Plant Anatomy's 300th Anniversary

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Precise datings for beginning-points of ideas or disciplines in science are difficult. One can choose the date of a discovery, the date on which an oral report was made, the date on which publication was achieved, or even (as in the case of Mendelian genetics) the date on which the significance of an earlier discovery was appreciated by the scientific community. In the case of plant anatomy, the question is complicated by the simultaneity of the work of Marcello Malpighi and that of Nehemiah Grew. In a situation much like the Darwin–Wallace creation of evolutionary theory, the work of Grew and Malpighi, performed independently, emerged simultaneously. As the fore-page of Grew’s *The Anatomy of Vegetables Begun* indicates, Grew’s paper was read on November 9, 1671, before the Royal Society of London. Sachs (1890) tells us that Grew presented his manuscript in May 1671, and that Malpighi’s work was received by the Royal Society on December 7, 1671. However, Malpighi’s (1675) *Anatome Plantarum* gives the date and the place of writing as November 1, 1671 and Bologna. Grew’s *The Anatomy of Vegetables Begun* was published on December 7, 1671, according to Sachs, although the title page bears the date 1672. We know that both Malpighi and Grew were studying aspects of plant anatomy several years before 1671. The various 1671 dates cited above are all close, however, and we may, along with Sachs, cite 1671 as the year in which the ‘anatomy of vegetables’ was indeed ‘begun’, although I am citing his book here as Grew (1672).

Hooke’s *Micrographia* of 1667 cannot be called the first volume to be published in the field of plant anatomy, despite Hooke’s figuring of cork cells, and giving them that term. Hooke was, as Zirkle (1965) rightly claims, a zestful describer of various and sundry objects to pass beneath the lenses of that new tool in science—the microscope. Plant anatomy, however, was sure to follow the invention of that instrument in short order. The dates in 1671 are convenient starting-points for the discipline because both Malpighi and Grew used the microscope systematically in an attempt to describe tissues and cells in a manner as comprehensive as their rather crude tools could permit. As Zirkle (1965) states, both men probably worked diligently to over-
of monocotyledony is unfortunate (although Grew only spoke of 'lobes', not cotyledons), but 300 years later we are still using slides of longisections of *Zea mays* as examples whereby to teach elementary botany students the nature of a monocotyledonalous embryo, and the morphological nature of the parts of a graminean embryo has been securely established only recently. One notes with interest that Grew could not discern embryos easily in some seeds (presumably because of small embryo size and the presence of endosperm), but he evidently knew they were present, merely beyond elucidation with his relatively crude techniques. Grew's best work, as might be expected, was in objects of clarity and size, as in the case of the bean seed:

This part is not, like the *Radicle*, an entire Body but divided at its loose end into divers[e] pieces, all very close set together as feathers in a Bunch; for which reason it may be called the *Plume*. They are so close, that only two or three of the outermost are at first seen, but on a nice and curious separation of these, the more interior still may be discerned. Now as the *Plume* is that part which becomes the Trunk of the Plant, so these pieces are so many true, and already formed, though not displayed, Leaves, intended for the said Trunk and folded up in the same plicature wherein, upon the separating of the Bean, they afterwards appear.

One may note here the origin of the term 'radicle,' and our present term 'plumule' is only a minor variant on Grew's 'plume.' His use of 'lobes' for cotyledons is a natural and logical descriptive device. Likewise, we find the initiation of other terms still in usage in Grew's (1672) little book. In his study of the bean seed, he says: "Next to the cuticle [=testa], we come to the *Parenchyma* itself; the Part throughout which the inner Body, whereof we shall speak anon, is disseminated; for which reason I call it the *Parenchyma.*"

Grew thus not only invents basic term in plant anatomy, he notes the similarity of cotyledonary parenchyma to parenchyma of pith, a noteworthy achievement. He does not, in his studies of wood anatomy, comprehend precisely that ray cells, too, are parenchyma, but he comes close: the ray cells are, for Grew, 'insertions' of the 'cortical body' into the axial tissue of secondary xylem, and he does draw a distinction between fascicular and interfascicular tissue in wood:

Next the Insertions of the *Cortical Body*, which in the Trunk of a tree saw'd athwart [transversely], are plainly discerned as they run from the Circumference toward the Center; the whole Body of the Tree being visibly compounded of two distinct Substances, that of the several Rings, and that of the Insertions, running cross; shewing that in some resemblances in a Plain, which the Lines of Latitude and of the Meridian do in a Globe. See Fig. 16.

One of the interesting and farther reaches of Grew's observation, unashamedly augmented with bits of speculation, is his account of pollination biology. In this, we see the very rude beginnings of an appreciation of sexuality in flowers. Although Zirkle (1965) makes a good case for Grew's rudimentary comprehension of these pro-
cesses at a later date, it is doubtful if he had more than a feeling, in his *The Anatomy of Vegetables Begun*, of curiosity concerning the peculiar behavior of insects with relation to flowers and the distinctiveness of such structures as ‘globulets’ (pollen grains) must have been tempting objects for which an explanation would be appropriate:

A farther use hereof [of the perianth] therefore we must acknowledge, and may observe; and that is for Food; for Ornament and Distinction to us, and for Food to other Animals. I will not say, but that it may serve even to these for Distinction too, that they may be able to know one Plant from another, and in their flight or progress settle where they like best; and that therefore the varieties of these small parts are many, and well observed by them, which we take no notice of: Yet the finding out of Food is but in order to enjoy it: Which, that it is provided for a vast number of little animals in the *attires* of all *Flowers*, observation persuades us to believe. For why else are they evermore here to be found? Go from one Flower to another, great and small, you shall meet with none untaken up with these Guests. In some, and particularly the *sunflower*, where the parts of the *Attire* and the animals for which they provide, are larger, the matter is more visible. We must not think, that God Almighty hath left any if the whole Family of his Creatures unprovided for; but as the Great Master, some where or other carveth out to all; and that for a great number of these little Folk, He hath stored up their peculiar provisions in the *Attires of Flowers*; each *Flower* thus becoming their Lodging and Dining-Room, both in one.

Wherein the particular parts of the *Attire* may be more distinctly serviceable, this to one Animal, and that to another, I cannot say: Or to the same animal, as a *Bee*. whether this for the *Honey*, another for their *Bread*, a third for the *Wax*: Or whether all only suck from hence some *Juice*; or some may not also carry some of the *Parts*, as of the *Globulets*, wholly away: Or lastly, what may be the primary and private use if the *attire* (for even the above-said, though great, yet is but secondary) I now determine not.

Indeed, we can, if we wish, be amused by the whimsy and the homely comparisons with which Grew endows his work. We can fault him for overreaching into plant physiology, where he was ill-equipped: for him, the function of the leaves is to ‘warm’ and ‘protect’ the developing fruits, and such odd concepts as conversion, by ‘fermentation’ of sap into fruits and seeds are invoked. Protection was a factor upon which Grew relied heavily, as with the calyx:

The Design of the *Empalement*, is to be security and Bands to the other two Parts of the *Flower*: To be their security before its opening, by intercepting all extremities of Weather: Afterwards to be their Bands, and firmly to contain all their Parts in their due and most decorous posture; so that a *Flower* without its *Empalement*, would hang as uncouth and taudry as a *Lady* without her *Bodies* [Bodice].

Hence we have the reason why it is various, and sometimes wanting. Some *Flowers* have none, as *Tulips*; for having a fat and firm Leaf; and each Leaf likewise standing on a broad and strong Basis, they are thus sufficient to themselves. *Carnations*, on the contrary, have not only an *Empalement*, but that (for more firmitude) of one piece: For otherwise, the foot of each Leaf being very long and slender, most of them would be apt to break out of
compass; yet is the top of the Impalement indented also; that the Indentments, by being lapp'd over the Leaves before their expansion, may then protect them; and by being spread under them afterwards, may better shoulder and prop them up.

However naive and to us today, ridiculous, Grew's concepts may be, there is a high degree of sophistication in other respects. For example, comparative anatomy and petiolar anatomy are clearly appreciated and begun by him:

The Fibres of the Leaf neither shoot out of the Branch nor Trunk, nor stand in the Stalk, in an even Line; but always in either an Angular or Circular posture, and usually making either a Triangle, or a Semi-Circle, or Cord of a Circle; as in Cycory, Endive, Cabbage, &c. may be observed: And if the Leaf have but one main Nerve, that also is postur'd in a Circular or Lunar Figure; as in Mint and others. The usual number of these Nerves or Fibres is 3, 5, or 7. See the Figures from 20, to 29.

Finally, one must cite Grew's little book for a most moving and inspiring appreciation of the various techniques and breadth of investigation with which one ideally should approach studies in plant anatomy. Study the whole plant, he says, study its ontogeny, study it at various seasons of the year, and study plant anatomy in a comparative way. One is surprised at how few plant anatomists have fulfilled the very fine manifesto proposed by Grew as the last paragraph of his Preface for The Anatomy of Vegetables Begun. Few disciplines in science have begun with such a fine statement of principles. I wish to close this essay merely by letting Grew speak for himself: he is also speaking for generations of plant anatomists past, present, and yet to come:

Those that shall think fit to examine, as well as to peruse these Observations, we advertise them, First, That they begin, and so proceed till they end again, with the Seed; For they will hardly be able to avoid Error and Misapprehension, if either partial or preposterous in their Enquiries. Next, that they confine not their Enquiries to one time of the Year; but to make them in several Seasons, wherein the Parts of a Vegetable may be seen in their several Estates. And then, That they neglect not the comparative Anatomy; for as some things are better seen in one estate, so in one Vegetable, than another.

References
Thursday, November 9, 1671.

At a Meeting of the Council of the R. Society.

Ordered,

That the Discourse presented to the R. Society, Entitul'd, The Anatomy of Vegetables begun, with a General Accomp't of Vegetables thereon, By N. Grew, M.D. be Printed by Spencer Hickman, one of the Printers of the R. Society.

Brouncker Pres.

THE ANATOMY OF VEGETABLES Begun.

With a GENERAL ACCOUNT OF VEGETATION Founded thereon.

By NEHEMIAH GREW, M. D. and Fellow of the Royal Society.

LONDON,
Printed for Spencer Hickman, Printer to the R. Society, at the Rose in St. Paul's Church Yard, 1672.

PLATE I

The title page and fore-page of Nehemiah Grew's *The Anatomy of Vegetables Begun*. 
The third of three plates from Grew's *The Anatomy of Vegetables Begun*. Figs 6 and 7 are transections of roots; Fig. 6 is unidentified, while Fig. 7 is that of a barberry. Fig. 8 represents a transection with dissectional aspects on the fore-side, of a turnip. Figs 20-29 represent the vascular bundles of petioles, and are as follows: Fig. 20, endive; Fig. 21, coltsfoot; Fig. 22, chicory; Fig. 23, ivy; Fig. 24, asarabacca; Fig. 25, mint; Fig. 26, dock; Fig. 27, borage; Fig. 28, mullein; and Fig. 29, cabbage.