ONTOGENY OF TRACHEA

[What are Trachae or Vessel elements?]

The Tracheae or Xylem vessels are long, non-living, thick walled elements of xylem and are composed of rows of single cell units, the end walls of which are perforated forming a continuous water conducting tube.

[Where do they originate form and how?]

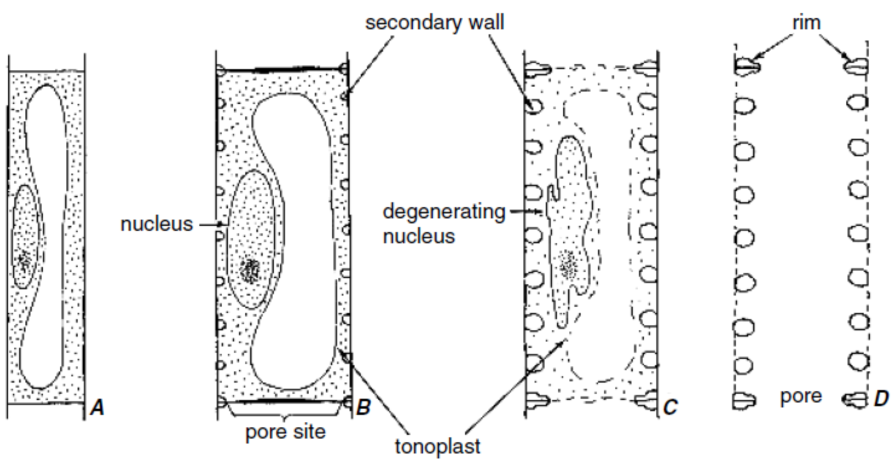
Trachea originates from meristematic cells which are grouped together in a longitudinal file. These cells are known as the **xylem mother cell** that develop from the procambium in primary xylem and form cambium in secondary xylem. During the last stages of development, the fusion of xylem mother cells end to end results in the formation of trachea. Due to the fusion and subsequent loss of end walls, these vessels are grouped together to form a continuous long tube.

[What is the process of their development]

The formation of mature vessels involves a number of steps which are summarized as follows-

(i) Elongation, Expansion of Deposition of Secondary Wall materials: -

Each xylem mother cell forms a vessel member. The primordial vessel member may or may not elongate in length during differentiation, but it widens laterally. After the completion of lateral expansion and longitudinal elongation, the secondary wall materials are deposited. The deposition does not occur uniformly and forms specific pattern characteristic for a particular vessel element. The secondary wall material does not cover certain portion of the primary wall and these portions are the site for future pits and perforations. The cell wall of the future perforation region becomes thicker than the rest of primary wall later disintegrates to form perforations. This happens after the completion of deposition of secondary wall substances.



Diagrams illustrating development of a vessel element with a helical secondary thickening. **A**, cell without secondary wall. **B**, cell has attained full width, nucleus has enlarged, secondary wall has begun to be deposited, primary wall at the pore site has increased in thickness. **C**, cell at stage of lysis: secondary thickening completed, tonoplast ruptured, nucleus deformed, wall at pore site partly disintegrated. **D**, mature cell without protoplast, open pores at both ends, primary wall partly hydrolyzed between secondary thickenings. (From Esau, 1977.)

In longitudinal section, the end walls of primordial vessel element appear as lens-shaped (e.g. celery) or plate-like (eg. *Robinia*) after swelling. These layers are observed here – middle lamella and the two primary walls of two adjacent cells.

(ii) Disintegration of Nucleus and Cytoplasm:

The Xylem mother cells are thin-walled, densely cytoplasmic, uninucleate and vacuolated. The cytoplasm remains active throughout the development of vessel elements. The Cytoplasm and nucleus slowly disintegrate as the vessel members mature. The tonoplast-bound vacuolar sap contains hydrolytic enzymes. After the rupture of tonoplast, the cytoplasm and nucleus are exposed to hydrolytic enzymes and as a result, autolysis of cytoplasm occurs.

Evidences suggest that microtubules present in the xylem mother cell direct the deposition of new secondary wall materials. The concentration of microtubules increases at the region of developing thickening of wall.

(ii) Dissolving of End walls:

Now, the end walls of differentiating vessel members ultimately get dissolved and the developing vessel members are grouped together and converted to a series of connected tubes. Thus, cell to cell continuity is established and a continuous tube is formed. Now the vessels become functional in conduction.

ONTOGENY OF SIEVE TUBE

[*What are Sieve Tubes?]*

The Sieve Tube is defined as the thin walled, living, enucleate, longitudinally arranged conducting elements of angiospermous phloem with sieve plates and sieve areas on their transverse end walls.

[*Where do they originate form and how?]*

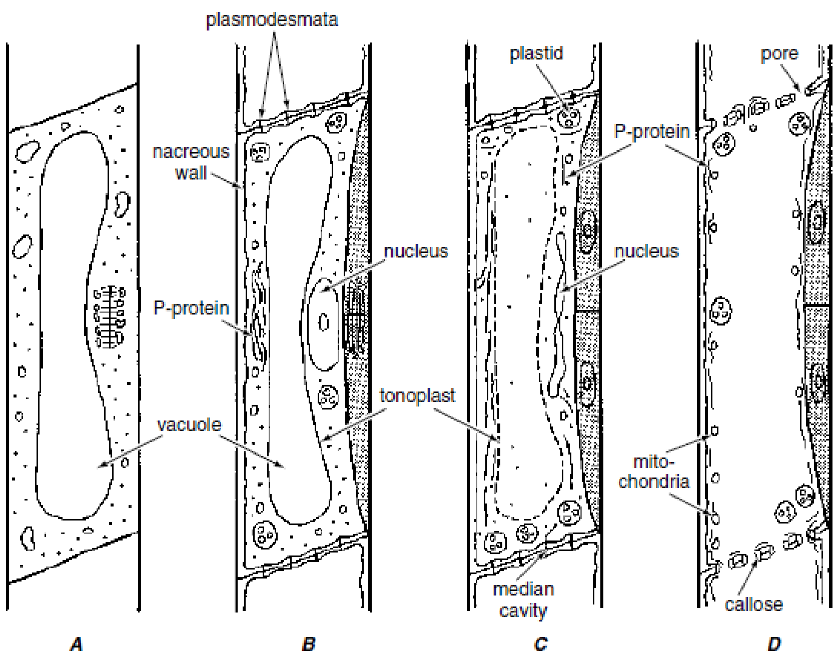
The Sieve tubes are present in primary and secondary phloem and accordingly they originate from procambium and cambium respectively. The procambium and cambium is arranged in a longitudinal file and contain living protoplast with prominent nuclei, ER, dictyosomes, tonoplast-bound vacuoles, ribosomes, mitochondria, chloroplast etc.

[*What is the process of their development?]*

The formation of mature Sieve Tube involves a number of steps which are summarized as follows-

(i)The initial division:

The mother cells divide longitudinally to form two daughter cells. One of the daughter cells forms the companion cell while the other cell develops into sieve tube member. The differentiating sieve tube member increases in length subsequently.



Diagrams illustrating differentiation of a sieve-tube element. **A**, precursor of sieve-tube element in division. **B**, after division: sieve-tube element with nacreous wall and P-protein body; dividing companion cell precursor (stippled). **C**, nucleus degenerating, tonoplast partly broken down, P-protein dispersed; median cavities in future sieve plates; two companion cells (stippled). **D**, mature sieve-tube element; pores in sieve plates open; they are lined with callose and some P-protein. In addition to plastids, mitochondria are present. No endoplasmic reticulum is shown. (From Esau, 1977.)

(ii)The profound change of Protoplasts and fate of cell organelles:

During this stage its protoplast undergoes a profound change. In mature sieve tube, mitochondria, plastids, P-proteins, plasmalemma and some ER persist whereas other cellular components degenerate during differentiation. The nucleus disappears or may persist as a collapsed body. However, the nucleus does not degenerate in *Taxus,Neptunia* etc. Ribosomes and dictyosomes are abundant in the differentiating sieve tube members, but are absent at the later stage. Initially, the ER is of rough type due to the presence of Ribosomes, but later ER becomes smooth by loosing the ribosomes attached to it and becomes aggregated in parallel stacks to form cisternae. As the development continues, the ER diminishes in amount. In mitochondria, the inner membrane disorganizes so it lacks cristae. Then, the vacuolar membrane ruptures and as a result there is no delimitation between cytoplasm and vacuole. After the disappearance of the tonoplast the P-Protein occupies the parietal position of sieve tube member and sieve plate pores.

(iii)Development of Sieve plates in transverse walls : The sieve plate is the common transverse wall of sieve tube elements. At the early stages, the future sieve plate is smooth with no sign of primary pit fields. Later, the plasmodesmata appear, which mark the site of the future sieve area. A single plasmodesmata occupies the future pore site. Callose accumulates on both sides of the wall encircling the plasmodesmata and assumes the shape of platelets, the primary walls of two adjacent cells and the middle lamella are present. Callose deposition continues, platelets further increase in thickness, plasmodesmatal canal enlarges and a cavity is developed at the middle lamellar region. At a later stage, the two cell walls between the paired platelets disappear and thus a pore is formed. The end result is full differentiation of sieve tube elements become continuous.