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Nº 13 - this Volume
21 - 22 - 15 in 1917 - 22 v. same

1925. p. 209. He says:-
"In my opinion, Beer & Arber's description of a new type of cell division
by means of a "phagocytosis", etc. [is] based on a misinterpretation of
pollen views of the various stages of cell division in vascular cells."
See also Bailey, L.H. Bot. Mag., 70, 469-471. 1920

(See also account of my beginning floral anatomy from a letter of 1908, in Flower
& Reverie)

Agnes Arber. 1910-1915.

1. A Note on Caricacarpion compressum Will. Proc. Camb. Phil Soc. Vol. XV p 393, 1910.
2. On the Structure of the Palaeozoical Integumentum Compressum (Will.) Ann Bot Vol. XXIV p 491, 1910
3. The Cactaceae & the Study of Seedlings. New Phyt. Vol. IX p 333, 1910
4. On the Structure of the Androecium in Parnassia & its bearing on the Affinities of the Genus. Ann. Bot Vol. XXVII p 491, 1913
5. The Botanical Philosophy, of Guy de la Brosse: a Study in Seventeenth Century Thought. Isis. Vol I p 341, 1913
6. Review of J.E. Loebe on "Aristotle's Recumbent - Natural Science. Isis. Vol I p 505, 1913
7. ~~Reichenbach's~~ ~~Journal~~ ~~of~~ ~~Botany~~ ~~and~~ ~~Botanical~~ ~~Science~~ ~~Vol. I~~ ~~Part I~~ ~~1913~~
8. A Note on Jugmocarpos. Ann Bot. Vol. XXVIII p 195, 1914 (Two figs. belong to the paper will be found in a paper by E.A. Muhlberg included)
9. An Anatomical Study of the Palaeozoic Coniferous Lophocarpus. Trans. Linn Soc. Lond. 2nd Ser. Bot. Vol 8 pt 6, p 205, 1914.
10. On Root Development in Statice alba L. etc. Proc. Camb Phil Soc. Vol. XVII p 361, 1914
11. The Anatomy of the Stamens in Certain Indian Species of Parnassia. Ann Bot Vol. XXIX p 167, 1915
12. (Jointly with Miss Ethel Jayson) The Comparative Morphology of the Embryo & Seedling in the Gramineae. Ann. Bot. Vol. XXIX p 161, 1915
13. (Jointly with Mr. Robert J. Bear) On the Occurrence of Binucleate & Multinucleate Cells in growing Tissues. Ann. Bot. Vol. XXIX p. 598 1915

Besides the papers in the volume, the following books also belong to this 5 years: -

Herbals. Their Origin & Evolution. A Chapter in the History of Botany 1470-1670. XVIII + 253 pp.
22 plates, 113 text figs. Cambridge University Press 1912.

A note on Cardiocarpon compressum, Will. By Mrs E. A. NEWELL ARBER, D.Sc., Newnham College. (Communicated by Mr E. A. Newell Arber.)

[Read 7 February 1910.]

In 1877 Williamson* described and figured a small unattached winged seed showing binary symmetry, from the Lower Coal Measure nodules of Oldham, which he referred to Brongniart's† genus *Cardiocarpon*. On account of its flattened form he gave it the specific name *compressum*. Other *Cardiocarpus* had previously been described from the British Coal Measures, but only their external appearance was known, whereas in the new species the internal structure was preserved. Williamson figured sections cut from three specimens. The most characteristic feature of the seed was that the testa was divisible into two very distinct layers,—an exotesta of coarse parenchyma, and an endotesta of much smaller cells. No further description of the internal structure of *Cardiocarpon compressum*, or of that of any other seed showing bilateral symmetry from the British palaeozoic rocks, has been published since Williamson's time. The main interest of the genus *Cardiocarpon* lies in the great probability that it represents the seeds of *Cordaites*‡. The possibility is not however excluded, that seeds of this type were borne by Pteridosperms, for seeds of binary symmetry have been found attached to fronds of *Anemites*§ and *Pecopteris Pluckeneti*¶. The following note is based on material collected by Prof. F. W. Oliver, Dr D. H. Scott, and Prof. Weiss, and generously made over to the present writer for examination. The material consists entirely of sections of unattached seeds occurring in the "coal balls." The same seed is seldom met with in more than one section. The contrast between exotesta and endotesta already mentioned affords the readiest means of identifying *Cardiocarpon compressum* in microscopic section. There is sufficient variation among the specimens, both in dimensions and structure, to suggest that *Cardiocarpon compressum*, instead of being a single species, may possibly represent an assemblage of seeds belonging to closely

* W. G. Williamson, "On the Organisation of the Fossil Plants of the Coal Measures," Pt. viii, *Phil. Trans. Roy. Soc.* Vol. cxlvi. Pt. 1, p. 213.

† A. Brongniart, *Prodrome d'une histoire des végétaux fossiles*, Paris, 1828.

‡ F. C. Grand'Eury, *Mémoire sur la Flore Carbonifère du Département de la Loire*, 1877, p. 223.

§ David White, "The Seeds of *Anemites*," *Smithsonian Miscellaneous Collection*, Vol. xlvii. 1905, p. 322.

¶ F. C. Grand'Eury, "Sur les graines trouvées attachées au *Pecopteris Pluckeneti*, Schlied," *Comptes Rendus*, t. cxi. 1906, p. 929.

On the Structure of the Palaeozoic Seed
Mitrospermum compressum (Will.).

BY

AGNES ARBER, D.Sc., F.L.S.

With Plates XXXVII-XXXIX, and two Figures in the Text.

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I. INTRODUCTION.

THE numerous fossil seeds occurring in the Palaeozoic rocks have been conveniently grouped by Oliver¹ under the names *Platyspermeae* and *Radiospermeae*, these names corresponding to the two series originally distinguished by Brongniart.² As the words imply, the *Platyspermeae* are flattened seeds with a bilateral symmetry, while the *Radiospermeae* are radially symmetrical. Our knowledge of the internal structure of the *Radiosperms* has of late years progressed very rapidly. To realize this we need only recall the memoirs on *Lagenostoma Lomaxi*,³ *Stephanospermum*,⁴ *Trigonocarpus*,⁵ and *Physostoma*,⁶ which all fall within half

¹ Oliver ('93).² Oliver ('94).³ Brongniart ('74).⁴ Scott and Maslen ('97).⁵ Oliver and Scott ('04).⁶ Oliver ('99).

NOTES ON RECENT LITERATURE.

THE CACTACEÆ, AND THE STUDY OF SEEDLINGS.

[Re-printed from THE NEW PHYTOLOGIST, Vol. IX., Nos. 8 & 9,
October and November, 1910.]

AN interesting contribution to our knowledge of seedling anatomy—namely a study of the “transition phenomena” in seedlings of the Cactaceæ—has recently been made by Miss de Praine.¹ The anatomy of the seedlings of this order has hitherto remained unknown, but this gap in our knowledge has now been very thoroughly filled, since Miss de Praine has investigated no less than forty-seven species, belonging to eleven genera. The most striking results of her enquiry into the mode of transition from stem to root-structure may be briefly stated as follows:²—

In the group of genera whose seedlings most closely resemble those of ordinary Dicotyledons (*Piresia*, *Opuntia*, and *Nopalxau*) a type of transition is found corresponding to that known as the “*Anemarrhena* type.”³ In those genera, on the other hand, whose seedlings are more profoundly modified, in accordance with the xerophytic habit of the mature plant (*Phyllocactus*, *Cereus*, *Echinocactus*, etc.), the transition corresponds to Van Tieghem's third type.⁴

¹ Ethel de Praine. “The Seedling Structure of Certain Cactaceæ.” *Annals of Bot.*, Vol. XXIV, p. 125, 1910.

² Summarised *l.c.*, p. 164.

³ Ethel Sargent. “The Origin of the Seed-leaf in Monocotyledons.” *New PHYTOLOGIST*, Vol. I, p. 107, 1902.

⁴ Ph. van Tieghem. *Traité de Botanique*. 2nd French Edn., Paris, 1891, Vol. I, p. 782.

(Van Tieghem's types of transition are also enumerated by Miss Sargent in “A New Type of Transition from Stem to Root in the Vascular System of Seedlings.” *Annals of Bot.*, Vol. XIV, p. 634, 1900).

THE NEW PHYTOLOGIST.

A BRITISH BOTANICAL JOURNAL.

EDITED BY A. G. TANSLEY, M.A., F.L.S.,

UNIVERSITY LECTURER IN BOTANY, CAMBRIDGE.

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The New PHYTOLOGIST is well illustrated, and is issued once a month, except August and September; the minimum size of the annual volume is 360 pages. The subscription price is 15/- post free. Single numbers, 2/- each.

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Business letters and subscriptions should be addressed to A. W. Grey, Botany School, Cambridge.

A. ARBER STRUCTURE OF THE ANDROECIUM IN PARNASSIA

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RT 6.

ON.

The botanical philosophy of Guy de la Brosse :

A study in seventeenth-century thought.

GUY DE LA BROSSÉ, physician to Louis XIII, is chiefly remembered to-day as the founder and first superintendent of the « Jardin des plantes » of Paris. He deserves, however, fuller recognition than usually falls to his share as an exponent of the more theoretical aspects of Botany, from the standpoint of the early seventeenth century. The date of his birth is unknown, but he died in 1641, the year in which Nehemiah Grew, the English « Father of Plant Anatomy », was born. He was thus a contemporary of many of the great men to whom we owe that scientific reformation which was based, as JESSEN (1) has finely said, upon the perception of the eternal harmony of changeless law which governs the Universe: FRANCIS BACON, GALILEO, KEPLER, JOACHIM JUNG and DESCARTES.

In 1628, a date which marks an epoch in biology since it witnessed HARVEY's discovery of the circulation of the blood, DE LA BROSSÉ expounded his botanical opinions in a book entitled :

« *De la Nature, Vertu et Utilité des Plantes...* par GUY DE LA BROSSÉ, « Conseiller et Medecin ordinaire du Roy. A Paris, Chez Rollin Baragues, au second pillier de la grand' Salle du Pallais. »

The author tells us that the idea of composing this work came to him while he was elaborating his scheme for the construction of the « Jardin Royal des Plantes Medecinales ». The book contains a detailed account of his theoretical views concerning the plant world, and is marked by considerable originality of treatment. To those who would reproach him for wandering from the beaten track he

(1) JESSEN, K. F. W., *Botanik der Gegenwart und Vorzeit in culturhistorischer Entwicklung*, Leipzig, 1864, p. 208.

ISIS

REVUE CONSACRÉE A L'HISTOIRE
ET A L'ORGANISATION DE LA SCIENCE

BUT. — Étudier la genèse et le développement des théories scientifiques, en tenant compte de tous les échanges d'idées et de toutes les influences que le progrès de la civilisation met constamment en jeu. Réunir tous les matériaux nécessaires pour cette étude et perfectionner ses méthodes et ses instruments de travail. — Il est à peine besoin de faire remarquer que cette œuvre de synthèse n'intéresse pas seulement les historiens de la science, auxquels elle est plus spécialement destinée, mais aussi les historiens proprement dits, les savants, les philosophes, les sociologues, en un mot, tous ceux qui désirent mieux comprendre l'évolution intellectuelle de l'humanité.

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En général, la rédaction d'*ISIS* sollicitera elle-même le concours de ses collaborateurs, d'après un programme déterminé; toutefois, elle examinera avec plaisir les propositions qui pourraient lui être faites. Les personnes qui seraient aptes et disposées à faire des analyses critiques (*objections*) d'ouvrages récents, sont priées d'écrire à la rédaction en indiquant leur spécialité (époque, science, pays) et les langues qu'elles savent lire. Les auteurs devront s'efforcer d'être aussi *précis* et *concis* que possible, l'emploi de la machine à écrire est vivement recommandé, surtout aux collaborateurs n'écrivant pas en français. — Les auteurs de contributions originales recevront gratuitement cinquante tirés à part de leurs articles. Les tirés à part ne peuvent être mis dans le commerce. — Les ouvrages parus ou à paraître en la rédaction seront éventuellement analysés et critiqués et, en tout cas, signalés dans la partie bibliographique.

ISIS. Vol. I 6^e Nov. 1913

ANALYSES.

505

de l'antitotémisme professé *a priori* par certains historiens hostiles à l'école sociologique : grâce à ce libéralisme, A. MORET a composé deux excellents chapitres, l'un qui compare l'autorité pharaonique à celle d'un chef de clan totémique (III), l'autre qui recherche si la complexe notion du *ka*, tout ensemble double, génie protecteur, substance et subsistance des êtres, n'est pas une survivance du concept de totém (IV). Les deux maîtres auxquels hommage est rendu dans l'avertissement sont non seulement G. MASPERO, auquel le livre est dédié, mais FRAZER, dont l'inspiration se retrouve particulièrement dans le pittoresque essai sur les Rois de Carnaval (V). Mais où l'auteur paraît être le plus lui-même, c'est dans les deux chapitres qui intéressent le plus directement les idées philosophico-religieuses. Dans l'un d'eux, consacré au Verbe créateur (II), est mise en évidence l'origine égyptienne du *lôgô* hermétique; après tant de commentaires qui furent composés sur cette notion alexandrine et tant de débats entre érudits à propos du *mâ-hrou*, on lit avec satisfaction ces pages aussi précises que claires. Cependant l'étude la plus étendue est celle qui donne son nom à l'ouvrage entier (I). On y trouvera de précieuses indications sur ces représentations allégoriques, parlées et mimées, qui, par l'efficacité magique du rite, perpétuaient à travers une mort simulée et une renaissance fictive, la vie du monarque et celle même de l'homme ordinaire, lui aussi bénéficiaire du sacrifice osrien, à la condition qu'il se fit initier. On saisira par des exemples typiques les difficultés avec lesquelles est aux prises la science moderne pour reconstituer, non plus, comme aux temps héroïques de l'égyptologie, le sens littéral des hiéroglyphes, mais la signification religieuse de notions jusque-là énigmatiques, bien qu'elles soient apparentées à des croyances encore vivantes parmi nous sous des formes à peine différentes. D'abondantes illustrations, fac-similés exacts des documents, mais si bien choisis qu'elles ont la clarté démonstrative de schémas abstraits, rendent la lecture de cet ouvrage aussi attrayante qu'instructive.

P. MASSON-OURSSEL (Paris).

LONES (Thomas East). — *Aristotle's Researches in Natural Science*. London, West, Newman and Co., 1912, viii and 274 pages, 10 text figures, in-8°, 6 shillings net.

It is impossible to arrive at any just understanding of the history of scientific thought without some knowledge of the work of ARISTOTLE, the fundamental importance of which is admitted on all hands. Many students of Natural Science, however, are unable to read his writings in the original, and, in these days of strenuous specialisation, are also too fully occupied with their own chosen subjects to attempt the

Reprinted from *The Makers of British Botany*

Cambridge University Press
1913

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NEHEMIAH GREW

1641—1712

By AGNES ARBER

Ancestry and Life narrative—his versatility—state of Botany—Grew and Malpighi—Grew's *bona fides* vindicated—*The Anatomy of Vegetables Begun*—seed structure—his treatise on the Root—its dedication—*The Anatomy of Trunks*—*The Anatomy of Plants*—illustrations—Grew's conception of cells and tissues—the plant as a textile fabric—analogy with the animal body—medullary rays—secondary thickening—his understanding of external morphology—physiological notions—suggestions for experiments—importance of the habitat—the sexes of flowers—floral and seed structure—estimate of his contributions to Botany.

NEHEMIAH GREW, who, with the Italian botanist Marcello Malpighi, may be considered as co-founder of the science of Plant Anatomy, lived in stirring and troubled times. His life extended from 1641 to 1712; that is to say, he was born the year before King Charles I proclaimed war upon the parliamentary forces, and he lived through the Protectorate, the reigns of Charles II, James II, William and Mary, and the greater part of the reign of Queen Anne. He came of a stock remarkable for courage and independence of mind. His grandfather, Francis Grew, is described as having been a layman, originally of good estate, but "crush'd" by prosecutions for non-conformity in the High Commission Court and Star Chamber. Francis Grew had a son Obadiah, who was a student of Balliol, and entered the Church. When the Civil War broke out, he sided with the parliamentary party, but was by no means a blind adherent of Cromwell, with whom he is said to have pleaded earnestly for the life of King Charles I. In 1662 Obadiah Grew resigned

¹ *Dist. Nat. Bug.*, edited by Leslie Stephen and Sidney Lee, vol. XXIII, 1890.

Plate IV



NEHEMIAH GREW (1701)

Portrait of Nehemiah Grew after the portrait by R. White which is reproduced in the *Cosmologia Sacra*, 1701

NDON.

Y, W.

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PART 6.

ARBER

A REVISION OF THE SEED IMPRESSIONS
OF THE BRITISH COAL MEASURES

(Plate VI Figs 6. 7 belong to notes by
Agnes Arber which follow)

NDON.

[Annals of Botany, Vol. XXVIII. No. CIX. January 1914.]

3, W.

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A Revision of the Seed Impressions of the British Coal Measures.

BY

E. A. NEWELL ARBER, M.A., Sc.D., F.L.S.,
Trinity College, Cambridge; University Demonstrator in Palaeobotany.

With Plates VI-VIII and eight Figures in the Text.

THE occurrence of a variety of impressions or casts of seed-like bodies in the British Coal Measures has been known since the days of John Woodward¹ (1729), yet at the present time there is probably no set of Coal Measure fossils which stands in greater need of systematic revision than these. The most recent list of such objects, published by Dr. Kidston² in 1894, includes only five genera with nineteen species from the whole of the British Coal Measures. Of these genera one, *Carpolithus*, containing nearly one-third of the total number of species, is nondescript, and amounts to little more than the word 'seed'. It is a useful term under certain circumstances, but should be regarded only as a temporary expedient. There is little doubt, I imagine, that the Coal Measure seeds which have been referred to this genus are of several fundamentally distinct types.

When determining Coal Measure fossils, one frequently finds that, while there is no hesitation as to the specific assignment of a particular seed, there is often doubt as to whether such and such a species really belongs to the genus to which it has commonly been assigned, and especially whether it possesses any real morphological affinity to the other species contained therein. In my own case, however, I have found it necessary to defer any opinion on such questions until an opportunity should occur for re-investigating the grouping of Coal Measure seeds in general.

In attempting this difficult task here, I am well aware that the principles on which a nomenclature should be founded are to some extent matters of opinion, and that in some cases differences of opinion are likely to arise as to matters of fact. The botanical interpretation of the features exhibited by a particular impression is sometimes by no means an easy

¹ Woodward (1729), p. 53.

² Kidston ('94).

[Annals of Botany, Vol. XXVIII. No. CIX. January, 1914.]

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PART 6.

ARBER
NOTE ON TRIGONOCARPUS

NDON.

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[Annals of Botany, Vol. XXVIII, No. CIX, January 1914.]

Y, W.

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[VOL. VIII. PART 6.

THE
TRANSACTIONS
OF
THE LINNEAN SOCIETY OF LONDON.

AN ANATOMICAL STUDY OF THE PALEOZOIC
CONE-GENUS LEPIDOSTROBUS.

BY

AGNES ARBER, D.Sc., F.L.S.,

FELLOW OF NEWNHAM COLLEGE, CAMBRIDGE.



LONDON:

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July 1914.

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ON ROOT DEVELOPMENT IN *STRATIOTES ALOIDES* L. WITH SPECIAL REFERENCE TO THE OCCURRENCE OF AMITOSIS IN AN EMBRYONIC TISSUE

BY

JAMES ARBER, D.Sc. (Lond.), F.L.S., formerly Fellow of Newnham College

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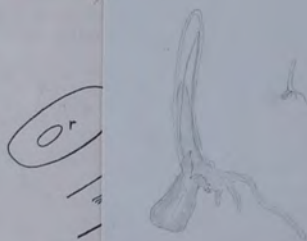
SARGANT, ETHEL, AND ARBER,
AGNES
THE COMPARATIVE MORPHOLOGY OF THE
EMBRYO AND SEEDLING IN THE
GRAMINEAE

[Annals of Botany, Vol. XXIX, No. CXIV, April, 1945.]

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orientation is different. For in *Elettaria* the bundle P' travelled through an angular distance of about 90° in the sheath before running into the stele. Taking the insertion of the stalk on the sheath as a fixed point, and making the diameter of the section which passes through it vertical, the cotyledonary traces P and P' in VIII lie on the horizontal diameter. But in *Roscoea* the trace P' runs straight into the stele from the stalk, and P travels round to the opposite extremity of the vertical diameter before entering the stele.

In the two other *Roscoea* seedlings there is no lower sheath at all, which leads to greater modification of the vascular skeleton. The insertion of the upper sheath coincides with

TEXT-FIG. 33. *Roscoea purpurea*.

the sheath is already run. Root-plates are formed early of cauline roots at the node found above the node; in the other they begin just below it. Between root-insertions the root-plates sometimes break up. Sections can be found which suggest the symmetrical arrangement of VII in the *Elettaria* diagrams.

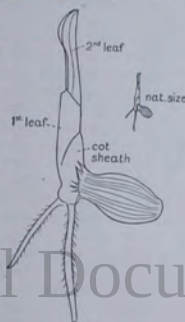
Though we have used Diagrams VII and VIII from *Elettaria* to explain the structure of *Roscoea*, there is one great difference between the two genera. In all three *Roscoea* seedlings the central group of protoxylem is absent. Each root-plate and each cotyledonary trace retains its own protoxylem, which is more or less definitely internal to the other elements.

Alpinia calcarata, Rosc. We have made preparations from four seedlings, and drawings of five. They are small compared with those of *Elettaria*. The cotyledonary sheath is short, and the plumule very soon

emerges from it. The first foliage leaf of the plant is the second in order on the axis, for the first is reduced to a mere sheath.

Two distinct bundles enter the stalk of the cotyledon from the sucker.¹ The stalk is inserted rather above than below the junction of sheath with axis. There is no true lower sheath. In three seedlings the upper bundle P runs a little way into the upper sheath before it turns down to join the axis. In the remaining seedling, the youngest, P runs up from the stalk, and continues its course through the sheath into the axis. The second bundle, P' , commonly enters the axis from the stalk below the apparent insertion. Since P and P' enter the stele from opposite sides, one or other of them must skirt it for some distance before turning in.

The stele of the hypocotyl is cut so obliquely in the three older seedlings, that its structure cannot be deciphered. In the youngest seedling, the traces settle down to three endarch bundles, which seem to correspond in position to the midrib and lateral bundles of the second leaf. They are separated by three rays of medullary tissue, forming angles of about 120° with each other. P enters by one of the two rays which border the midrib of the second leaf, and P' by the other. The third ray remains clear. Below this level the stele of this seedling too is bent, and the sections of it hopelessly oblique. Apparently there would be five bundles at the top of the hypocotyl, as in *Renealmia*.

TEXT-FIG. 34. *Brachychilum Horsfieldii*, O. G. Petersen. Outlines of seedling, life-size and enlarged.

Brachychilum Horsfieldii, O. G. Petersen. Preparations were made from five seedlings by one of us, including complete series through the cotyledonary sheath in four of them. The cotyledon is inserted partly on the sheath and partly on the axis as in *Alpinia*. The first leaf is reduced to a mere sheath (Text-fig. 34).

There are two distinct bundles in the apex of the cotyledon, and they run side by side through the stalk into the axis. In three seedlings neither bundle enters the sheath at all; in the fourth, one trace (P') lies rather above the other, and it curves upwards into the base of the sheath, just entering it before turning back into the axis. The short upper sheath.

¹ For apparently mesarch structure of stalk-bundles in *Alpinia*, *Brachychilum*, and *Renealmia*, see E. M. Berridge in Ann. of Bot., vol. xxiv, p. 495, 1916.

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BEER, RUDOLF, AND ARBER, AGNES
ON THE OCCURRENCE OF BINUCLEATE
AND MULTINUCLEATE CELLS IN GROWING
TISSUES

[Annals of Botany, Vol. XXIX, No. CXVI, October, 1915.]

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"Science"

At the present moment the word "science" is on everyone's lips, and does yeoman service in almost every column of every newspaper. Like the word *Misophrasia*—no longer, alas, a blessed association—it is constant repetition seems to give comfort alike to the journalist and the man in the street. The inhabitant of another planet, transported to the English to-day, might be excused for imagining that "science" was a kind of alder which could be bought for hard cash, and which would ensure salvation to any nation abiding in it, and which would ensure safety to any nation abhorring it, and which would ensure quantity. Its very name seems to have suddenly acquired talismanic power, which is somewhat perplexing and disconcerting to those who have all their lives been concerned with it in study and laboratory, and who now find their dim paths measured by a glare of intelligence. But after the first dazzling effect has passed over, they realise that there is no need for embarrassment; the lightning is entirely wide of the mark, since the "science" of the daily paper has no more in common with science, as for instance, veterinary, know her, than the "science" of a flying victory "has with her of Milo.

To the present generation of newspaper writers and publicists the word science apparently calls up nothing but vision of the telegraph and telephone, the aeroplane, explosives and poison-gases, and the countless other examples of man's power to tame the forces of nature for his own convenience and as an armament against his enemies. But these practical applications of science are principles which a scientific work has brought to light as a necessary and more relative importance, from the standpoint of pure science, than the savings that accumulate beside the carpenter's bench. The existence of these utilitarian developments, which have made their roots in scientific soil, has been indeed, from this point of view, almost a handicap to science itself. Instead of freedom of content with their legitimate and honourable position in the domain of technology, they have, like unfeeling children, made their mother's place, and added a modern meaning to a term which was so-called. They have talked of science as meaning to a world that they have induced the fertility of the soil, and that thus the aim of science is the development of the material resources of humanity. This is one of the latest expressions of that anthropocentric view of the universe, according to which nature, in its infinite variety, is entirely without significance except in relation to human needs.

The Philistine expects science, in all its stages, to be directed useful, and even the man who seeks himself on his culture thought he is sufficiently enlightened to see that pure science must be fostered in order that it may serve as the source of the applied sciences, too often perceived as other reasons for its existence. His attitude is merely that of respect for the genius which lays the golden eggs; he has far in advance of the Philistine as to refrain from attempting to kill it, but if it ceased to be productive it need look to him for no further protection. Other boundaries of man's endowment, such as music, poetry, and the pure arts, enjoy the great advantage of having no utility connected with the bread-and-butter side of life that they are either pursued for themselves or not at all, while science, like an hedonist bound to

November 4, 1916.

often charged in the case of literature and the arts. The solution of a scientific problem, at first laboriously pursued by means of exhausting work with many false starts in wrong directions, at length seems to acquire an independent life of its own. Those who have assisted, in however small a way, in the process of discovery, will recognise the occurrence of a psychological moment at which the work suddenly begins, as it were, to accomplish itself. The researcher, from being in entire control, feels himself deposited into the position of a mere agent and recorder. He gave the solution of the problem its initial impetus, but, in the final stages, the reins slip from his hands and he becomes a mere spectator,—he finds himself, in fact, in the position of Mother Carey, who made things make themselves. The false premises of the necessary connection between science and utility is no doubt responsible for the unbridled opposition so often encountered when there is an attempt to enlarge any

with his hands, is liable to be importuned, not only by those who desire but for her own sake, but by the far more numerous band who have only employed love to give. Practical inventions and discoveries have so obscured the real meaning of the word science, that the question, "What useful purpose will it serve?" is constantly heard when any piece of scientific research is mentioned. And yet no one dreams of putting such a question in the case of a poem or a picture. Why should a work of art be regarded to be "useful" while a work of science is not considered to have justified its existence, unless it aims at administering in some way to man's convenience, unless it aims at well-being? It is all sufficient, as a reason *for it*, if a picture or a poem guesses beauty, truth and originality, and the possession of the same qualities should be the sole criterion by which a scientific work is judged, while its possible material utility is the merit by-product. The idea throw up seaweed which serves to fertilise the farmer's fields, but the humblest teleologist would hesitate to claim that it is with this end in view that the waxing and waning moon

"Moves all the labouring stages of the world."

The beauty of a work of science is in general less obvious than that of a work of art, and its appreciation often requires special training. But, to those who have won the necessary discrimination, by long labour and mental apprenticeship, the study of a scientific work which has achieved those approaches to perfection, fully recognisable only by a fellow of the craft, brings a thrilling sense of pleasure in the beauty of a fine thing nicely done; this sense is exactly comparable with the delight of a musician in Beethoven or Brahms, or of a painter before Titian or Velázquez.

The qualities needed for scientific work are much more closely allied than is usually supposed, to those of the artist. It is not necessary to insist that, in art, personality is of the utmost importance, and in science this is equally, though perhaps less obviously, true. At least in the biological and philosophical sciences, a piece of research worthy of the name, which is accomplished and recorded on some considerable scale, is the expression of the personality of the writer. This is because of its relative freedom from self-consciousness. In its structure again, a work of science is markedly analogous to a work of art. Like a picture or a piece of music, it must, if it is to do any value, have its *leitmotiv* round which dependent harmonies are grouped. A sense of proportion in the relation of the parts to one another and to the whole is as essential as in the case of architecture, and the satisfaction to the scientific senses, when this proportion is achieved, is comparable with that received through the eye from the exquisite co-ordination of some great cathedral. It is, indeed, with architecture that a scientific work can be most closely compared. In both there is the same underlying structural severity, and in both, largeness of conception and due subordination of detail play a greater part than the more facile forms of beauty.

Artistic work is generally regarded as creative, while this distinction is denied to science, but yet the process by which scientific research is achieved is almost identical with that of creative work. This is too often regarded by the supporters of the humanities as synonymous with the entry of the cloven hoof of individualism, and they believe that, if science be granted an inch, the beauty and idealism, which have had a age-long home in the humanities, will flee away for ever. But in truth, the sternness of science, when stripped of the garish trappings with which they have been overlaid by the money-changers in the market, are revealed in a beauty as great, in its severity, as that of the most lovely and pleasant of the arts. Indeed, between art and science there is no antagonism, concerned, as they are, with the beauties of the same fundamental harmony. While art reveals the beauty of truth, science wrestles with the subtler and more exacting task of searching out the hidden truth which shines into visible beauty in man's sight.

A. A.

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