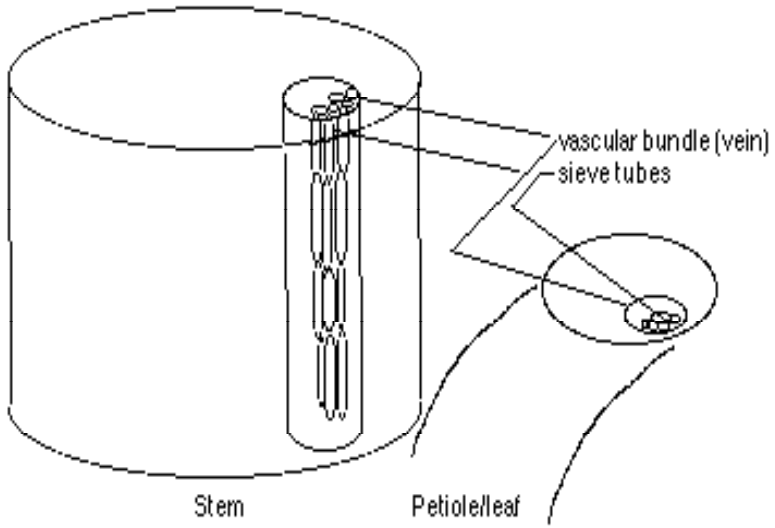
PHLOEM TRANSLOCATION

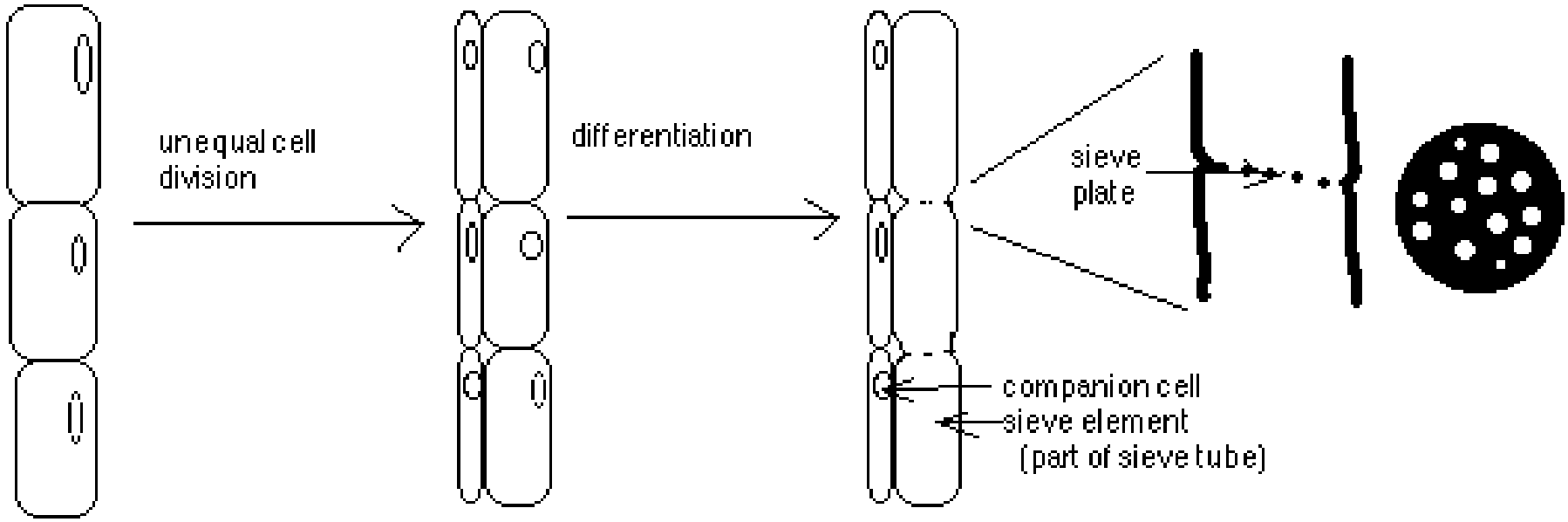
Photosynthate (often sucrose) from leaves must be used to nourish non-photosynthetic cells
Active transport occurs in phloem

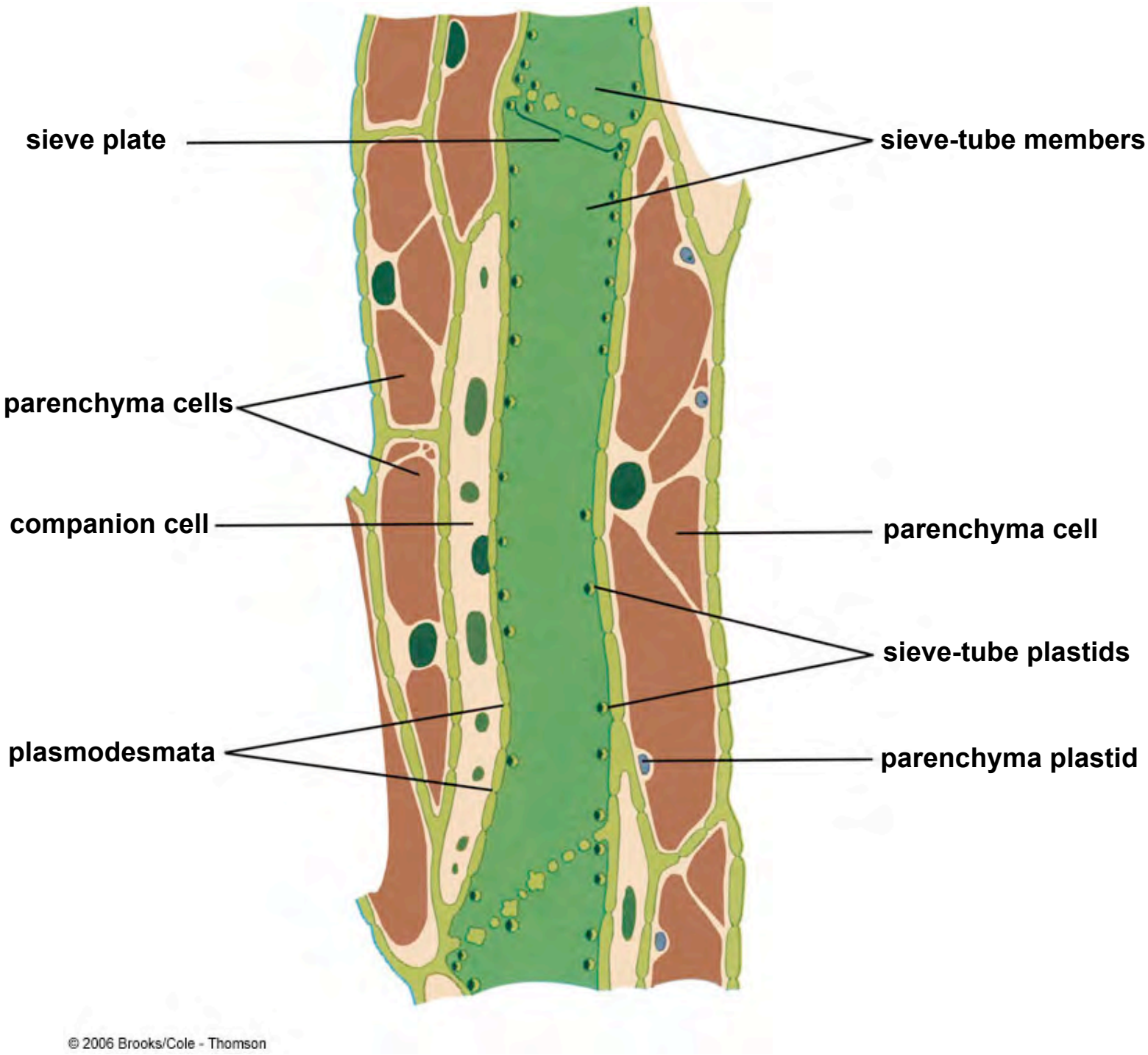
Phloem cell types:

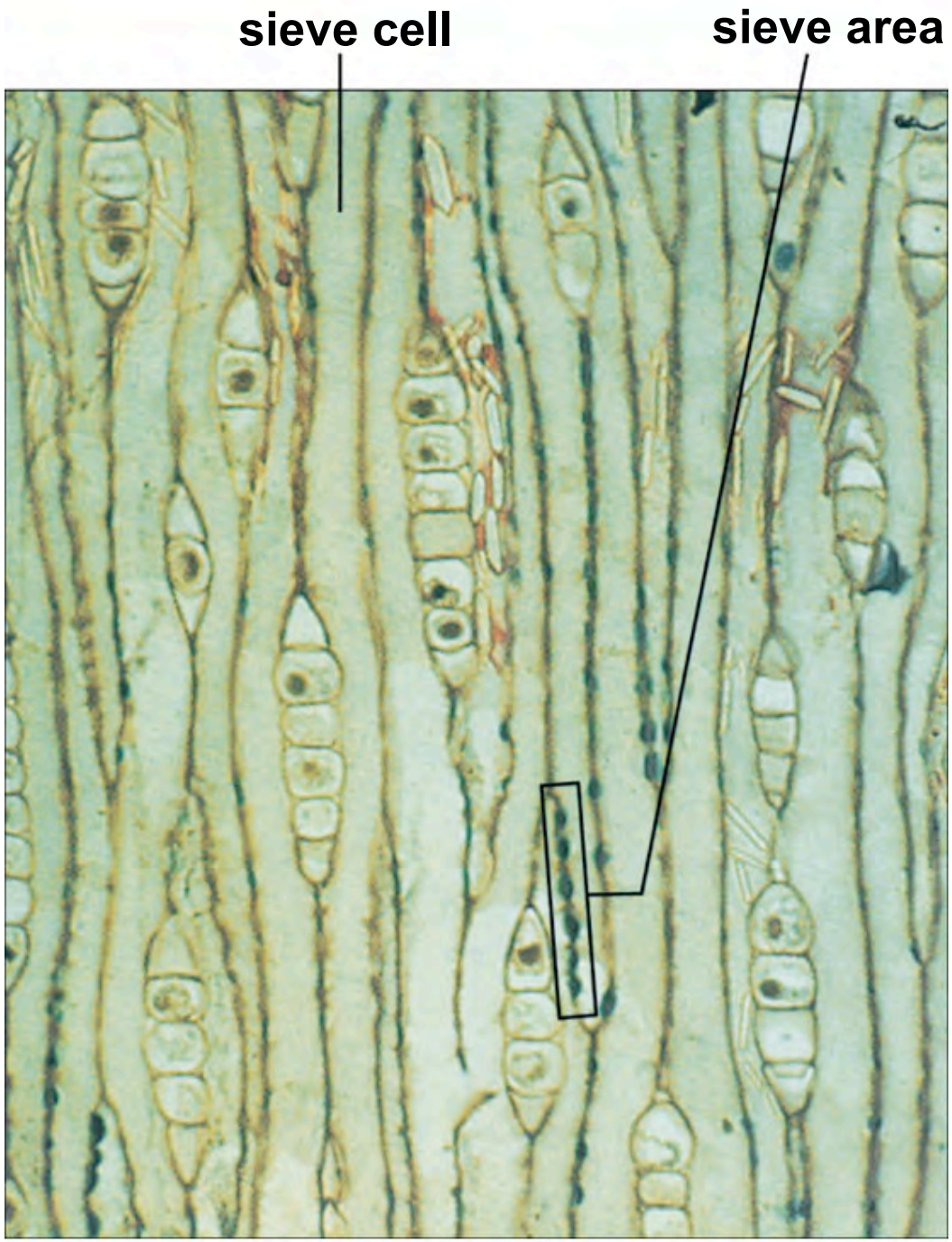
--parenchyma
--fibers (support)
--companion cells (support, nourish sieve tubes)
--**sieve tubes** (conduction)



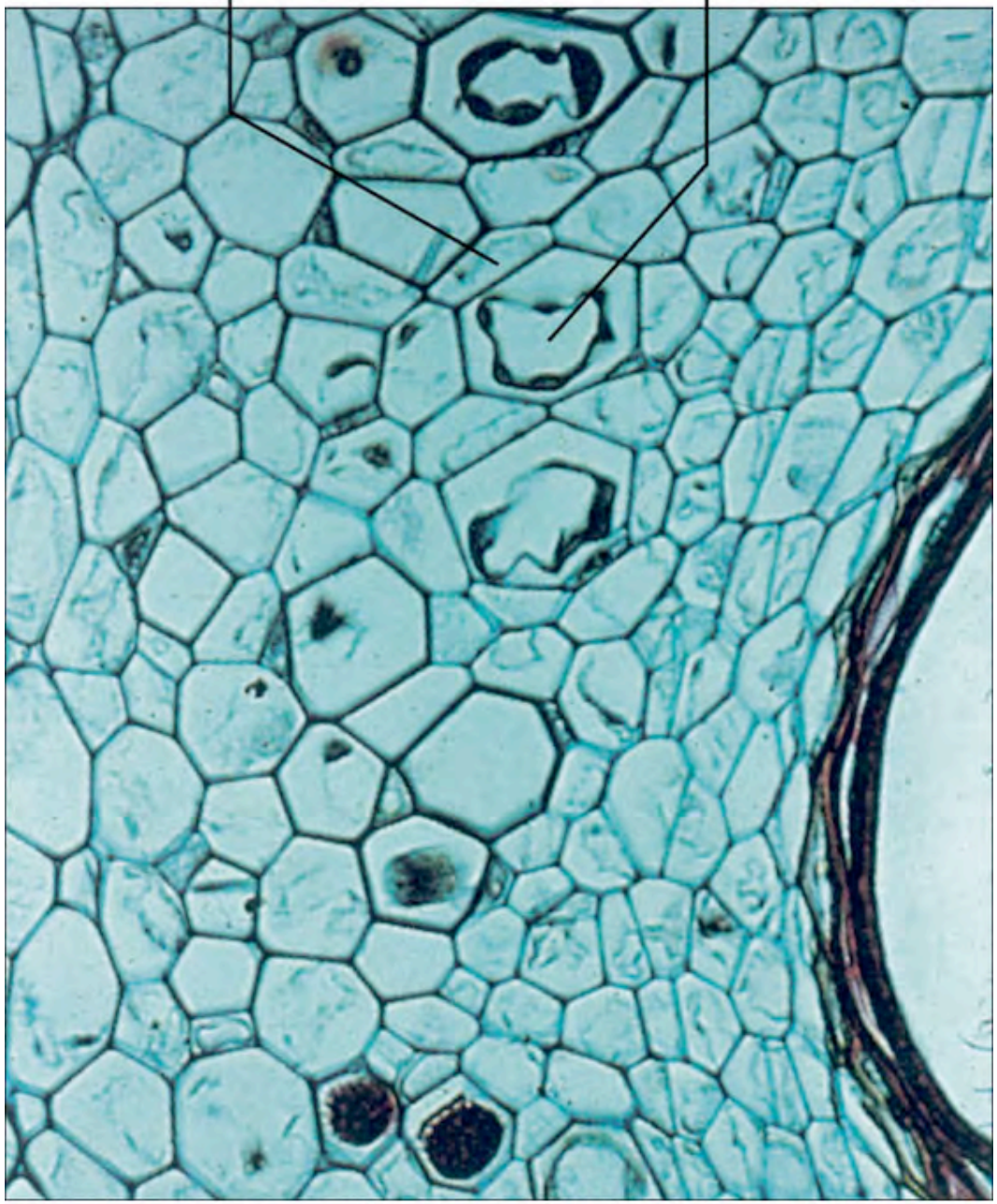
Sieve tubes form from sieve elements, which differentiate from parenchymal cells in vein: lose nucleus, mitochondria, most plastids, vacuole; develop thick cytoplasm, P-protein, thick cell wall (primary), sieve plates







companion cell sieve-tube member



Translocation demonstration:

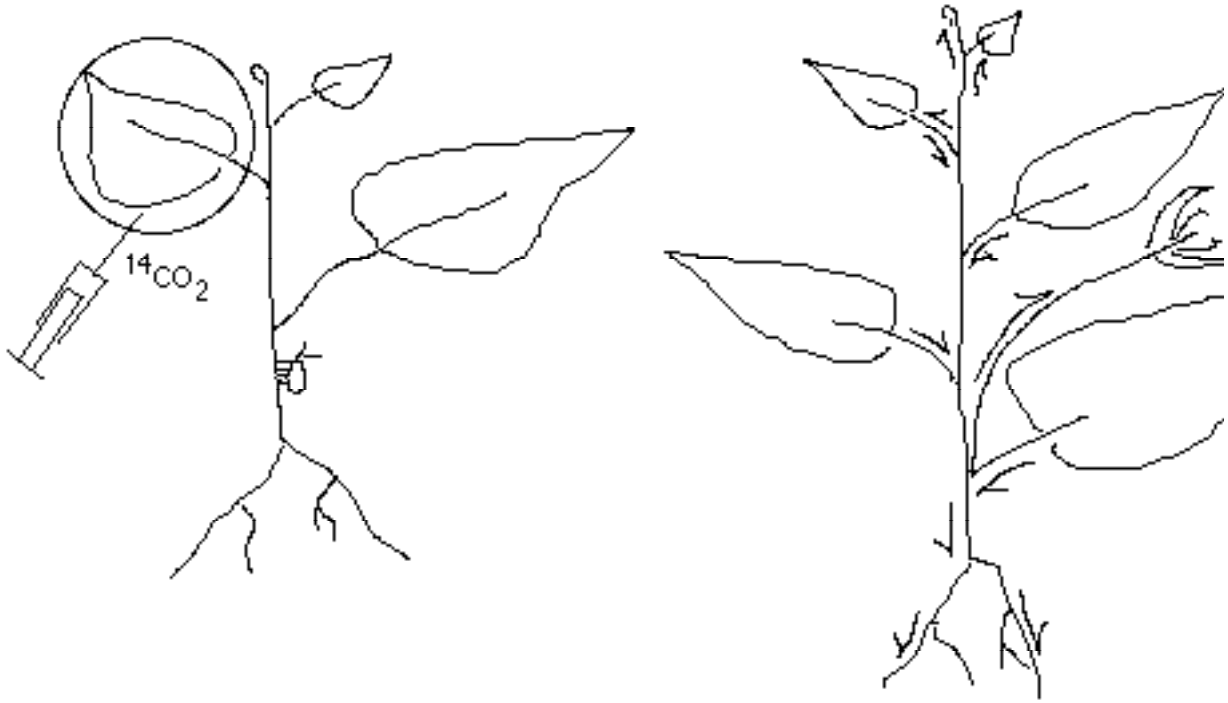
Use $^{14}CO_2$, light to produce radioactive photosynthate

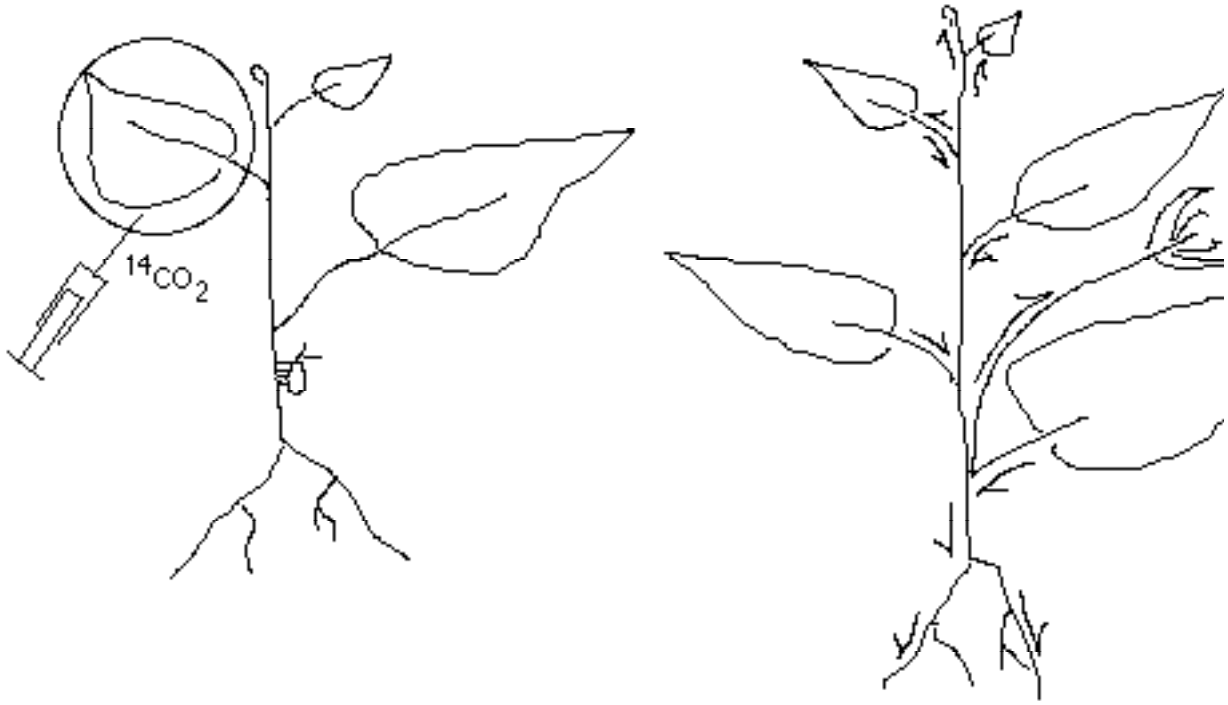
Use autoradiography to trace flow, position of ^{14}C

(expose whole plant or section of plant to film: ^{14}C produces black dots)

Demonstrate rate of movement of photosynthate (1-3 cm/min) and location of photosynthate (in sieve tubes)

Alternative: use phloem-sucking aphid to show ^{14}C in phloem (high pressure in sieve tube--10-20 atm--pushes out contents until P-protein forms plug)





Vary labeling position to show overall flow of photosynthate:

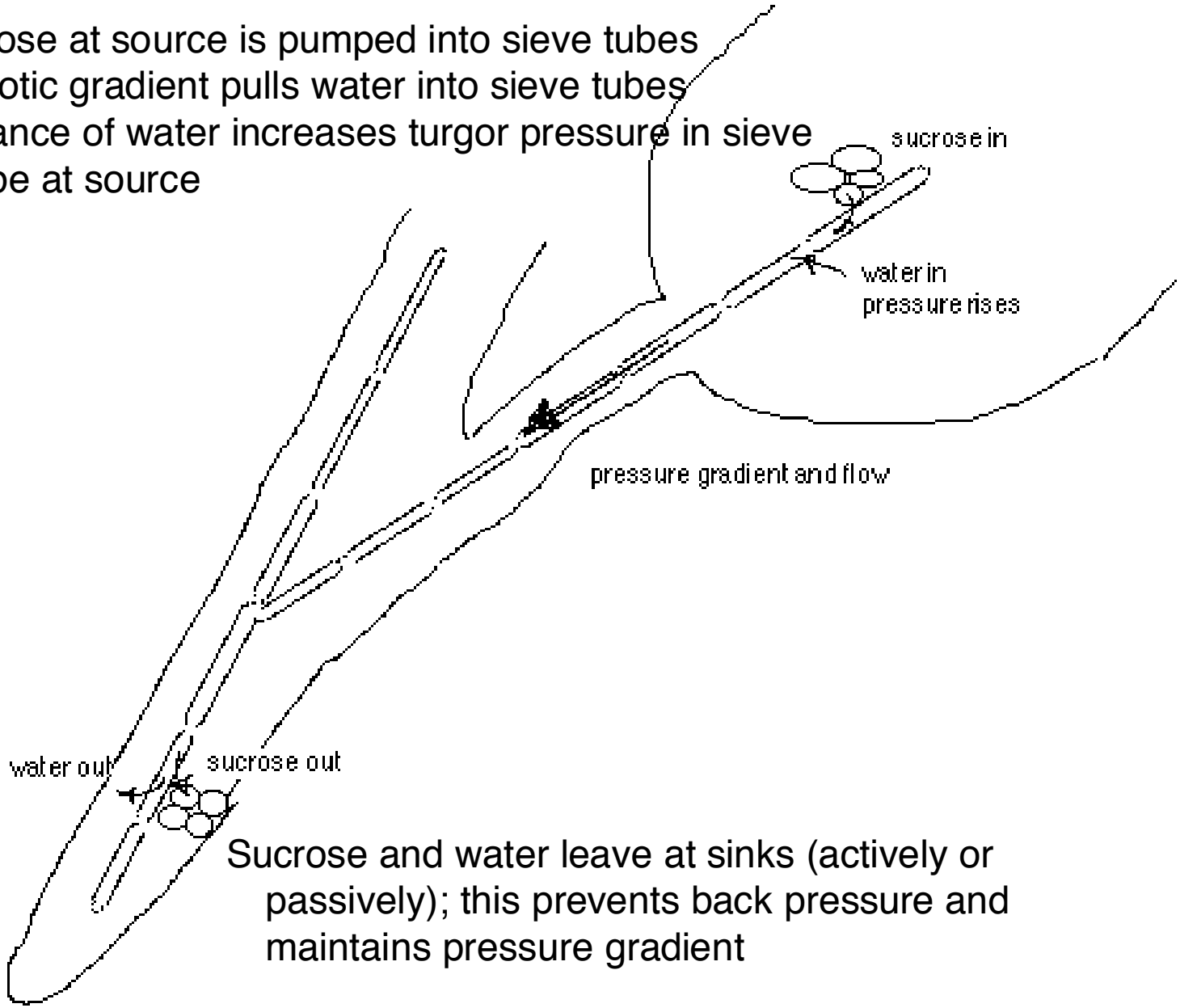
1) mature leaves export photosynthate
2) roots, apex, immature leaves, flowers, fruits import photosynthate
3) root, stem storage tissues import, then export ("mobilize") photosynthate
4) in general, photosynthate moves from sources to sinks

Mechanism of translocation

"Pressure-flow" or "mass-flow"

Sucrose at source is pumped into sieve tubes
Osmotic gradient pulls water into sieve tubes
Entrance of water increases turgor pressure in sieve tube at source
Gradient of turgor pressure causes mass of solution to flow away from source
Sucrose and water leave at sinks (actively or passively); this prevents back pressure and maintains pressure gradient
Pumping of sucrose across membranes at source (and sink?) controls flow

Sucrose at source is pumped into sieve tubes
Osmotic gradient pulls water into sieve tubes
Entrance of water increases turgor pressure in sieve tube at source



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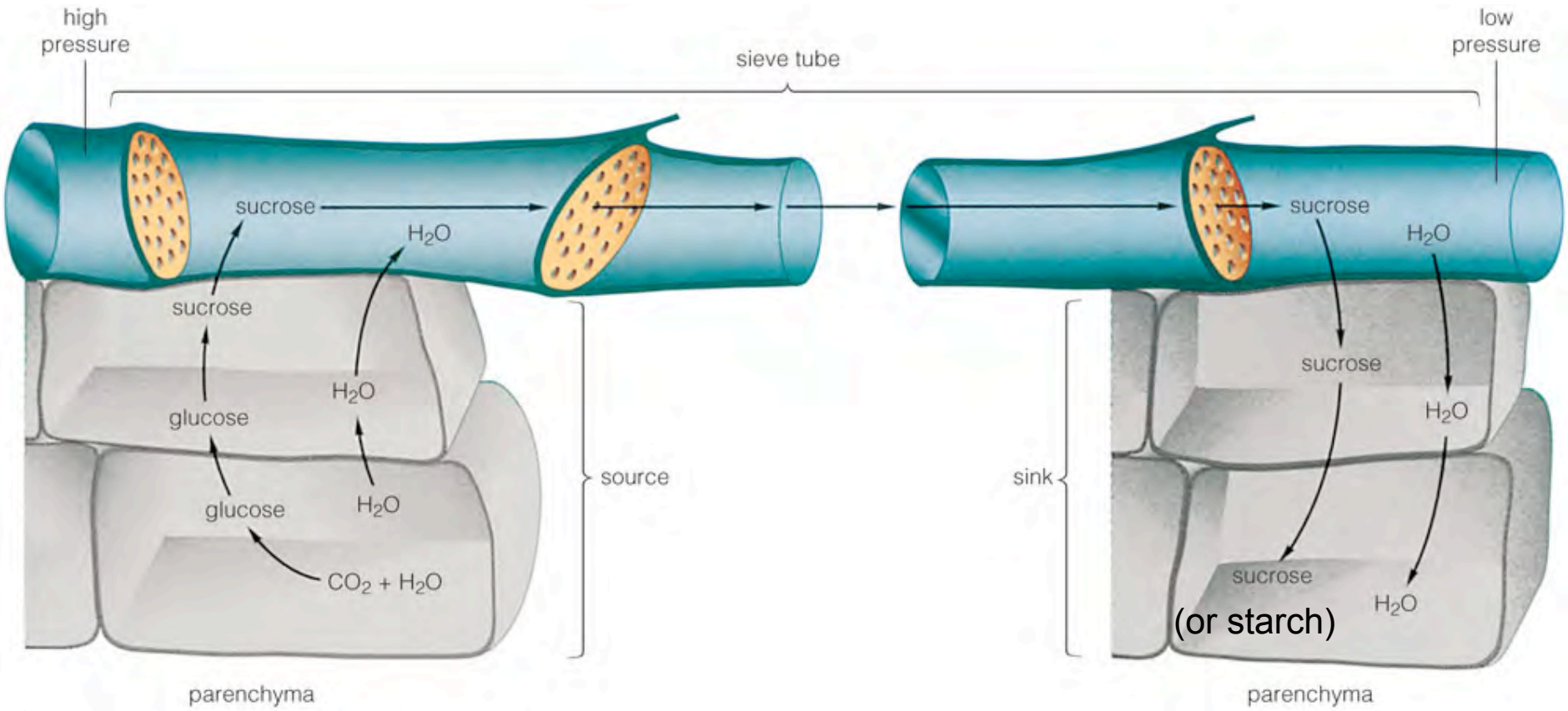

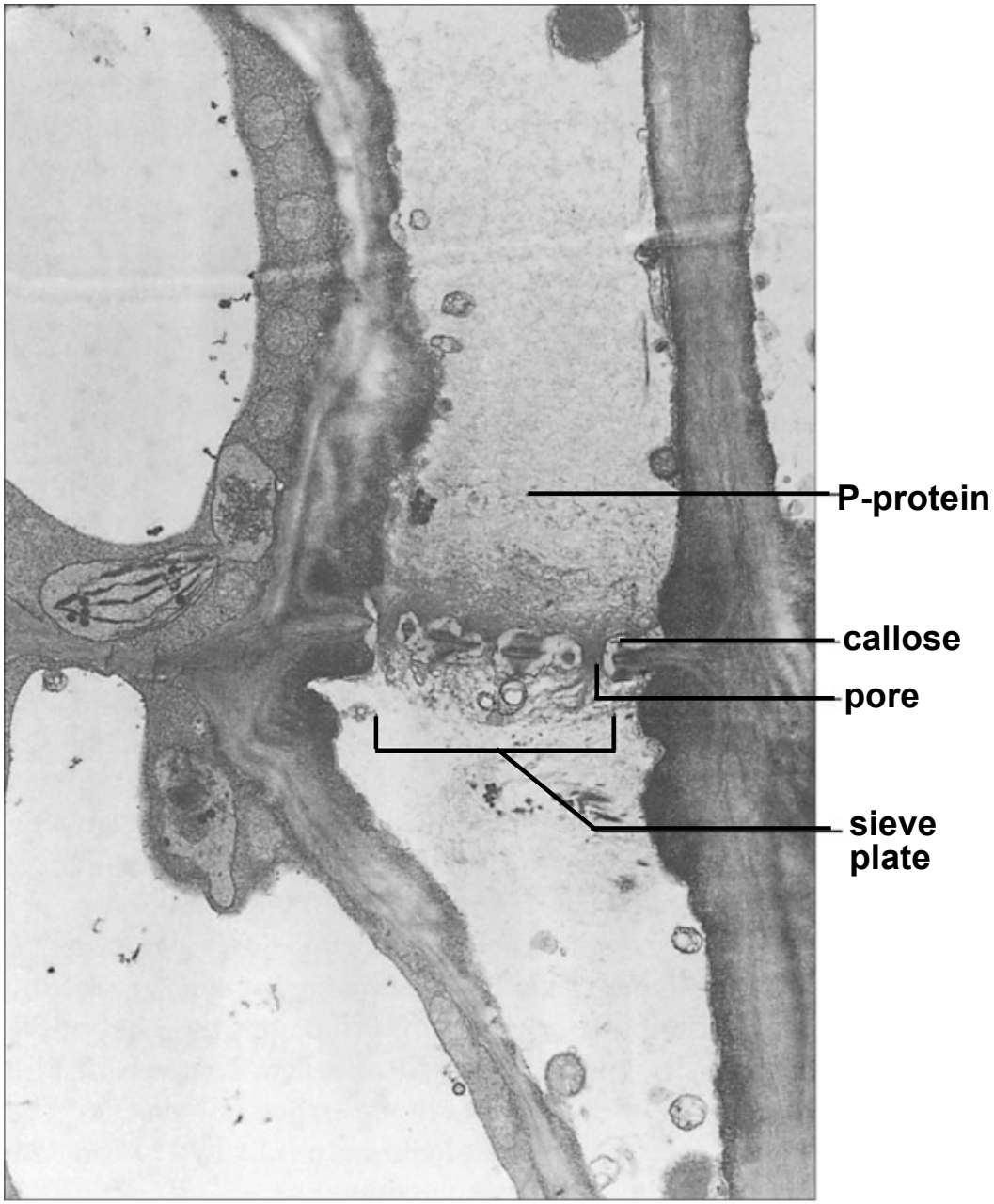

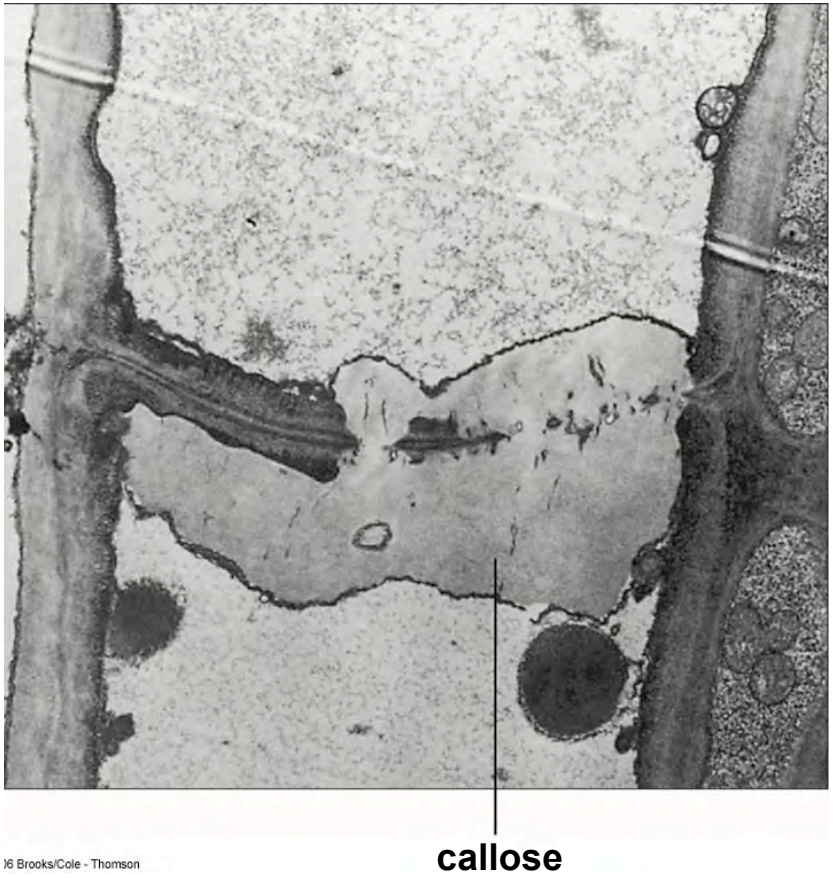

If sieve tubes are under heavy positive pressure, why don't they spurt when you cut a stem?

Direction of flow of sugar in a biennial plant (sugar beet) or a perennial plant (taro)

1st season

Photosynthate

Sucrose

Storage

2nd season

Glycolysis,
regrowth

Sucrose

Mobilization
(reload phloem)

Summary

Organic compounds--sugars, amino acids--are transported through the plant in the phloem

The phloem consists of a network of sieve cells, arranged in sieve tubes, which are continuous throughout the plant--not separated by membranes or cell walls

The mechanism powering transport is a gradient of pressure produced osmotically by a gradient of solute

The solute gradient is produced by active input and withdrawal of solutes from the sieve tube

Flow thus goes from source to sink and can change direction as production and use changes