EVIDENCE OF TELEOLOGY IN BOTANY: DIFFERENTIATION IN THE VASCULAR CAMBIUM INTO XYLEM AND PHLOEM*

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It is the purpose of this paper to examine the process by which ordinary cells differentiate from uniform cambium cells into xylem and phloem. It can be said that while the complexity of this process does not, perhaps, completely prove teleology, yet no "evolutionary" explanation is really adequate.

Introduction

It is the purpose of this paper to examine the process by which ordinary cells differentiate from uniform cambium cells into xylem and phloem. It can be said that the complexity of this process does not conclusively prove a case for teleology but, as will be shown, no "evolutionary" explanation is really adequate.

Cell differentiation is a marvelous, intricate system in vascular plants, microscopic in size. This process involves individual cells that differentiate to form functioning tissues. Katherine Esau has written:

> The formation of new cells, tissues, and organs through the activity of the apical meristem involves division of cells. Certain cells of the meristems repeat divisions in such a way that one product of a division becomes a new body cell while the other remains in the meristem.[1]

Out of this new tissue, lateral meristems are eventually formed called vascular cambium and cork cambium. Lateral meristems

> . . . make their appearance, developing from procambial and pith ray parenchyma cells in the case of the vascular cambium and from cortical parenchyma or collenchyma in the case of the cork cambium. Activity of lateral meristems results in the formation of secondary tissues. The vegetative plant body of a typical woody organism is made up of both primary and secondary tissues.[2]

The course of differentiation, then, progresses from a point where all cells are largely simple and similar to the formation of a much more complex woody stem. One wonders how anyone could believe that such a complicated process could take place in nature by chance.

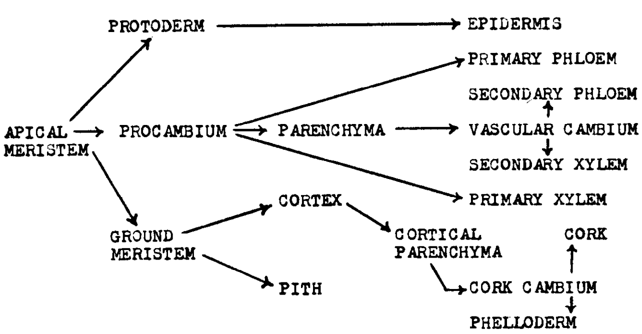

Chart of meristematic activity and the process of differentiation from the apical meristem to organized tissues.[3]

In this paper, primary concern will be with the functioning of the lateral cambiums, and especially the vascular cambium, from which secondary xylem and secondary phloem tissue develop.

Cambial Differentiation: An Experiment

Evert, Kozlowski, and Davis performed an experiment which seemed to suggest that there are natural processes which indirectly effect cambial differentiation. In a series of experiments with sugar maple, the phloem of several different trees was isolated by girdling during successive periods of the growing season. Then the effects of phloem isolation on cell differentiation in the cambium were observed, and compared from tree to tree. Also a careful check was made of a normal sugar maple, which had no phloem blockage. The experimenters commented on the very interesting results:

> Normal cambial activity in woody plants requires a continual supply during the growing season of phloem-translocated products from shoots. Thus, severing the phloem so as to prevent transports of carbohydrates and hormonal growth regulators to the lower stem greatly modifies production and maturation of xylem and phloem cells beneath the wound.[4]

If phloem isolation occurred in the dormant season, no new xylem or phloem was produced. If isolation occurred after the growing season started, then relatively undifferentiated parenchyma cells were produced. Some xylem were produced, but short in length. Phloem sieve tubes died early.

But, the later in the growing season the phloem blockage took place, the more nearly normal were the xylem and phloem cells formed. The researchers concluded:

> There is considerable evidence that the abnormal cambial growth below stem girdles involves a deficiency of hormonal growth regulators and carbohydrates. The fact that cell division in some species is curtailed more rapidly than all wall thickening below stem girdles suggests that different systems may be involved in different phases of cambial activity.[5]

From this experiment, it is evident that the mechanism of cell differentiation is very complex, involving many factors—hormonal regulators, the presence of carbohydrates, the health of the extant phloem, and so forth. This is as one would expect, if the system were the result of careful design.

Before differentiation takes place, virtually identical meristematic or cambium cells exist side by side. But, after cell divisions, the inner cells become xylem

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and the outer cells phloem. How is it possible for cells, originating by simple mitotic division, to become so radically different in make-up?

DNA theorists face the same problem. If DNA is the sole explanation for differentiation, will scientists ever understand why one particular cell, fitting perfectly into the order of things, becomes a sieve tube while another becomes a xylem vessel? But, that is not all, because environmental factors have a role in differentiation, as has already been noted.

Cell Differentiation: Another Experiment

In another experiment, Robnett and Morey discovered that chemical factors seem to be important in differentiation. They found that water deficits are only indirectly causal to formation of spring and summer wood.[6] They also discovered that "auxins are clearly involved in vessel member differentiation in some hard woods."[7] Salisbury and Parke have stated:

> *Auxin* is a chemical substance that can cause stem cells to elongate. . . . If *auxin* is applied to an intact stem at concentrations considerably above those that result in cell elongation, the stem cells begin to divide again, producing tumor-like growths called *callus*. Thus, auxin is capable of starting one form of meristematic activity.[8]

Robnett and Morey also discovered that certain other chemical treatments had an effect on xylogenesis. They wrote:

> Although reduced in diameter, the vessels formed during 2,4-D and 2,4,5-T treatment are so numerous there is no significant difference between phenoxyacetic acid and control seedling groups with regard to total area of xylem occupied by vessels. The preferential maturation of xylem cells over parenchyma and the transformation of fusiform initials into septate parenchyma strands in phenoxyacetic acid-treated *Prosopis* resemble the structural changes reported to occur after girdling in the cambial tissue of other arborescent angiosperms. Bending experiments indicate that tension-wood fibers of *Prosopis* differentiate in response to an auxin deficiency.[9]

Further, 2,4-D increases cell proliferation and elongation but, at the same time, it unfortunately causes xylem to become very narrow with thick lignified cell walls.[10]

Therefore, the role of chemicals in cambium differentiation is established. Exactly how chemicals initiate and carry out specific cases of cell differentiation has not been determined yet. Still, it is known that cell division is caused by cytokinins.[11] But the problem remains a difficult one.

David R. Dobbins pointed out that secondary tissues are produced in an organized, predictable manner even when seeming abnormality is the result. His work with *Doxantha unguis-cati* demonstrated that cell differentiation is always an organized process. He wrote:

> In this case, four normally functioning areas of vascular cambium cease or reduce xylem production while continuing to produce phloem. The secondary xylem becomes lobed by deep furrows of phloem.[12]

To this species, an abnormal mode of differentiation is considered normal. And, even with abnormalities, it is clear that, whatever the factors that influence xylem and phloem differentiation, they would appear to operate in a similar manner in obedience to a set design in all plants containing genuine vascular systems. Regarding chemical influences on differentiation, it is well to remember Salisbury and Parke's statement:

> The effect can be roughly duplicated by attaching a small source of auxin (such as an agar block containing auxin) onto a callus. Further control is gained by adding sugar (sucrose or glucose) along with auxin.
>
> Low sugar concentrations result mostly in xylem formation, high sugar in phloem formation, and intermediate sugar levels in formation of xylem and phloem with cambium between. Sometimes nodes of vascular tissues formed in these cultures, in which case the xylem is always on the inside and the phloem on the outside as in the normal plant.[13]

Thus, auxin is not the only factor in cell differentiation. Sugars also are important, in fact they may be crucial, since it is true that

> . . . the secondary phloem constitutes much less of the secondary growth in the stem than does the xylem, and as thickening proceeds the primary phloem and even in its turn the first-formed secondary phloem, may become crushed and functionless.[14]

It seems that one may assume there is a relatively low sugar concentration in the cambium area.

Much remains to be told; however, the complexity of mechanisms involved in xylem and phloem differentiation have been demonstrated.

Cell Differentiation: Fossil Evidence

Of further significance to the creationist, however, is the fact that there has been no known change in the basic processes of forming secondary vascular tissue since studies of the processes were begun. There is evidence that this same differentiation process was not unknown in the period of massive fossil formation.

For instance, *Sphenophyllum,* a trailing Articulate type of plant resembling the Equisetums or horsetails and found from the Devonian to the Permian periods of geologic time, had a clear xylem arrangement, even though some stems were "incompletely preserved and have a circumxylary lacuna marking the original position of the outer tissues of the stele."[15]

Furthermore, "there is incomplete preservation of stems to include meristematic vascular cambium."[16] It is illogical to assume that there were xylem cells apart from phloem, since functions of xylem and phloem are known to be complementary. A vascular plant with no phloem is a contradiction in terms.

And there is evidence that the phloem may have been there originally. The secondary tissue in *Sphenophyllum* was created by a "bifacial vascular cambium."[17] The process was the same. Based on what is known about modern vascular systems, it is not surprising that phloem failed to survive the fossilization process, since phloem has a higher mortality rate than xylem and less of it is produced in living plants.

Rhynia, a fossil plant from the Devonian period unlike any modern species, also contains a vascular system. As in *Sphenophyllum,* the phloem was poorly preserved in the fossil specimens. Satterthwait and Schopf have reported:

> Phloem tissue is so poorly preserved in most fossils that commonly, in the illustrations, the phloem is labeled as such because the position is assumed to be appropriate for the tissue.[18]

In this case, xylem tissue was surrounded by a narrow zone of thin-walled cells, which must have been phloem, and which would have been surrounded, in turn, by cortex. Sieve tubes have not yet been discovered in *Rhynia.* Even with the absence of sieve tubes, however, it is clear that vascular bundles have not changed much since the chert beds were laid down.

Conclusions

Based on the above, one may conclude that differentiation is a complex, but clearly defined, process by which similar cells in a meristematic zone become unlike. The processes involved at such microscopic level are so intricate that one can argue strongly in favor of adoption of a belief in teleology with regard to botanical science.

Furthermore, the process of differentiation has not changed demonstrably since the period when the *Rhynia* were fossilized in chert beds. This, too, is evidence of teleology in nature. Taken alone, it may not be conclusive; but, combined with all the other available evidence, it falls into a familiar pattern.

The Psalmist stated that the heavens declare the glory of God, but it is likewise clear that vascular bundles, though only microscopic in size, perform the same function.

References

[1]Esau, Katherine 1960. Anatomy of seed plants. John Wiley and Sons, Inc., New York, p. 22.

[2]Salisbury, F. B. and R. V. Parke 1970. Vascular plants: Form and function. Wadsworth Publishing Company, Belmont, California, p. 78.

[3]*Ibid.,* p. 83.

[4]Evert, R. F., T. T. Kozlowski, and J. D. Davis 1972. Influence of phloem blockage on cambial growth of Sugar Maple, *American Journal of Botany,* 59 (6):632-41. See p. 632.

[5]*Ibid.,* p. 639.

[6]Robnett, William E. and Philip R. Morey 1973. Wood formation in *Prosopis, American Journal of Botany,* 60 (8): 745-54. See p. 752.

[7]*Ibid.,* p. 752.

[8]Salisbury, F. B. and R. V. Parke. *Op. cit.,* p. 86.

[9]Robnett, William E. and Philip R. Morey. *Op. cit.,* p. 745.

[10]Robnett, William E. and Philip R. Morey. *Op. cit.,* p. 750.

[11]Salisbury, F. B. and R. V. Parke. *Op. cit.,* p. 88.

[12]Dobbins, David R. 1971. Studies on the anomalous cambial activity in *Doxantha unguis-cati* (Bignonceae). II. A case of differential production of secondary tissues, *American Journal of Botany,* 58 (8):691-705. See p. 697.

[13]Salisbury, F. B. and R. V. Parke. *Op. cit.,* pp. 93-94.

[14]Brook, Alan J 1964. The living plant. Aldine Publishing Company, Chicago, Illinois, p. 137.

[15]Eggert, D. A. and D. D. Gaunt 1973. Phloem of *Sphenophyllum, American Journal of Botany,* 60 (8):755-70. See p. 757.

[16]*Ibid.,* p. 757.

[17]*Ibid.,* p. 768.

[18]Satterthwait, Donna F. and J. William Schopf 1972. Structurally preserved phloem zone tissue in *Rhynia, American Journal of Botany,* 59 (4): 373-6. See p. 373.

ARCHAEOLOGISTS, INSCRIPTIONS, MEANINGS

In 1973, when new sidewalks were built in Kingston, Ontario, the contractors had forgotten apparently to change the stamp used to mark certain information in the concrete. Hence the sidewalks are dated 1972 in places. Some attempts were made to change the "2" into a "3" before the concrete had hardened, but in some places the figure is still more likely to be taken for a "2".

A somewhat similar example is provided by some commemorative china. Items appeared marked "Marriage of Queen Elizabeth II, 1948," or something to that effect. Now the wedding was in 1948; but the present Queen was not Queen then. She was then the Princess, and became Queen in 1952.

The point in mentioning these matters is that were either of these examples found by future archaeologists, they could be mislead. Is it not likely, then, that some inscriptions from the past are similarly misleading? Indeed, it would seem to be most likely.

Specialists agree that literacy was not very common. It is quite likely that some stone-carvers, for instance, did not know the meaning of some of the things which they carved. So they would be less likely to catch mistakes. Is this the reason, perhaps, why the symbols in hieroglyphics are sometimes interchanged in order?

The reason for mentioning this point, of course, is to notice that inscriptions are not infallible. So if inscriptions should seem to conflict with Scripture, as some might, it is perfectly reasonable to continue to believe the Scripture.

—Contributed by Harold Armstrong