K., *P. pusillus,* L., and *P. trichoides,* Cham. & Schlecht.

Attention has already been drawn to the great variability exhibited by certain species, and those British botanists who have studied the genus most carefully have strongly affirmed their belief that many of the so-called varieties are in reality only *growth-forms* or *states,* produced under varying environmental conditions. The problem has been investigated recently by Messrs. Pearsall along the lines of experimental enquiry, and these workers, dealing especially with *P. pusillus,* have shown (Journal of Botany, 1921, pp. 160--164) that light intensity is the chief factor in producing variation. Further observations by the same authors (Journal of Botany, 1923, pp. 1--7) deal with variations observed in the larger-leaved species. *P. perfoliatus* is discussed in detail, and from experimental results the writers are led to suggest that "the proportion of lime in the soil is an important factor in determining leaf-shape in *P. perfoliatus,* and that along with the effects of light-intensity, it may enable us to account for all the leaf-variations observed in this species in nature."

XX.—*Note on Charophytes collected at Lochs Lubnaig and Vennachar and on Cotyledon Umbilicus found near L. Vennachar.*

By NOEL J. G. SMITH, M.A., B.SC.

(Read 13th April, 1923.)

The following Charophytes were collected at Loch Lubnaig in July, 1921 :—

Nitella opaca, Agardh.
N. translucens, Agardh.
N. flexilis (probably) Agardh.
N. spanioclema, Groves and Bullock-Webster.

This last Nitella is a particularly interesting find. The species was first found by Canon Bullock-Webster in Lough Shannach, Co. Donegal, in 1916, and has been collected there since, but has never been recorded elsewhere. Canon Bullock-Webster identified specimens sent by me from Loch Lubnaig, and noted the new record for Great Britain in the *Journal of Botany,* June, 1922.

Plants collected at or near Loch Vennachar at the same date were :—

CHAROPHYTA—

Nitella opaca.
N. translucens.

FLOWERING PLANT—

Cotyledon Umbilicus-Veneris.

The most interesting find was the Cotyledon, in a wall near Loch Vennachar. It is not recorded for Perthshire in Buchanan-White's Flora, but was, I believe, reported by Traill to occur in that county, "probably planted." The specimen I found was a considerable distance from any house, and had every appearance of being a native.

The Charophytes were all named by Canon Bullock-Webster, and the Cotyledon verified by the Curator of the Herbarium, Royal Botanic Garden, Edinburgh.