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LVII.—Observations on the Structure of the Pollen Granule, considered principally with reference to its eligibility as a means of Classification

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This also varies considerably in size, from eleven-sixteenths to less than one-fourth of an inch.

	Cor. Crag.	*Red Crag.*	*Mam. Crag.*	*Recent.*
6. Trivia retusa (Cypræa retusa, *Min. Con.* t. 378. f. 2).	Sutton.	Sutton.		
7. — globulosa, n. s.		Sutton.		

1. Erato lævis, *Gray* (Erato cypræola, *Risso, Hist. Nat. des prin. prod. de l'Eur.* vol. iv. p. 240. pl. 7. f. 85. Marginella voluta, *Flem. Brit. An.* p. 335. Cypræa voluta, *Mont. Test. Brit.* t. 6. f. 7. Voluta lævis, *Don. Brit. Shells*, t. 145).

2. — Maugeriæ, *Gray* (*Sow. Conch. Illust.* f. 47).
Sutton. | Sutton. | ..... | West Indies.

The West Indian specimens are generally a little smaller and rather more delicately formed than the crag shell.

1. Ovulum Leathesii, *Sow.* (*Min. Con.* t. 476. Calpurna Leathesii, *Flem. Brit. An.* p. 331).
Sutton. | Walton Naze. | |

Corrigenda.

Vol. vi. page 245. *Note* § refers to *Cultellus*, and not to *Solen siliqua*.
Do. do. *Sphenia cylindrica* is the young of *Panopæa*.
Do. page 251. *Cardium nodulosum* is *Cardium nodosum*, Turt.
Do. do. *Nucula tenera* is *Arca tenuis* of Mont.

LVII.—*Observations on the Structure of the Pollen Granule, considered principally with reference to its eligibility as a means of Classification.* By Arthur Hill Hassall, Esq., M.R.C.S.L., Corresponding Member of the Natural History Society of Dublin.

[Continued from vol. viii. p. 108.]

[With 6 Plates.]

The second portion of this communication comprises a particular description of the principal forms of pollen granules met with by the author during his investigations, together with the names of all the plants examined, arranged according to Lindley's 'Natural System,' which is followed in every particular, save that the order of arrangement is reversed, the lower tribes of Phanerogamic plants being first enumerated.

VASCULARES.

ENDOGENS OR MONOCOTYLEDONS.

Glumosæ.

Cyperaceæ.

Char.—Outline of pollen grain ovate-lanceolate; extine covering only a portion of the intine, being deficient on either side, and at the

smaller end of the figure; but one pollen tube, which issues from the larger extremity of the granule. The entire figure bears a rude resemblance to an acorn when in its cup. Pl. XIII. fig. 1.

Isolepis Holoschœnus.	Scirpus capitatus.
I. romana.	Carex tomentosa.
Cyperus longus.	C. Œderi.
Scirpus atrovirens.	C. præcox.
S. carinatus.	C. acuta.
S. triqueter.	

The pollen grain of the following plant resembles that of the next order in every particular but size. See fig. 2.

Papyrus Antiquorum.

Graminaceæ.

Pollen granules separate, circular at first, but on the emission of the single pollen tube with which each grain is furnished generally becoming ovoid, the larger end corresponding to that from which the pollen tube issues; extine containing a distinct circular aperture for the escape of the pollen tube, which aperture is said by Fritzsche to be provided with a valve, of which I have not been able to detect the smallest trace. Pl. XIII. fig. 4.

Dactylis glomerata.	Triticum hibernum.	Zea Mays.
D. abbreviata.	Lolium perenne.	Zizania aquatica.
Sesleria elongata.	Avena fatua.	Andropogon furcatus.
Poa fertilis.	Aira vaginata.	Panicum palmifolium.
Elymus striatus.	Spartina juncea.	Phragmitis communis.
E. sabulosus.	S. cynosuroides.	Arundo littorea.
Triticum rigidum.		

Spadicosæ.

Typhaceæ.

Pollen grains united in fours, generally disposed upon the same plane, and each emitting a single pollen tube. See fig. 5.

Typha latifolia.

Araceæ.

Calleæ.

Pollen grain, when dry, in outline describing a parallelogram, very flat; in water it changes to an ellipse, emitting a pollen tube from each extremity. See fig. 6.

Calla palustris.

Pollen grain of an elongated ovoid form, bearing some resemblance to a flask. Extine apparently without any provision for the pollen tube, which escapes from the small end of the figure by the rupture of that membrane. See fig. 7.

Calla æthiopica.

Hypogynosæ.

Juncæ.

Pollen granules united in fours, three being placed upon the

same plane and one resting upon these; each granule emits a single pollen tube. Pl. XIII. fig. 8.

Juncus articulatus.

Obs.—The plants examined in the following orders of the groups *Hypogynosæ* and *Epigynosæ*, commencing with the *Butomaceæ* and going up to *Musaceæ*, are with two exceptions characterized by the possession of a pollen grain of the same form and structure as indicated below. The first exception occurs in *Limnocharis Humboldtii*, and is very remarkable, inasmuch as its pollen granule presents a more complicated structure than that of any other endogenous plant hitherto met with, while the second is seen in *Anigozanthus coccineus*.

Char.—Granules of an elongated form, tapering towards either extremity, sometimes slightly curved, each having on one side down its long axis a fissure through which the pollen tube quits the extine; this fissure is sometimes covered by an oval piece of membrane which curls up and falls off the extine when placed in water; extine either plain or reticulated. The whole granule may be very aptly compared to a grain of wheat while it remains dry; but as soon as it is immersed in fluid, and before the emission of the pollen tube, it becomes nearly circular. Extine often reticulated, and presenting a very beautiful appearance under the microscope. See fig. 10 and the following ones up to fig. 26.

Butomaceæ.

Butomus umbellatus.

1*st Exception.*

Pollen grain of *Limnocharis Humboldtii* circular; extine reticulated, perforated with six or seven apertures for the escape of pollen tubes. See fig. 9.

Commelinaceæ.

Pollen grain somewhat curved. See fig. 10.

Tradescantia virginica.	Tradescantia discolor.

Liliaceæ. Pl. XIII. fig. 11, 12.

Haworthia radula.	Arthropodium cirrhatum.
Aloe obscura.	Hyacinthus orientalis.
A. saponaria.	Bessera elegans.
Yucca filamentosa.	Eucomis striata.
Asparagus officinalis.	Albuca minor.
Peliosanthes Teta.	Ornithogalum speciosum.
Convallaria majalis.	Allium fragrans.
Czackia Liliastrum.	Scilla maritima.

Pollen granules of most of the following genera reticulated, and furnished with an oval appendage; (two of the genera enumerated above, *Yucca filamentosa* and *Czackia Liliastrum*, have their pollen grains provided with a similar appendage). See fig. 13, 14, 15.

Polianthes tuberosa.	Tulipa Gesneriana.
Agapanthus umbellatus.	Lilium longiflorum.
Funkia Sieboldiana.	L. album.
Hemerocallis flava.	L. tigrinum.

MELANTHACEÆ.

Pollen granule reticulated.

Colchicum autumnale.

PALMACEÆ.

Kunthia speciosa.

EPIGYNOSÆ.

BROMELIACEÆ.

Billbergia amœna.

IRIDACEÆ.

Iris florentina. Ixia florida. Antholyza æthiopica.
Moræa racemosa. Crocus vernus.

Pollen granule reticulate. See fig. 16.

Watsonia irioides. Gladiolus florabundus.

XÆMODORACEÆ.

2nd Exception.

Pollen grain of an elongated form, expanding into a bulb at either extremity, from an aperture in each of which a pollen tube issues; it may be compared to a dumb-bell, in which the cross bar connecting the two globes is somewhat curved. See fig. 17, 18, 19.

Anigozanthus coccineus.

AMARYLLIDACEÆ. See Pl. XIII. fig. 23, 24, 25, 26.

Obs.—An *apparent* exception to the usual form occurs in the pollen granule of *Crinum amabile*, which possesses two furrows instead of one. See fig. 20, 21, 22.

Galanthus nivalis. Narcissus Jonquilla.
Amaryllis purpurea. Zephyranthes grandiflora.
Hæmanthus tigrinus. Alströmeria ovata.
Griffinia hyacinthina. A. psittacina.
Imatophyllum Aitoni. Hypoxis stellata.
Pancratium declinatum.

Obs.—The closely allied orders *Musaceæ*, *Marantaceæ*, *Zingiberaceæ* or *Scitamineæ* possess a pollen granule of the same form and structure, which is thus characterized.

CHAR.—Circular; extine of considerable thickness, either smooth or spinous, not provided with apertures or fissures for the escape of pollen tubes, but bursting irregularly, and so exposing the intine, which elongates into a pollen tube wherever thus denuded. Plate XIV. fig. 30, 31, 32, 33.

MUSACEÆ.

Extine smooth. See Pl. XIV. fig. 30, 31.

Strelitzia humilis. Strelitzia Reginæ.

MARANTACEÆ.

Extine covered with spines, having their summits perforated, which disappear on the immersion of the pollen in water, leaving

only small apertures in the surface of the now smooth extine, but the pollen tubes do not pass through these. See fig. 32, 33.

Canna Occidentalis. C. Indica.

ZINGIBERACEÆ.

Extine covered with spines, which are permanent.

Roscoea purpurea.

Extine smooth.

Hedychium Gardnerianum. H. flavescens. H. coronarium.

VASCULARES.

EXOGENS OR DICOTYLEDONS.

GYMNOSPERMS.

CONIFERÆ OR PINACEÆ.

Pollen grain kidney-shaped, and according to Fritzsche furnished with three membranes; extine cracking to admit of the emission of the pollen tubes. See fig. 34, 35.

Pinus sylvestris. Pinus Nova Zealandica.
P. Pinaster. P. Tæda.

Pollen granule circular, furnished with three membranes and pollen tubes escaping by the rupture of the extine, as in the previous instance.

Juniperus communis. J. Sabina.

TAXACEÆ.

Pollen granule similar to that of Juniperus.

Taxus baccata.

ANGIOSPERMS.

DICARPOSÆ.

JASMINACEÆ, OLEACEÆ, AND LOGANIACEÆ.

Pollen grain in its dry state of an elongated form, trilobate, each lobe being separated from the others by a fissure passing through the extine; in water becoming spherical or triangular and emitting three pollen tubes; this change of form results from the approximation of each end of the granule, occasioned by the imbibition of the fluid surrounding it.

OBS.—As the above type of pollen granule occurs hereafter in families not allied to the above, in order to avoid the repetition of its characters, just enumerated, the term cylindrical will be employed to designate it when again met with. Although the same *type* of granule is of frequent occurrence, it is not to be inferred that it agrees either with that of the above orders or any others in its exact form or size, which varies considerably. It is to be regretted that the size of all granules of the above form has not been ascertained.

Jasminum odoratissimum. Olea europæa.
Ornus europæa. Gærtnera racemosa.
Syringa vulgaris.

APOCYNACEÆ.

Primary form of pollen granule cylindrical, very large, but when

taken from the stigma spherical, from the inhibition of the abundant secretion furnished by that organ.

Allamanda cathartica.	Vinca herbacea.
Plumeria conspicua.	V. rosea.

Pollen grain spherical when removed from the stigma and furnished with four pollen tubes. Pl. XIV. fig. 37.

Nerium Oleander.

GENTIANACEÆ.

Pollen grain cylindrical, three-lobed.

Chironia pubescens. Gentianella cruciata. Gentiana asclepiadea.

SOLANACEÆ.

Cylindrical, three-lobed. Pl. XIV. fig. 38, 39, 40, 41, 42.

Hyoscyamus niger.	Saracha viscosa.
H. pallidus.	Atropa belladonna.
Petunia atropurpurea.	Physalis oxalidifolia.
P. violacea.	P. Alkekengi.
P. rosea.	Solanum Dulcamara.
Lycopersicum erythrocarpum.	S. stramonifolium.
Datura Stramonium.	Capsicum annuum.

Many of the granules of the two following species are four-lobed.

Nicotiana Tabacum.	Solanum tuberosum.

SCROPHULARIACEÆ.

Pollen grain cylindrical, three-lobed. See fig. 43.

Buddleia globosa.	Francisca mutabilis.
Veronica longifolia.	Schizanthus pinnatus.
V. Chamædrys.	Rhodochiton volubile.
Gratiola officinalis.	Antirrhinum majus.
Mimulus guttatus.	Linaria pilosa.
M. elatus.	L. genistoides.
M. roseus.	L. purpurea.
Digitalis purpurea.	L. dalmatica.
Russelia juncea.	Scrophularia nodosa.
Penstemon pubescens.	S. aquatica.
P. pentaphyllum.	Alonsoa urticifolia.
P. speciosum.	Calceolaria elegans.
P. diffusum.	Celsia Cretica.
Anthocercis albicans.	Verbascum Phœniceum.
Franciscea Hopeana.	V. Thapsum.

Exception.

Pollen granules united in fours, three upon the same plane and one resting on these; the three lower granules appear to emit but two pollen tubes, the third being most probably suppressed by the union of the granules, while the upper one sends off three tubes; those in the lower grains issue opposite to each other near the point of juncture of the granules, while those of the upper one are given off at equal distances round the circumference, alternating with the

others. See fig. 44. This form seems to result from the union of four of the preceding granules.

Salpiglossis atropurpurea.

GESNERACEÆ.

Gloxinia speciosa. Gesnera bulbosa.
Trevirania coccinea. G. Douglassii.

ACANTHACEÆ.

Pollen granules cylindrical, not diminishing in size towards either extremity; ends rounded; extine perforated apparently with minute apertures. Pollen tubes three, issuing through longitudinal fissures. Pl. XIV. fig. 45.

Justicia variabilis.

Pollen grain of an oval form, with but one longitudinal fissure and one pollen tube issuing from the smaller end. The comparison of pollen of this form to a *Pholas* is not inapt. See fig. 46.

Acanthus spinosa.

Circular, surface presenting a lobulated appearance, the lobes being separated by lines which cross each other, in some of which fissures are placed for the escape of the pollen tubes. See fig. 47.

Thunbergia alata.

Pollen grain in its dry state cylindrical; when moist nearly circular, reticulated, reticulation apparently formed in the same way as that of *Cobæa scandens*. See fig. 48.

Eranthemum pulchellum.

BIGNONIACEÆ.

Pollen grain cylindrical, three-lobed.

Eccremocarpus scaber. Bignonia radicans.

DUCAMENTOSÆ.

MYOPORACEÆ.

Pollen grain cylindrical, three-lobed.

Myoporum parviflorum.

VERBENACEÆ.

Pollen grain cylindrical, three-lobed.

Lantana Sellowii. Clerodendrum florabundum.
Verbena teucroides. Aloysia citriodora.

Pollen grain of considerable size, triangular, sides of triangle much incurved, furnished with three membranes, the second of which, or exintine, protrudes through the apertures in the extine, forming at each angle of the figure a prominent rounded projection; a pollen tube of large dimensions issues from each angle. Extine covered with a number of oval-looking bodies. See fig. 49, which exhibits an abnormal form of the pollen granule of Stachytarpheta mutabilis.

Stachytarpheta mutabilis. S. Jamaicensis.

LABIATÆ OR LIMARIACEÆ.

Pollen grain cylindrical, three-lobed.

Teucrium lucidum. T. pyrenaicum.

Molluccella lævis.	Stachys coccinea.
Marrubium vulgare.	Galeobdolon luteum.
Ballota nigra.	Physostegia virginica.
Sideritis fœtida.	Dracocephalum speciosum.
S. taurica.	Westringia ermicola.
Stachys iberica.	Scutellaria galericulata.
S. setifera.	S. lupulina.

Many of the granules of *Sideritis scordioides* are four-lobed.

Pollen grain oval, six-lobed, resembling a melon, changing its form in water and emitting six pollen tubes. See fig. 51, 52.

Gardoquia multiflora.	Salvia splendens.
Origanum heracleoticum.	S. Sclarea.
Glechoma hederacea.	Ocimum basilicum.
Monarda didyma.	

Cylindrical, three-lobed.

Lycopus europæus.

Boraginaceæ.

Pollen granule of an elongated form with either rounded or truncated extremities, centre constricted in its dry state. See Pl. XIV. fig. 53, 54, and Pl. XV. fig. 55, 56, 57, 58.

Pollen tubes two, opposite each other, issuing from longitudinal fissures placed near the centre of the figure. See fig. 53, 54.

Symphytum officinale. Cerinthe aspera. C. major.

Pollen tubes ten; pollen granule before the emission of the tubes becoming circular. Pl. XV. fig. 55, 56, 57, 58.

Borago officinalis.

Number of pollen tubes not known.

Myosotis palustris.

Pollen tubes four.

Anchusa semperflorens. Cynoglossum pictum?

Pollen granule three-lobed, pyramidal.

Onosma echioides. Echium fruticosum.

Hydrophyllaceæ.

Cylindrical, three-lobed. See fig. 59.

Phacelia bipinnatifida.	Eutoca multiflora.
Eutoca viscosa.	E. Wrangelana.

Pollen granule small, triangular, sides of triangle straight; pollen tubes three. See fig. 60.

Nemophila phacelioides. N. atomaria. N. insignis.

Aggregosæ.

Plumbaginaceæ.

Pollen granule reticulated, in its dry state cylindrical, when moist somewhat triangular, with the sides of the triangle curved outwards to some extent; pollen tubes three, issuing from the angles of the grain. See fig. 61.

Armeria vulgaris.	Statice latifolia.	S. tartarica.
Statice sinuata.	S. speciosa.	

Pollen granule of large size, not reticulated, cylindrical, three-lobed in its dry state, when moist nearly circular; between each lobe

is a fissure, in connexion with which is a small strip of membrane. Pl. XV. fig. 62, 63.

Plumbago rosea. P. cærulea.

PLANTAGINACEÆ.

Pollen granule small, circular, perforated with about ten apertures for the escape of pollen tubes. It is probable that the number of apertures in each granule is determinate, but it is no easy matter to ascertain what that is exactly. See fig. 64.

Plantago lancifolia. P. oblongifolia.

DIPSACEÆ.

Pollen granule three-lobed in its dry state, extremities not tapering and nearly truncate; in connexion with each of the fissures is almost invariably a piece of membrane of not any very defined form: extine spinous, with traces of reticulation; in water becoming nearly triangular and emitting three pollen tubes.

Scabiosa caucasica. Dipsacus fullonum.
S. atropurpurea. D. sylvestris.

COMPOSITÆ.

Pollen granule of the following species of *Cynaraceæ* does not differ materially from that of the preceding order *Dipsaceæ*; the spines are however more strongly marked. See fig. 65, 66.

Centaurea scabiosa. Arctium Lappa.
Cnicus Marianus. *Echinops sphærocephalus.*
C. nutans. Cynara scolymus.
C. tenuiflorus.

Pollen granule polyhedral, emitting three pollen tubes; extine covered with a raised hexagonal reticulation of some breadth, on which are placed a number of spines touching each other. See fig. 67.

Scorzonera hispanica.

Pollen grain small, if examined in a sufficiently early stage of its formation trilobate; subsequently becoming spherical or triangular and emitting three pollen tubes; extine covered with strong spines. No pieces of membrane in connexion with the fissures. See fig. 68, 69.

Leontodon Taraxacum. Pascalia glauca.
Siegesbeckia orientalis. Silphium cornutum.
Catananche cærulea. Helianthus annuus.
Relhania pungens. Dahlia glabrata.
Senecio nemorensis. Inula Helenium.
Ozothamnus cinereus. Solidago Virgaurea.
Tanacetum vulgare. Tussilago Farfara.
Artemisia vulgaris. Eupatorium purpureum.
Chrysanthemum viscosum. Chrysocoma coma-aurea.
Anthemis nobilis. Cineraria Andersonii.
Bellis perennis.

EPIGYNOSÆ.

STELLATÆ OR GALIACEÆ.

Pollen granule oval, extine containing about eight longitudinal fissures. See fig. 70, 71.

Crucianella stylosa. Galium porrigens.

CAPRIFOLIACEÆ.

Pollen granule large, cylindrical, three-lobed; extine of *Leycesteria formosa* dotted with a few small spines.

Viburnum Lantana. Sambucus Ebulus. Leycesteria formosa.

CINCHONACEÆ.

Pollen granule cylindrical, three-lobed in its dry condition. See fig. 73, 74.

Serissa fœtida. Pavetta Caffra. Burchellia capensis.

Pollen granules of *Oxyanthus speciosus* united in fours in the same manner as those of *Salpiglossis atropurpurea*, from which I cannot discover that they differ in any more material respect than size. See fig. 72.

GOODENIACEÆ.

Pollen grain flattish, somewhat triangular, united in fours, the union of which forms an oval figure; each of the two lateral granules, which are somewhat larger and more in contact with each other than those which form the ends of the oval figure, contain eight apertures for the passage of pollen tubes, one placed at each free angle of the granule, and three on either surface, while the end ones have each but six apertures, one at each free angle and two on either surface. See fig. 75.

Leschenaultia formosa.

CAMPANULACEÆ.

Pollen granule spherical; pollen tubes varying from three to five, and issuing from apertures placed upon the equator of the granule. Extine slightly spinous. See fig. 76, 77.

Campanula pyramidalis. Campanula Speculum.
C. pumila alba. C. rotundifolia.
C. patula.

LOBELIACEÆ.

Cylindrical, three-lobed. See fig. 78.

Siphocampylus bicolor. Lobelia decumbens. L. erinus.
Lobelia teucroides. L. ignea.

MONOPETALÆ.

POLYCARPOSÆ.

CONVOLVULACEÆ, Don.

Pollen granule globular, covered with an elevated hexagonal reticulation, which is apparently formed by the apposition of a number of elongated cells placed vertically in reference to the circumference of the granule; apertures amounting to about forty, each being situated in one of the hexagonal spaces formed by the reticulation, and surrounded by a circle of six hexagonal spaces not perforated with apertures. The sides of those hexagons in which apertures are placed are all of equal length, while the unperforated ones have three short and three long sides. Pl. XV. fig. 79.

Cobæa stipularis. Cobæa scandens.

POLEMONIACEÆ.

Pollen granule describing a circular flattened disc; pollen tubes

eight, issuing from apertures placed upon the equator of the granule. Pl. XVI. fig. 80.

Collomia grandiflora. Collomia coccinea.
C. rosea. C. lateritia.

Pollen granule spherical; extine perforated with about sixteen apertures, which are scattered irregularly over its surface. See fig. 81.

Gilia achilleæfolia. Leptosiphon densiflorus.
G. tricolor. L. androsaceus.
G. capitata. Polemonium cæruleum.

Pollen granule reticulated, spherical, apertures about fourteen. See fig. 82.

Phlox acuminata. Phlox Drummondii.
P. paniculata. P. undulata.

Pollen granule reticulated; pollen tubes six or seven, issuing from apertures placed upon the equator of the granule. See fig. 83, 84.

Ipomopsis elegans.

CONVOLVULACEÆ.

Pollen granule cylindrical, three-lobed, but quite characteristic. See fig. 85, 86.

Convolvulus farinosus. Convolvulus pentanthus.
C. arvensis. C. Scammonia.

Pollen granule spherical, extine perforated with very large apertures. See fig. 87.

Calystegia arvensis.

Extine covered with spines; in other respects the pollen granule same as that of the preceding species. See fig. 88.

Ipomæa Sellowii. Ipomæa purpurea. Convolvulus major.
I. Horsfalliæ. I. insignis.

NOLANACEÆ.

Pollen granule cylindrical, three-lobed. See fig. 89.

Nolana paradoxa.

AQUIFOLIACEÆ.

Pollen granule cylindrical, three-lobed.

Ilex Aquifolium.

EBENEACEÆ.

Pollen granule cylindrical, three-lobed.

Cargillia australis.

PRIMULACEÆ.

Pollen granule cylindrical, three-lobed. See fig. 90.

Anagallis arvensis. Primula vulgaris.
Primula Sinensis. Cyclamen autumnale.

EPACRIDIACEÆ.

Pollen granules permanently united in fours, three being placed upon the same plane and one upon these; three pollen tubes (the emission of which is produced artificially with great difficulty) in

each granule, which issue in pairs opposite to each other. See Pl. XVI. fig. 91.

Epacris grandiflora.

ERICACEÆ.

Pollen granule resembling that of the preceding order.

Kalmia latifolia.	Gaultheria Shallon.
Azalia indica.	Arbutus Unedo.
Rhododendron ponticum.	Andromeda multiflora.
R. maximum.	Menziesia Daboeci.
R. caucasicum.	Erica multiflora.
Sedum latifolium.	E. vulgaris.
Gaultheria procumbens.	

Pollen granule cylindrical, three-lobed.

Clethra ferruginea.

BREXIACEÆ.

Pollen granule cylindrical, three-lobed.

Brexia spinosa.

CURVEMBROSÆ.

NYCTAGINACEÆ.

Pollen granule very large, spherical; extine perforated with from forty to fifty apertures. See fig. 92.

Mirabilis Jalapa.

TUBIFEROSÆ.

PROTEACEÆ.

Pollen granule elongated, curved, furnished with three membranes; pollen tubes two, one from each extremity of the granule. See fig. 93.

Dryandra formosa.	Banksia verticillata.
D. longifolia.	B. speciosa.
D. armata.	

Pollen granule furnished with three membranes; triangular pollen tubes three, one from each angle. See fig. 94, 95, 96, 97, 98.

Lambertia formosa.	Grevillea sulphurea.
Hakea pedunculata.	Anadenia Manglesii.
H. pugioniformis.	Isopogon anemonifolium.
Grevillea linearis.	

THYMELACEÆ.

Cylindrical, three-lobed.

Pimelea hispida.	Daphne Mezereum.
P. decussata.	D. Laureola.

ACHLAMYDOSÆ.

SALICACEÆ.

Cylindrical, three-lobed.

Salix viminea.

RECTEMBRYOSÆ.

JUGLANDACEÆ.

Pollen granule spherical; pollen tubes seven, usually issuing

through apertures placed in a line round the centre of the granule. See fig. 99.

Juglans regia.

ULMACEÆ.

Pollen granule spherical, emitting five pollen tubes.

Ulmus campestris.

URTICACEÆ.

Pollen granule spherical, emitting three pollen tubes. See fig. 100.

Parietaria officinalis. Urtica dioica.

BETULACEÆ.

Pollen granule either circular or quadrangular, according as three or four pollen tubes are emitted from it.

Alnus glutinosa. Betula alba

CUPULIFERÆ OR CORYLACEÆ.

Pollen granule cylindrical, three-lobed.

Quercus robur. Castanea vesca. Ostrya vulgaris.

The majority of granules in *Ostrya vulgaris* are four-lobed.

Pollen granule nearly spherical, furnished with three membranes, and emitting three pollen tubes.

Corylus Avellana.

APOCARPOSÆ.

CRASSULACEÆ.

Pollen granule cylindrical, three-lobed. See fig. 102.

Sedum glaucum. Crassula coccinea.

SAXIFRAGACEÆ.

Pollen granule cylindrical, three-lobed.

Heuchera americana. Adamia cyanea.
Saxifraga longifolia. Hydrangea nivea.
S. umbrosa.

BAUERACEÆ.

Pollen granule cylindrical, three-lobed. See fig. 103.

Bauera rubioides.

LEGUMINOSÆ OR FABACEÆ.

RECTEMBRIÆ.

Tribe MIMOSEÆ.

Pollen granules very small, united in fours or multiples of four up to sixteen. See fig. 104, 105, 106, 107.

Pollen granules united in fours, spherical, three upon the same plane and one resting on these. See fig. 104.

Mimosa Mexicana. Mimosa marginata.

Pollen granules cohering in eights, each emitting two pollen tubes, the third being suppressed by the union of the granules. See fig. 105.

Acacia rigens.

Pollen granules cohering in twelves. See fig. 106.

Acacia decipiens. Acacia ciliata
A. nigricans. A. pulchella.

Pollen granules cohering in sixteens. See fig. 107.

Acacia undulæfolia. Acacia trigonocarpa. Acacia sulcata.
A. marginata. A. Lophantha. A. linearis.
A. decurrens glauca. A. flavescens. A. ruscifolia.

CÆSALPINEÆ.

Pollen granule cylindrical, three-lobed.
Cassia australis.

PAPILIONACEÆ.

Pollen granule elongated, more or less prismatic, with three fissures for the escape of pollen tubes. See fig. 108.

Pterocarpus erinaceus. Trifolium pratense.
P. echinatus. Medicago arborea.
Faba vulgaris. Anthyllis polycephalus.
Pisum sativum. Ononis hircina.
Hedysarum Onobrychis. Cytisus capitatus.
Astragalus virescens. Genista tinctoria.
Swainsonia alba. Spartium scoparium.
Colutea arborescens. Lupinus luteus.
Indigofera psoraloides. Viminaria denudata.
Psoralea glandulosa. Virgilia capensis.
Callistachys ovata. Sophora racemosa.
Lotus corniculatus.

Pollen granule provided with three membranes, triangular, sides nearly straight. See fig. 109.

Erythrina laurifolia.

AMYGDALEÆ.

Pollen granule cylindrical, three-lobed.

Amygdalus persica. Prunus Cerasus. Armeniaca vulgaris.
A. lævis. P. domestica.

POMEÆ.

Pyrus Malus. P. communis.

ROSACEÆ.

Spiræa ulmifolia. Agrimonia nepalensis. Fragaria vesca.
S. ariæfolia. Geum sinense. Rosa bracteata.
S. Ulmaria. Potentilla anserina. Rubus fruticosus.
Agrimonia Eupatoria. P. argentea.

Many of the granules in *Rosa bracteata*, and nearly all of *Rubus fruticosus*, are four-lobate.

GYNOBASEOSÆ.

LIMNANTHACEÆ.

Pollen granule reticulated, bent twice nearly at right angles; pollen tubes three, one issuing from each end and one from the centre of the granule. Pl. XVI. fig. 110, 111.

Limnanthus Douglassii.

SURIANACEÆ.

Pollen granule cylindrical, three-lobed.

Cneorum tricoccum.

TROPÆOLEÆ.

Pollen granule cylindrical, three-lobed.

Tropæolum peregrinum. Tropæolum majus.

BALSAMINACEÆ.

Pollen granule elongated, quadrilateral, and emitting a pollen tube at each angle. Pl. XVII. fig. 112.

Impatiens noli me tangere. I. glandulifera. I. parviflora.

GERANIACEÆ.

Pollen granule very large, somewhat spheroid in its moist condition, emitting three pollen tubes. See fig. 113.

Geranium sylvaticum. Pelargonium peltatum.

RUTACEÆ.

Pollen granule cylindrical, three-lobed.

Correa alba. Ruta graveolens.

ALSINACEÆ.

Pollen granule spherical; extine perforated with about ten apertures, placed nearly at equal distances from each other. See fig. 114.

Dianthus barbatus. D. deltoides. Gypsophila elegans.

SILENACEÆ.

Pollen granule same as the preceding.

Silene Armeria. Silene vespertina. Saponaria officinalis.
S. inflata. Saponaria viscida.

PORTULACACEÆ.

Pollen granule cylindrical, three-lobed. See fig. 115.

Calandrinia speciosa. C. discolor.

MALPIGHIACEÆ.

Pollen granule spherical, pollen tubes about sixteen. See fig. 116.

Malpighia punicea.

CELASTRACEÆ.

Pollen granule cylindrical, three-lobed.

Celastrus Pyracanthus.

EUPHORBIACEÆ.

Pollen granule cylindrical, with three lobes.

Ricinus communis.

RHAMNACEÆ.

Pollen granule small, triangular, furnished with three membranes. Pl. XVII. fig. 117.

Zizyphus Paliurus.

Pollen granule cylindrical, three-lobed.

Ceanothus pallidus.

AURANTIACEÆ.

Pollen granule, in its primary condition, four-lobate; subsequently it becomes circular, and emits four pollen tubes. See fig. 118.

Citrus Aurantium. C. Limonium.

LYTHRACEÆ.

Pollen tube cylindrical, three-lobed.

Lythrum Salicaria. Cuphea viscosa.

TILIACEÆ.

Pollen granule spherical, furnished with three membranes; extine not covering entirely the exintine. See fig. 119.

Tilia europæa. Tilia americana.

MALVACEÆ.

Pollen granule globular; extine reticulated, spinous, and perforated with apertures, fitting into which, in many species, are circular detached pieces of membrane; apertures very numerous, amounting in some genera to between fifty and sixty; each reticulum is the seat of either a spine or an aperture. See fig. 120.

Hibiscus liliflorus.	Althæa officinalis.
H. syriacus.	Malva sylvestris.
H. annuus.	M. fragrans.
Pavonia præmorsa.	M. virgata.
Lavatera acerifolia.	Kitaibelia vitifolia.

Pollen granule with but three pollen tubes. See fig. 121.

Abutilon striatum.

CISTACEÆ.

Pollen granule cylindrical, three-lobed.

Cistus Helianthemum.

LINACEÆ.

Pollen granule somewhat square, emitting six pollen tubes, one from each angle of the figure, and one on either surface. See fig. 122. Linum usitatissimum.

Cylindrical, three-lobed.

Linum africanum.

ÆSCULACEÆ.

Pollen granule cylindrical, three-lobed.

Æsculus hippocastanus.

ACERACEÆ.

Pollen granule cylindrical, three-lobed.

Acer Pseudo-platanus.

POLYGALACEÆ.

Primary form of pollen granule cylindrical, fluted; extremities truncate, in water becoming spherical and emitting about twenty pollen tubes. Pl. XVII. fig. 123, 124, 125.

Muraltia filiformis.	Polygala myrtifolia.
M. Myxta.	P. speciosa.
Polygala grandiflora.	P. Chamæbuxus.

PARIETOSÆ.

HYPERICACEÆ.

Cylindrical, three-lobed. See fig. 126.

Hypericum hircinum.

TURNERACEÆ.

Pollen granule cylindrical, three-lobed.

Turnera elegans.

PASSIFLORACEÆ.

Pollen granule spherical, reticulated, and provided with three large valves, first noticed by Purkinje. See fig. 127.

Passiflora cærulea. P. cærulea, var. racemosa. P. alata.

VIOLACEÆ.

Pollen granule of an elongated form, four-sided, with square truncate extremities; in water it changes its shape and becomes square in outline, emitting four pollen tubes which issue from fissures concealed in the dry granule, one in each of the lines which separate the four sides of the figure. The change of form arises from the approximation of the ends of the granule occasioned by the water which it imbibes, which stretches the membrane, which can only yield in one direction. See fig. 128, 129.

Viola tricolor.

Pollen granule cylindrical, three-lobed. See fig. 130, 131.

Viola montana.

RESEDACEÆ.

Cylindrical, three-lobed.

Reseda odorata.

CAPPARIDACEÆ.

Pollen granule cylindrical, three-lobed.

Cleome spinosa.

CRUCIFERÆ OR BRASSICACEÆ.

Pollen granule three-lobed, cylindrical. See fig. 132, 133.

Heliophila arabioides.	Alyssum maritimum.
Sinapis alba.	Cheiranthus Cheiri.
Brassica oleracea.	C. mutabilis.
Iberis alba.	Matthiola incana.

EPIGYNOSÆ.

BEGONIACEÆ.

Pollen granule same as the preceding.

Begonia glabrata.

FICOIDEÆ OR MESEMBRYACEÆ.

Pollen granule cylindrical, three-lobed.

Mesembryanthemum reflexum.

CACTACEÆ.

Pollen granule same as the preceding.

Opuntia vulgaris.

LOASACEÆ.

Pollen granule cylindrical, three-lobed.

Bartonia aurea.

CUCURBITACEÆ.

Pollen granule cylindrical, three-lobed. See fig. 134.

Momordica Elaterium.

HAMAMELACEÆ.

Pollen granule cylindrical, three-lobed.

Trichocladus crinitus.

CORNACEÆ.

Pollen granule cylindrical, three-lobed.

Cornus canadensis. Aucuba japonica.

MYRTACEÆ.

Pollen granule cylindrical, three-lobed.

Punica Granatum. Leptospermum ambiguum.

Pollen granule triangular, that of *Calothamnus villosus* possessing three membranes, and the extine of *Angophora racemosa* exhibiting three radiating lines upon its surface. Pl. XVII. fig. 135, 136, 137.

Melaleuca hypericifolia. Angophora cordata.
Calothamnus villosus. Tristania neriifolia.
Angophora racemosa.

MELASTOMACEÆ.

Pollen granule cylindrical, three-lobed.

Melastoma corymbosa. M. heteromalla. Arthrostemma lineata.

ONAGRACEÆ.

Pollen granule furnished with four membranes; either triangular, and emitting three pollen tubes, one from each angle; or cylindrical, and sending forth two pollen tubes; this difference of form arising merely from the suppression of one of the pollen tubes. Generally separate, but sometimes united in threes or fours.

Pollen granule triangular, separate.

Lopezia coronata. L. racemosa. Gaura biennis.

Pollen granule united in threes.

Epilobium hirsutum.

Pollen granule united in fours. Pl. XVIII. fig. 138.

Epilobium roseum.

Pollen granule triangular, separate. See fig. 139, 140, 141.

Epilobium angustifolium. Œnothera biennis.
Clarkia elegans. Œ. quadrivalva.
C. pulchella. Œ. suffruticosa.
Godetia rubicunda. Œ. Drummondii
Œnothera serotina.

Pollen granule triangular, separate. See fig. 142.

Fuchsia coccinea. Fuchsia globosa major.
F. gracilis. F. conica.
F. grandiflora. F. lycioides.
F. longipedunculata.

OBS.—Many of the pollen granules of some hybrid *Fuchsia* appear

to acquire a fourth pollen tube, and hence become of a square form. Pl. XVIII. fig. 143.

Fuchsia Devonia. F. Clintonia. F. Atkinsonia.

Pollen granule cylindrical, a pollen tube issuing from either extremity. See fig. 144, 145.

Fuchsia fulgens. Fuchsia Thymifolia.
F. corymbifera. F. cylindrica.

Albuminosæ.

Francoaceæ.

Pollen granule cylindrical, three-lobed.

Francoa racemosa.

Vitaceæ.

Pollen granule cylindrical, three-lobed.

Vitis vinifera.

Berberaceæ.

Pollen granule cylindrical, three-lobed.

Epimedium alpinum.

Escalloniaceæ.

Pollen granule cylindrical, three-lobed.

Escallonia rubra.

Grossulaceæ.

Pollen granule in its dry state obscurely six-lobed, and when moist becoming circular and emitting six pollen tubes.

Ribes grossularia. Ribes rubrum.

Araliaceæ.

Pollen granule cylindrical, three-lobed.

Hedera Helix. Aralia sambucifolia.

Umbelliferæ or Apiaceæ.

Pollen granule most probably furnished with three membranes, of a prismatic form in its dry state, with slightly contracted sides, becoming in water cylindrical, with rounded ends, and emitting three pollen tubes, which issue from fissures placed in the angles of the prism. See fig. 146, 147, 148.

Conium maculatum. Œnanthe crocata.
Daucus Carota. Œ. fistulosa.
Pastinaca sativa. Bupleurum rotundifolium.
Anethum fœniculum. B. fruticosum.

Pollen granule cylindrical, ends rounded, three fissures for the pollen tubes; form but slightly changed by water. See fig. 149.

Eryngium alpinum. Didiscus cæruleus.

Dilleniaceæ.

Pollen granule cylindrical, three-lobed.

Hibbertia dentata. Candollea cuneiformis.

MAGNOLIACEÆ.

Pollen granule elliptical, tapering towards either extremity, *with a single furrow* running down its long axis. Pl. XVIII. fig. 150.

Magnolia grandiflora. Magnolia glauca.

NYMPHÆACEÆ.

Pollen granule oval, with but a *single furrow* passing down one side. See fig. 151, 152.

Nymphæa alba. Nymphæa lutea.

FUMARIEÆ.

Pollen granule furnished with three membranes, spheroidal; extine perforated with six apertures for the passage of pollen tubes; four of these are placed on a line dividing the granule into two hemispheres, in the centre of each of which one of the two remaining apertures is situated. See fig. 153.

Fumaria officinalis. F. lutea. Diclytra formosa.

OBS.—Most of these granules in the last two species appear to be imperfectly formed, having but three or four pollen tubes; but the presence of three membranes in them all, and the occasional appearance of a perfectly formed granule, prove that there is no essential difference in the pollen of the three species.

PAPAVERACEÆ.

Pollen granule cylindrical, three-lobed.

Papaver Rhœas. Argemone mexicana.
P. somniferum. Glaucium luteum.

Pollen granule spherical, with six fissures for the escape of pollen tubes. See fig. 154, 155.

Eschscholtzia californica.

RANUNCULACEÆ.

Pollen granule cylindrical, three-lobed.

Pæonia corallina. Helleborus fœtidus.
Aconitum Napellum. H. niger.
Delphinium Staphysagria. Thalictrum minus.
Aquilegia vulgaris. Clematis Flammula.

Pollen granule mostly four-lobed, cylindrical, in water becoming square and emitting four pollen tubes. See fig. 156, 157, 158.

Ranunculus acris.

OBS.—The term cylindrical, as applied to that form of pollen granule distinguished by the presence of three furrows, which divide it into three more or less prominent lobes, is perhaps objectionable, inasmuch as it is not properly cylindrical, and should have been removed for a more appropriate one, were it not that it has already been employed in that portion of the paper already published. All that is intended to be conveyed by the term is, that all pollen to which it is applied is of an elongated form.

One of the first things to be remarked, on a review of the preceding descriptions, is the great and striking simplicity of form and structure which characterizes the pollen of endogenous plants, compared with exogenous; and not alone is

this difference observable between the pollen of the two grand classes of the vegetable kingdom, but it will be further noticed, that the more or less complex structure of the pollen bears some reference to the station of the plant in these divisions, especially in the monocotyledonous; a fact hitherto denied by all vegetable microscopists who have paid attention to the subject, but one which can scarcely again be called in question after the very conclusive evidence of its truth furnished in the antecedent pages.

The pollen granule of *Cyperaceæ* and *Graminaceæ* is either oval or spherical (the simplest forms in nature), and has but a single pollen tube. Mounting a step higher to the *Typhaceæ* and *Juncaceæ*, we meet with the same type and structure of granule; but instead of being separate, as in the *Graminaceæ* and *Cyperaceæ*, the grains are united in fours. In *Calla* the form is oval, and a pollen tube issues from either end. In the genus *Butomus*, in the *Liliaceæ*, *Melanthaceæ*, *Bromeliaceæ*, *Iridaceæ*, and *Amaryllidaceæ*, it is more complex; each grain is of an elongated shape, tapering almost to a point towards either extremity, with a furrow running down one side, from which, however, only a single pollen tube issues, as in the *Cyperaceæ* and *Graminaceæ*. In *Zingiberaceæ*, *Marantaceæ*, and *Musaceæ*, the form of each granule again becomes very simple; it is a perfect sphere, and the extine, which is of great thickness, contains no provision in it for the passage of the pollen tubes, but possesses the power of cracking (a peculiarity met with only in the pollen of these allied orders and that of the *Taxaceæ* and *Coniferæ*), and so allowing of their escape. In *Orchideæ* the granules are united in fours, and are likewise of a very simple structure.

The *Taxaceæ* and *Coniferæ*, which, though usually placed among dicotyledons, ought to be regarded as forming the connecting links between monocotyledons and dicotyledons, also possess pollen of a very simple form and structure, but still somewhat more complex than that of any of the preceding orders. It is here for the first time that I have met with the third membrane, which Fritzsche however mentions as existing in *Tigridia pavonia*, and Mr. Giraud in *Crocus vernus**, both monocotyledons.

We come now to a class of plants decidedly exogenous, the *Jasminaceæ*: here the pollen is much more complicated; when dry it is cylindrical, and 3-lobed; in water it becomes triangular and emits three pollen tubes; while in *Labiatæ*, an order not very far removed from the preceding, it is 6-lobed and furnished with as many pollen tubes. In the remaining

* Mr. Giraud's papers on the structure of the pollen appeared in vol. ii. p. 399. pl. XVIII., and vol. iii. p. 127 of this Journal.—Ed.

orders of dicotyledons the pollen does not indicate any regular gradation of structure, although in many of the higher families it is surprisingly complex.

So great is the difference between the pollen of Exogens and Endogens, that it alone furnishes a character by which it may be at once determined to which class any plant belongs. The pollen granule of an endogen may thus be characterized. It is either spherical, oval, or elliptical; generally, if not always, composed of two membranes, rarely possessing more than one pollen tube, and, with a single exception, never more than two. This exception occurs in *Limnocharis Humboldtii*, in which the granule is spherical, and the extine perforated with six or seven apertures for the passage of the pollen tubes. The elliptical formation of granule prevails much among monocotyledons, and has been met with in forty-four of the seventy-three genera of Endogens submitted to the microscope. An exogenous pollen granule may be thus defined: it generally presents a more complicated organization; the number of enveloping membranes is either two, three, or four; its form is various, being most commonly either three-lobed, spherical, or triangular; and it is furnished with pollen tubes varying in number, exclusive of three exceptions, from three to upwards of fifty. Of these forms the three-lobed type is of the most frequent occurrence, and is absolutely characteristic, so far as my experience goes, of an exogen, being found in 187 of the 332 genera of dicotyledons examined by me.

The exceptions occur in the genera *Acanthus* (see fig. 44.), *Dryandra*, and *Magnolia*, the last a genus so evidently dicotyledonous as not to admit a doubt of its real nature; and yet here, strange to say, the granule, so far as has been observed, perfectly resembles the elliptical form so prevalent among monocotyledons. (See fig. 150.) The pollen granule of *Dryandra*, although provided with but two pollen tubes, is curved and has *three* distinct tunics. (See fig. 93.)

We come now to the more immediate purpose of this paper, viz. to consider how far the pollen granule may be relied on as a means of classification. It has already been said that by it alone a monocotyledon may be distinguished from a dicotyledon, and hence should be carefully consulted when any doubts are entertained of the position of a plant in the vegetable kingdom. Much has been written upon the position which the *Nymphæaceæ* occupy in the vegetable kingdom; some arguing that they ought to be placed among Endogens, to which they are united by so many evident affinities,—others referring them to Exogens; but the question is as yet an undecided one among botanists, although admitting, in my

opinion, of easy determination by a reference to the form and structure of the pollen granule. This would place them, as was originally done by L. C. Richard, among monocotyledons; and that this is their true station not the smallest doubt remains in my own mind, notwithstanding that the opinion of most modern botanists appears to lean in the opposite direction. The pollen granule of *Nymphæa* is oval, hispid, with a furrow down one side, and emits a single pollen tube, thus coming under the definition already given of endogenous pollen. (See fig. 151, 152.)

Mohl declares that the pollen varies extremely in form not only in genera of the same family, but also in species of the same genus; and that it even occurs that in some species the anthers contain grains "de formation assez diverses." The two latter assertions, and more especially the last one, are so contrary to the results of my own investigations, and are so opposed to all analogy and to that order and evident design that reign with such constancy throughout all the beautiful works of creation, that I should not have hesitated in confidently denying the accuracy of remarks, which would cause such confusion and chaos to hold dominion where nothing but creative skill and wisdom might have been looked for, even before I had personally examined a single granule.

With regard to Mohl's first statement, it must be admitted that the form and structure of the pollen granule does vary considerably in genera of the same family; but this is by no means the rule, which should be stated on the other side; and is, that natural orders, or sections of orders, are characterized by the possession of a pollen granule of one type, and that the more natural and more distinct the affinities of an order, the more frequently will the pollen be found characteristic of that order. That it should vary considerably in genera of the same family is nothing more than reason would lead us to anticipate; for it must be allowed that the exact limits of many of our orders are far from being satisfactorily determined, and that some of them contain genera whose true alliances are far from being clearly ascertained.

Again, the exact structure of the anthers of some of the genera forming a family will sometimes differ; and, where this is the case, it is only natural to anticipate that a corresponding deviation from the usual form of the pollen granule in that family should accompany such difference. Reference to this fact would frequently account for what otherwise might be ignorantly regarded as a senseless freak of nature, viz. the difference sometimes met with in pollen, the contents of two anthers derived from genera nearly allied, but which anthers

a close inspection will disclose to be not identical in their structure.

The same type of granule is frequently found to extend through more than one allied order, and sometimes through a whole alliance; thus, among monocotyledons, we find one form extending, with slight variations of size, &c., not only through the group *Glumosæ*, but likewise through the Alliance *Typhales* and the genus *Juncus*. Another distinct form is met with in the genera *Butomus* and *Tradescantia*, from these passing through *Liliales, Ixiales, Bromeales* and *Narcissales*; and lastly, a third formation of granule occurs which connects the orders of the Alliance *Amomales*. Among dicotyledons the three-lobed form prevails through the obviously connected orders *Rosaceæ, Pomeæ, Amygdaleæ* and *Saxifragaceæ*. The same type, differing only in exact form and size, unites the Alliances *Scrophulales* and *Solanales*. *Papaveraceæ* and *Cruciferæ* are also joined with each other in the form and structure of their pollen granules.

It is unnecessary to enumerate in this place the various orders and sections of orders which are characterized by the possession of a pollen granule of a peculiar and distinctive form, as all the information which can at present be given upon this subject may be learned by reference to the lists of plants examined under each order already mentioned. Further research will doubtless extend the number of these orders, clear up many apparent anomalies, and also, it may be reasonably expected, add somewhat to the number of exceptions.

The truth of Mohl's second and third assertions, contained in the statement in the preceding page, I would most distinctly deny, more especially that of the last; and in doing so I would observe, that I rely solely on the evidence which my own experience furnishes. Out of 366 genera submitted to the microscope, two exceptions only have occurred to the rule, that species of the same genus possess the same type of pollen granule; but I have little doubt future investigation will explain these isolated exceptions. The first exception occurs between two species of *Linum, L. usitatissimum* and *L. africanum*; in the former the granule is somewhat square, and the extine contains six perforations for the escape of pollen tubes; in the latter it is three-lobed, with three pollen tubes: the second is found in the genus *Viola*. In *Viola tricolor* the pollen is an elongated six-sided figure, emitting four pollen tubes, and in *Viola montana* and *V. odorata* it is small and three-lobed.

If the above statements be correct, it would appear that an examination of the pollen granule establishes and confirms in a remarkable manner the naturalness of many orders and

sections of orders, and that where it does not go so far as this, it is to be relied on as affording a character of at least generic importance.

Now with reference to the third assertion of Mohl, that in some plants the same anther contains distinct forms of pollen, I can affirm it to be wholly and without exception incorrect. The only difference ever observed in pollen of the same species arises either from the addition to the distinguishing type, or subtraction from it—most frequently the former—of one or more pollen tubes, generally of one; an anomaly which is of frequent occurrence in some species, especially in the following, *Stachytarpheta mutabilis*, *Rubus fruticosus*, *Nicotiana Tabacum*, *Solanum tuberosum*; and those granules so changed are to be regarded as malformations or monstrosities, of which an instance is exhibited in fig. 50, which represents a granule of *Stachytarpheta mutabilis* thus deformed. Every organ and part of the vegetable and animal fabric is subject to similar occasional departures from normal structure.

When a number of flowers are placed together for some time in a vessel, an intermixture of the pollen of each not unfrequently occurs, so that when that of any species is examined, more than one form of pollen granule may be observed; but no person would be so careless as to suppose for a moment that these were derived from the same anther.

These monstrosities are of very frequent occurrence among hybrid species, particularly of the *Fuchsiæ*. In the *pure* species of *Fuchsia* each granule is furnished with either two or three pollen tubes; now among the pollen of *F. Standishii*, a hybrid between *F. fulgens*, whose grains of pollen have but two tubes, and another species the granules of which have three tubes, the greatest confusion seems to prevail, some of the granules having but two or three tubes, thus following the type of either parent, while others have four tubes; and many of them appear altogether abortive, and consist of nothing more than the extine, which does not even contain fovilla. Here then a satisfactory reason is afforded why the seeds of hybrid species should be so frequently unproductive, since they either have not received the influence of the degenerated pollen at all, or have so in an imperfect manner.

The same form of pollen granule met with in one order sometimes occurs in another separated from it by every point of structure; but when this does happen, most frequently a difference either in the size of the granule, the number of membranes which envelope it, or of pollen tubes which issue from it, is observable; and when no such distinction can be discovered, the family in which it occurs may be so estranged from that possessed of pollen of similar formation, as that it

may serve equally as a means of distinguishing it from those orders to which it is evidently more or less closely allied.

The difference in the size of the pollen tubes of granules which in every other particular resemble each other, might of itself, were there no other cause, constitute a physical impediment to the fertilization of the seeds of one species by the pollen of another, as, on account of their magnitude, they might be unable to make their way through the intercellular passages of the style.

From all that has now been said it will be observed, that from an examination of the form and structure of the pollen granule, a useful confirmation may be gathered of the correctness of the principles upon which a natural system of classification is based. The propriety, likewise, of employing the pollen as a character, with others, in the definition of natural orders, will, I think, be at once acknowledged, as I am glad to see that it is by Dr. Lindley, who in a few cases has so employed it; but in the instances in which he has thus availed himself of it, the true structure of the pollen appears to have been either imperfectly or erroneously defined. As all the essential characters of the pollen granule of each family may be comprised in a few words, no difficulty can arise in employing it in the definitions of orders, sections of orders, or genera, on the score of its adding too much to their bulk; but, at the same time, I would observe, that great care is necessary in determining what the real structure of the pollen granule is, before venturing to make use of it; and this is not to be ascertained by a momentary examination of it on the field of the microscope, but requires frequently much patient and troublesome investigation.

For the numerous and beautiful drawings which accompany this communication, all of which have been carefully executed from rough sketches of my own, made of the object while under the microscope, I am indebted to the friendship of two ladies, Miss Hunter and Miss Nolcken, who are ever ready to lend their time and their talents to works of usefulness; and that not a little of either is requisite in undertaking the drawing of so many illustrations, will be readily allowed. About two-thirds of them were done by the latter lady, and the remainder by the former.

It now only remains for me to acknowledge the great obligation I am under to Mr. Smith of the Royal Botanic Gardens* at Kew, for the privilege so readily granted of ob-

Under the active management of their present director, Sir William Hooker, as well as that of Mr. Smith, the usefulness and efficiency of these Gardens will doubtless be much increased.

taining flowers for the purposes of my inquiry, without which the extent of my investigations must have been much narrowed. My best thanks are likewise due to Dr. Lindley, to Mr. Loddiges, and Mr. Anderson of the Chelsea Gardens, for a similar favour; but more particularly are they due to Dr. Lindley. To Mr. Choules of the Kew Botanic Gardens I am also much indebted for the correction and revision of the list of species.

I have now brought to a termination but one of a series of papers which it is my intention, if health and time permit, to publish on the subject of the pollen granule.

EXPLANATION OF THE PLATES.

All the figures are drawn to the same scale, and exhibit the relative sizes of the pollen granules.

Plate XIII.

Fig. 1. Pollen granule of Cyperus longus.
2. —— ——— of Papyrus Antiquorum.
4. —— ——— of Zea Mays.
5. —— ——— of Typha latifolia.
6. —— ——— of Calla palustris.
7. —— ——— of Calla æthiopica.
8. —— ——— of Juncus lacustris.
9. —— ——— of Limnocharis Humboldtii.
10. —— ——— of Tradescantia; side view.
11, 12. Pollen granule of Asparagus officinalis; 11, front view, exhibiting the single furrow with which it is furnished; 12, end view.
13, 14, 15. Pollen granule of Lilium longiflorum; 13, front views; 14, end ditto; 15, the appendage which rests upon and partly conceals the furrow.
16. Pollen granule of Watsonia irioides.
17, 18, 19. Represent three views of the pollen granule of Anigozanthus coccineus; 17, front aspect; 18, side ditto; and 19. exhibits its form when upon the stigma and just about to emit its two pollen tubes.
20, 21, 22, 23. Represent the pollen granule of Crinum amabile; 20, front view; 21, a section of the granule; 22, the form which it assumes previous to the emission of the pollen tubes; 23, one of the appendages to the furrows.
24, 25, 26; 24, front view of the pollen granule of Pancratium declinatum; 25, side view; 26. exhibits the intine with its contents just escaping through the fissure in the extine; 24 *a*, appendage.

Plate XIV.

Fig. 30, 31. Pollen granule of Strelitzia humilis; 31. shows the manner in which the extine cracks either on coming in contact with solutions of the mineral acids or when applied to the stigma.
32, 33. Pollen granule of Canna occidentalis; 32, in its dry state; 33, as it appears in water or in solutions of the mineral acids.
34, 35. Pollen granule of Pinus sylvestris; 34, side view; 35, front do.
37. Pollen granule of Nerium Oleander as seen upon the stigma.
38, 39, 40, 41, 42. Different views of the pollen granule of Petunia violacea; 38, a side view of it in its primary or dry state; 39, end do.; 40, the form which it assumes in water; 41, as it appears upon the stigma; 42. exhibits the extine detached from the intine.

Fig. 87. Pollen granule of Calystegia arvensis.
88. —— —— of Ipomœa Sellowii.
89. —— —— of Nolana paradoxa.
90. —— —— of Cyclamen autumnale.
91. —— —— of Rhododendron maximum, showing its structure and the mode of cohesion of the granules.
92. Pollen granule of Mirabilis Jalapa.
93. —— —— of Banksia speciosa.
94, 95. —— —— of Lambertia formosa; 94, front and 95, side views.
96. Pollen granule of Grevillea linearis.
97, 98. Pollen granule of Anadenia Manglesii; 97, front and 98, side views.
99. Pollen granule of Juglans regia.
100. —— —— of Urtica dioica.
102. —— —— of Sedum glaucum.
103. —— —— of Bauera rubioides.
104. —— —— of Mimosa Mexicana.
105. —— —— of Acacia rigens.
106. —— —— of Acacia decipiens.
107. —— —— of Acacia linearis.
108. —— —— of Colutea arborescens in its dry state.
109. —— —— of Erythrina laurifolia, showing its 3 membranes.
110, 111. Pollen granule of Limnanthus Douglassii; 110, in its primary; 111, in its secondary condition.

PLATE XVII.

Fig. 112. Pollen granule of Impatiens noli me tangere.
113. —— —— of Geranium sylvaticum.
114. —— —— of Dianthus caryophyllus.
115. —— —— of Calandrinia discolor.
116. —— —— of Malpighia punicea.
117. —— —— of Zizyphus Paliurus.
118. —— —— of Citrus Aurantium as it appears upon the stigma: in its dry state it is of an elongated form and four-lobed.
119. Pollen granule of Tilia europæa. Three membranes only should have been represented in the figure instead of four.
120. Pollen granule of Lavatera acerifolia.
121. —— —— of Abutilon striatum.
122. —— —— of Linum usitatissimum.
123, 124, 125. Pollen granule of Polygala grandiflora; 123, in its primary; and 124, 125, in its secondary forms.
126. Pollen granule of Hypericum hircinum.
127. —— —— of Passiflora cærulea.
128, 129. Pollen granule of Viola tricolor; 128, in its primary; 129, in its secondary form.
130, 132. Pollen granule of Viola montana in its dry and moist conditions.
131, 133. Pollen granule of Brassica oleracea; 131, in its primary; 133, in its secondary form.
134. Pollen granule of Momordica Elaterium in its primary form.
135. —— —— of Calothamnus villosus.
136. —— —— of Angophora cordata.
137. —— —— of Tristania neriifolia.

PLATE XVIII.

Fig. 138. Shows the mode of union and structure of the pollen granules of Epilobium roseum.

Fig. 139. Pollen granule of Epilobium augustifolium.
140, 141. Pollen granule of Godetia rubicunda; 141. exhibits the extine separated from the other membranes.
142. Pollen granule of Fuchsia coccinea.
143. —— ——— of Fuchsia Devonia.
144. —— ——— of Fuchsia fulgens.
145. —— ——— of Fuchsia thymifolia.
146, 147, 148. Pollen granule of Heracleum Spondilium; 146, its dry or primary form; 147, its moist or secondary condition; and 148, end views of it in the same state.
149. Pollen granule of Didiscus cæruleus.
150. —— ——— of Magnolia grandiflora.
151, 152. Pollen granule of Nymphæa alba; 151, in its dry, and 152, in its moist condition.
153. Pollen granule of Fumaria officinalis.
154, 155. Pollen granule of Eschscholtzia californica; in the second figure the pollen tubes are just emerging from the extine.
156, 157. Pollen granule of Ranunculus acris; 156. represents a side view of it in its primary form; 157, an end ditto in the same state; and 158, in its secondary form, with a pollen tube issuing through each fissure.

[The above paper was consigned to our care in the autumn of last year, the delay in its appearance having been occasioned by the number of illustrations.—Ed.]

PROCEEDINGS OF LEARNED SOCIETIES.

GEOLOGICAL SOCIETY.

June 30, 1841.—"A description of a portion of the skeleton of the Cetiosaurus, a gigantic extinct Saurian Reptile occurring in the Oolitic formations of different portions of England," by Professor Owen, F.R.S., F.G.S.

The remains described in this memoir consist of vertebræ and bones of the extremities obtained by Mr. Kingdon from the oolite quarries of Chipping Norton, in Oxfordshire; of vertebræ and other bones from the oolite of Blisworth, near Northampton, transmitted to the author by Miss Baker; and of other remains from the oolite of Staple Hill, Wotton, three miles north-west of Woodstock; from the oolite near Buckingham; the Portland stone at Garsington and Thame, in the collection of Dr. Buckland: Mr. Owen has likewise examined a vertebra and some bones of the extremities of the same saurian from the Yorkshire oolite, and preserved in the Scarborough Museum.

Caudal Vertebræ.—A caudal vertebra from near Buckingham, which presented the anchylosed neural arch entire, but with the transverse, oblique and spinous processes broken off, equalled in dimensions a middle caudal vertebra of a full-sized whale, the antero-posterior diameter being five inches, the transverse eight inches six lines, and the vertical seven inches. The sides and under part of the centrum are described as very concave; and the shape of the articular extremities as nearly circular, with a greater concavity in the anterior one than in the posterior. The posterior hæmapophysial