The "typical" plant cell

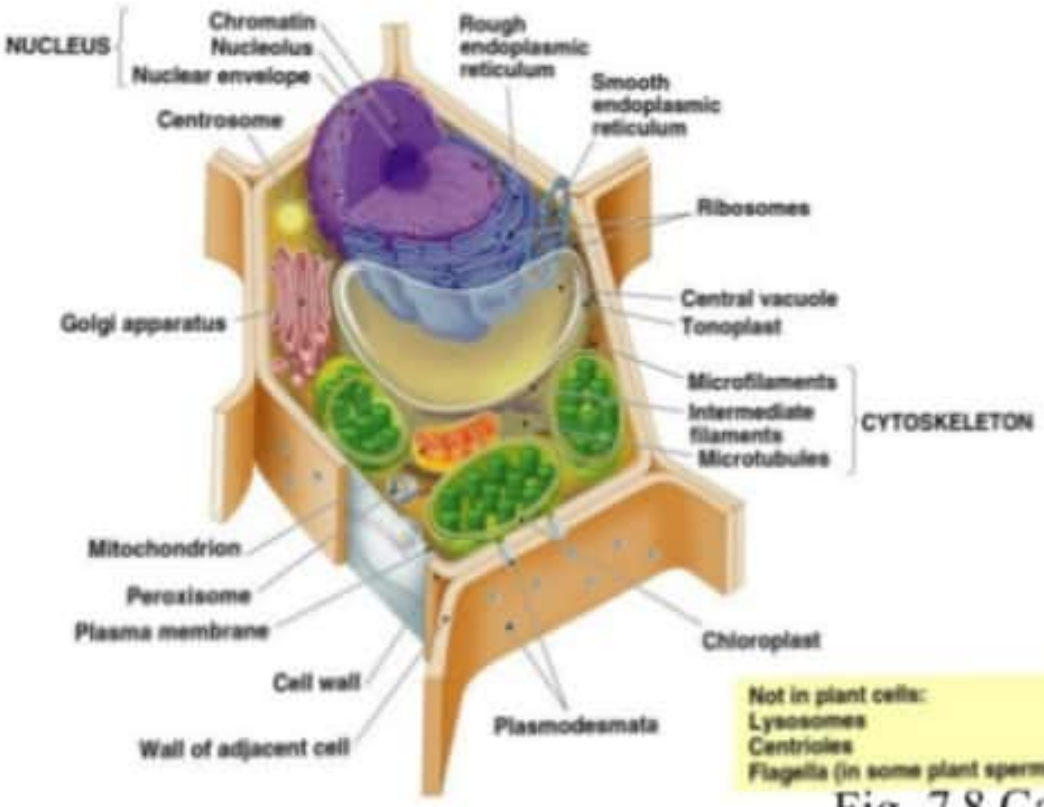


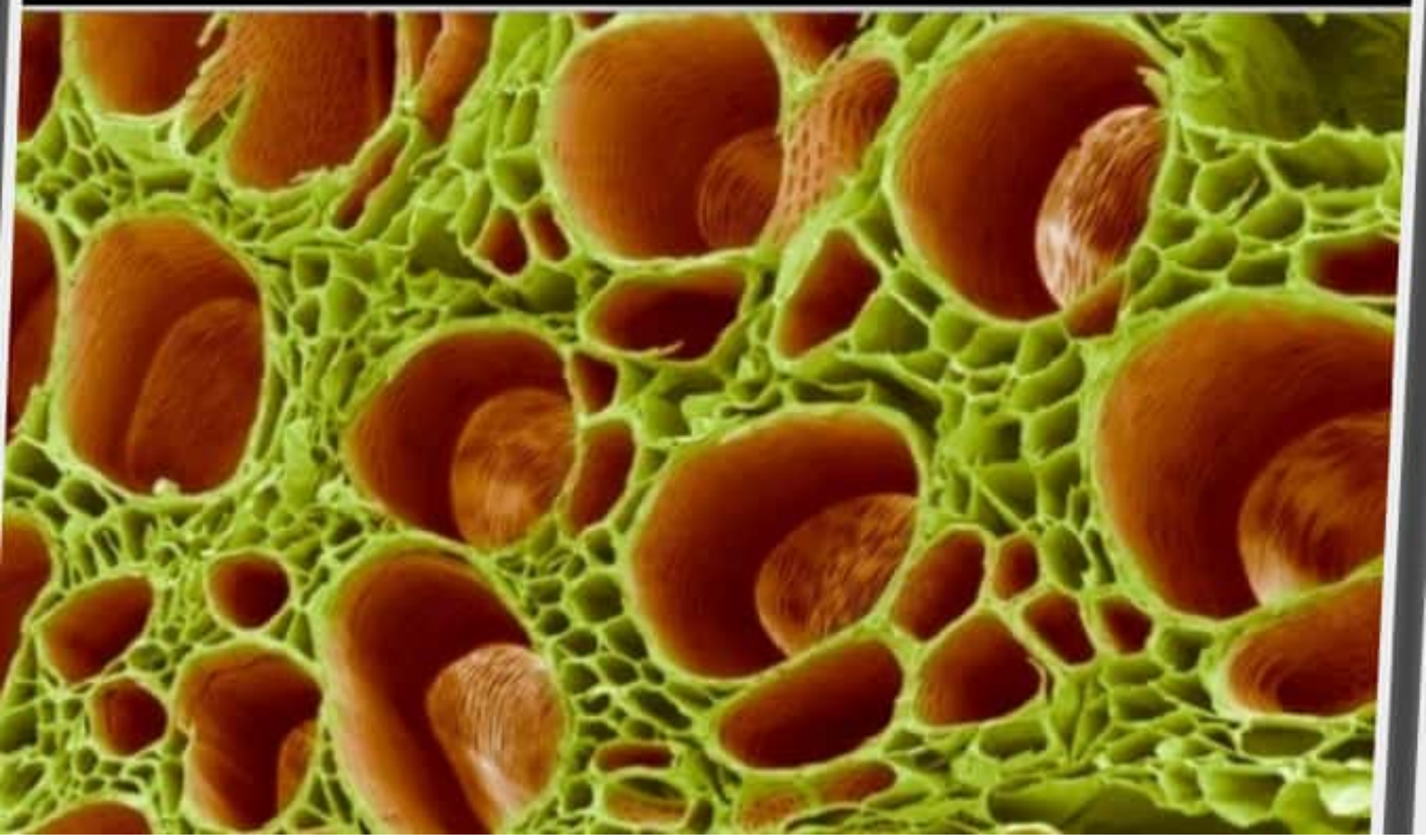
Fig. 7.8 Campbell

Cellular Differentiation

- Process of producing specialized cells
- Specialized cells have physical and chemical differences that allow them to perform a function that is different than other cells
- All specialized cells come from pre-existing cells so there must be a starter cell that is unspecialized

Specialized Plant Cells:

transport cells (xylem in orange, phloem in green)



Specialized Plant Cells:

storage cells (amyloplasts)

Examples of Cell Differentiation

Trichomes. The distinctive branched unicellular trichomes of plants such as *Arabidopsis* differentiate from undistinguished precursor cells in the protoderm. These precursor cells initiate the differentiation pathway by undergoing deoxyribonucleic acid (DNA) synthesis without accompanying cytokinesis, so that trichome precursors typically have eight or sixteen times the amount of DNA of adjacent pavement cells. Next, trichome precursors begin cell expansion in the plane perpendicular to the epidermis, forming a tubular extension. Once this stalk is formed, the nucleus migrates from the base of the stalk to its tip, using the cell's **cytoskeleton** to pull it to a new location. The trichome then undergoes an unusual pattern of cell wall growth, in which the cell wall balloons out at three locations, forming the

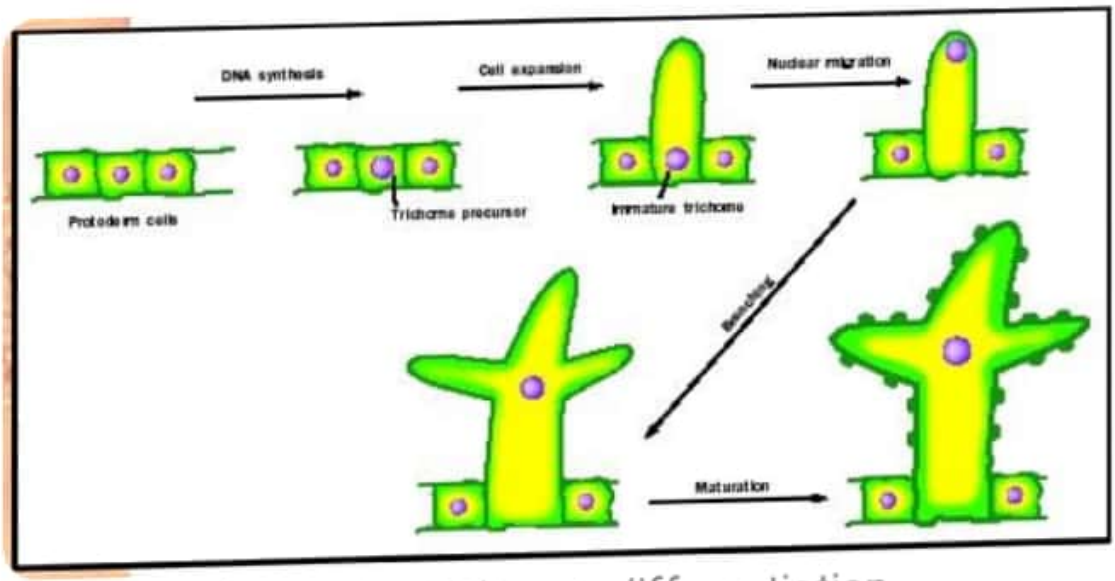


Figure 2. Trichrome differentiation.

three trichome branches. When the trichome cell has reached its full size and shape, it adds thickness to its cell wall and deposits sharp crystals of calcium oxalate on the surface of the trichome, adding to its effectiveness in defense against herbivores (see Figure 2).

Vessel Elements. Vessel elements differentiate from cells of the procambium. Vessel elements are first differentiated from other procambial cells because they expand more than their neighbors. Vessel element precursors next begin to deposit the thickened, lignified parts of their cell walls in either the ringlike, helical, netlike, or pitted pattern. The pattern can be predicted by the location of elements of the cytoskeleton within the cytoplasm that help guide wall precursor to the proper location. When cell wall synthesis is complete, special wall-degrading **enzymes** attack the end walls of the cell, forming the perforation between adjacent elements in a vessel. Finally, the vessel elements undergo programmed cell death. The cell makes protease enzymes and nuclease enzymes that reduce proteins and nucleic acids to their simple building blocks. Surrounding parenchyma cells absorb these small molecules, leaving an empty vessel (see Figure 3).

Bundle Sheath Cells. In most plants, the cells of the photosynthetic ground tissue are uniform in size, shape, and chloroplast development. Two types of photosynthetic parenchyma cells are sharply differentiated in plants that have the C4 photosynthetic pathway, however. These two cell types, the mesophyll and bundle sheath cells, begin differentiation as similarappearing ground meristem cells. During leaf expansion, the bundle sheath cells begin to enlarge first. The cell wall becomes thickened and impermeable to the diffusion of gases. Their plastids replicate, grow, and become asymmetrically placed within the cell. In contrast, the mesophyll cells undergo a minimal amount of enlargement and have thin, permeable cell walls. The number of plastids is low and the plastids remain small. During cell differentiation the **genes** encoding the enzymes of the C4 biochemical pathway

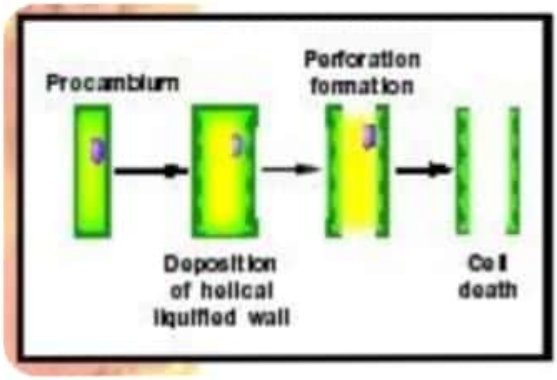


Figure 3. Vessel element differentiation.

are expressed exclusively in the mesophyll cells, whereas the genes encoding the enzymes of the

Figure 3. Vessel element differentiation.

are expressed exclusively in the mesophyll cells, whereas the genes encoding the enzymes of the C3 pathway are expressed only in the bundle sheath cells (see Figure 4).

Cell Differentiation and Development

Cell differentiation is only part of the larger picture of plant development. As plant organs develop (the process of organogenesis), the precursors of the tissue systems form in response to positional signals. Then, within each tissue system precursor, cell types must be specified in the proper spatial pattern. For instance, the spacing of trichomes and stomates within the protoderm must be specified before their precursor cells begin differentiation. Exchange of signals among neighboring cells is an important aspect of the processes of spatial patterning and cell differentiation. In addition, long distance signals are required so that the strands of xylem and phloem cells within the leaf vascular bundles connect perfectly with those in the stem.