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Communication

Symplastic Growth and Symplasmic Transport

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ABSTRACT

In current usage, the adjective symplastic has two different meanings: in the term, symplastic growth, as defined by Priestley; and in discussions of transport through the symplast, as defined by Münch. To avoid confusion, it is recommended that *symplastic* be reserved to characterize growth deformation, that *symplasmic* be used to refer to transport through the *symplasm*, and *apoplasmic*, to refer to the *apoplasm*.

The term *symplastic growth* was proposed by Priestley (12) to characterize growth of plant tissue in which "mutual adjustment of cell position takes place between semifluid protoplasts, separated from one another by plastic walls, which move as a common framework under tension and without any slip between the wall surfaces of neighbouring cells." He credited D'Arcy Thompson (Ref. 15 and a letter) with suggesting the concept, and W. Wight with suggesting the term. He contrasted symplastic growth with the earlier hypothesis of sliding growth or gliding growth. More recently Fahn (5) has defined symplastic growth as "the process of uniform growth of neighboring cells so that the adjacent walls do not alter position relative to each other and no new areas of contact are formed." Fahn has also defined intrusive growth as the process "in which the growing cell penetrates between existing cells and in which new areas of contact are formed between the penetrating and neighbouring cells." Esau (3) has proposed the term coordinated growth as an alternative for symplastic growth. In present day English, the suffix *-plastic* appears to carry the connotation of deformation, as when one speaks of a thermoplastic resin. Thus, the term symplastic aptly characterizes the growth deformation of plant tissue.

Münch (11) is often credited with defining the *symplast-apoplast* concept. He noted that all the cells of a higher plant are connected directly or indirectly by plasmodesmata into a single 'organism,' which he referred to as the symplast. All the cells, including their plasmodesmata, are bounded by a continuous semipermeable membrane, separating the symplast from the nonliving parts of the plant tissue (cell walls, xylem, etc.), which Münch termed the apoplast. He stressed the importance of this distinction between the symplast and apoplast in considerations of concentration, pressure and potential differences in plant tissues. The term symplast has been used earlier, by Hanstein (quoted by Ewart [4]) in the sense of a coenocyte or syncytium, and by Haberlandt (6) in the same sense as Münch's, but in the context of stimulus transmission. These terms and the adjectives symplastic and apoplastic are currently used by many authors in discussions of the movement of water and solutes through plant tissues, for example, Lüttge (8). Some authors, however, use the alternative terms symplasm, symplasmic, apoplasm, apoplasmic, for example, Läuchli (7), Molz (10), Spanswick (14). In some cases, both forms are used in the same text, or even in the same sentence. It may be that Arisz (1, 2) originated the use of the term symplasm. It would seem that the forms using *-plasm* would be preferable, as referring to cells collectively, just as one uses protoplasm in a general sense, and protoplast to refer to the contents of a single cell, or its isolated contents.

It could perhaps be argued that the existence of two meanings of the word symplastic is of no great consequence, since they usually appear in different contexts, or areas of research. However, the transport of water into plant cells is an important aspect of their growth. Silk and Wagner (13) have made this explicit, having derived an equation relating local growth rate of the primary root of *Zea* to local water potential in the expanding tissue. They write of 'symplastic growth' of the root, and of the 'symplasm' and 'apoplasm.' They also refer to 'symplastic' and 'apoplastic' pathways of water transport. In another theoretical study, McCoy and Boersma (9) make the assumption of symplastic growth, or in their words, "the hypothesis of shear free deformation," in defining spatial and material rates of particle movement in tissue, and in discussing tissue deformation. They then formulate the "hydraulic conductivity of the combined apoplastic and symplastic pathways."

In discussions of this sort it would obviously be desirable to avoid confusion of terms. I would urge that the adjective *symplastic* be reserved for its meaning as originally defined by Priestley, and that in referring to pathways of water and solute transport, the forms *symplasmic, apoplasmic,* and their variants be used, instead of symplastic and apoplastic. Unless, of course, other, more suitable terminology can be found.

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