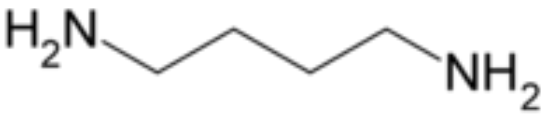
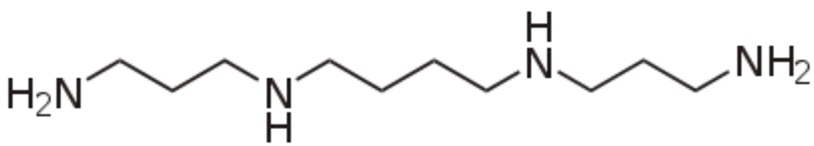
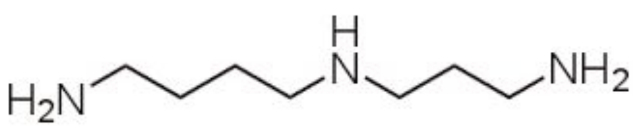
Кадаверин (1,5-пентандиамин)



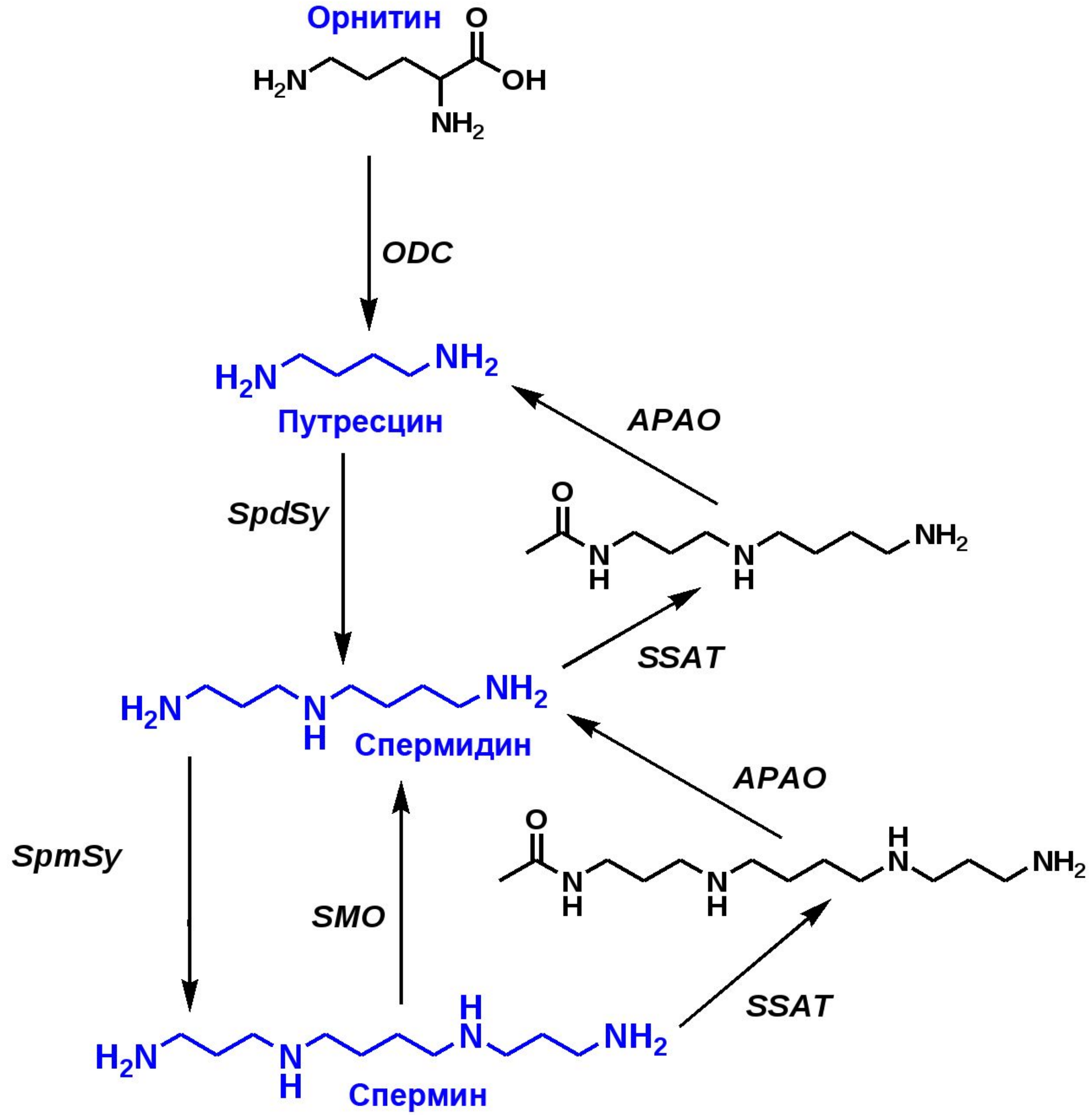
Путресцин (1,5-пентандиамин)



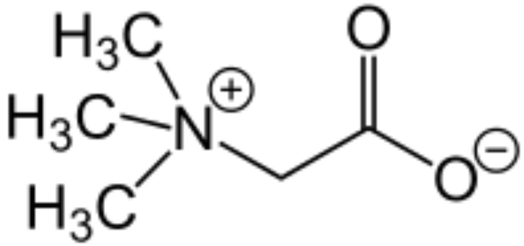
Спермин
N,N'-бис(3-аминопропил)бутан-1,4-диамин



Спермидин
N,N'-бис(3-аминопропил)бутан-1,4-диамин



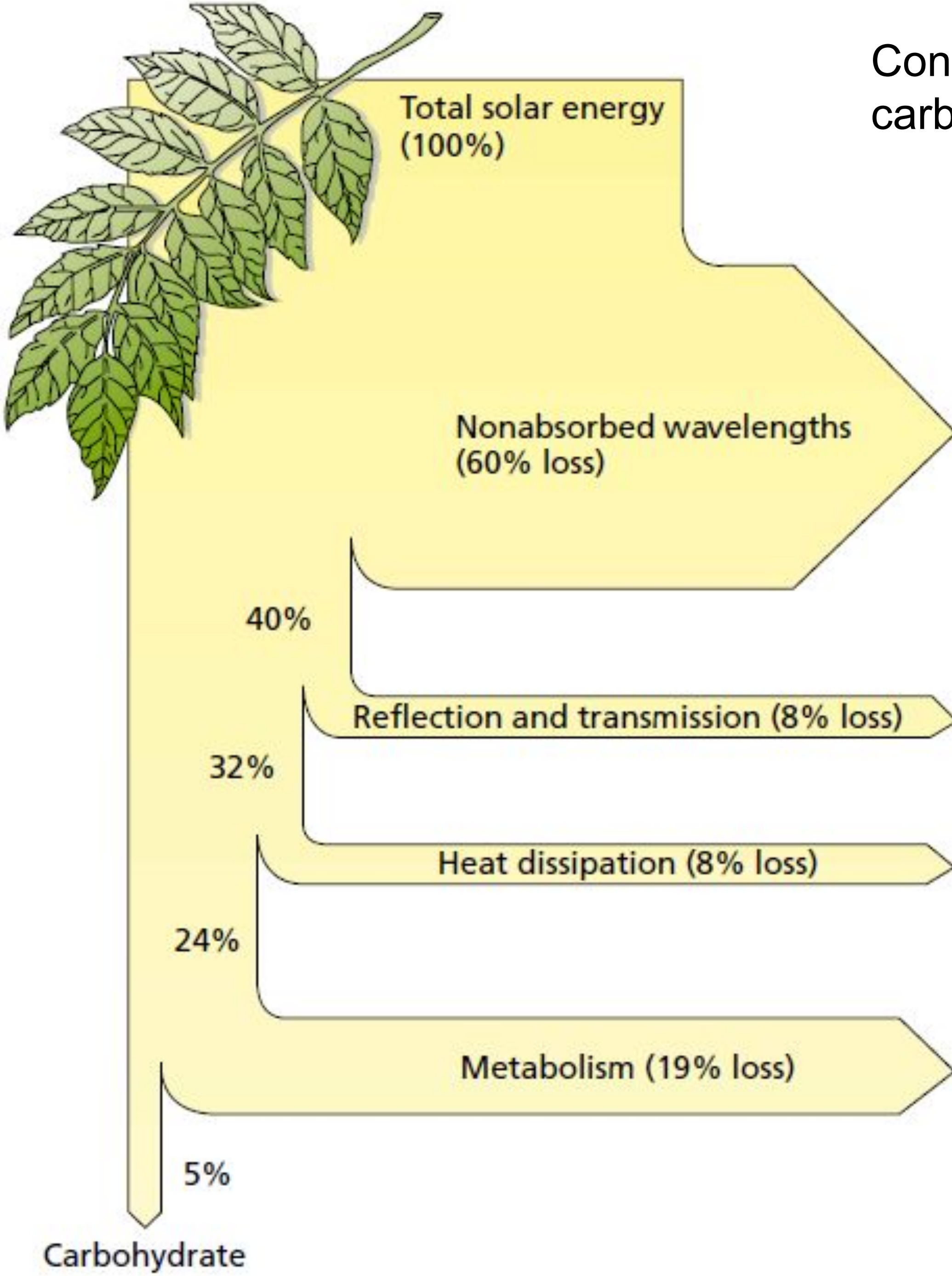
Орнитин
O
OH
H2N
NH2
ODC
H2N
NH2
Путресцин
APAO
SpdSy
O
N
H
N
H
NH2
SSAT
H2N
N
H
NH2
Спермидин
APAO
SpmSy
O
N
H
N
H
H
N
NH2
SMO
SSAT
H2N
N
H
H
N
NH2
Спермин



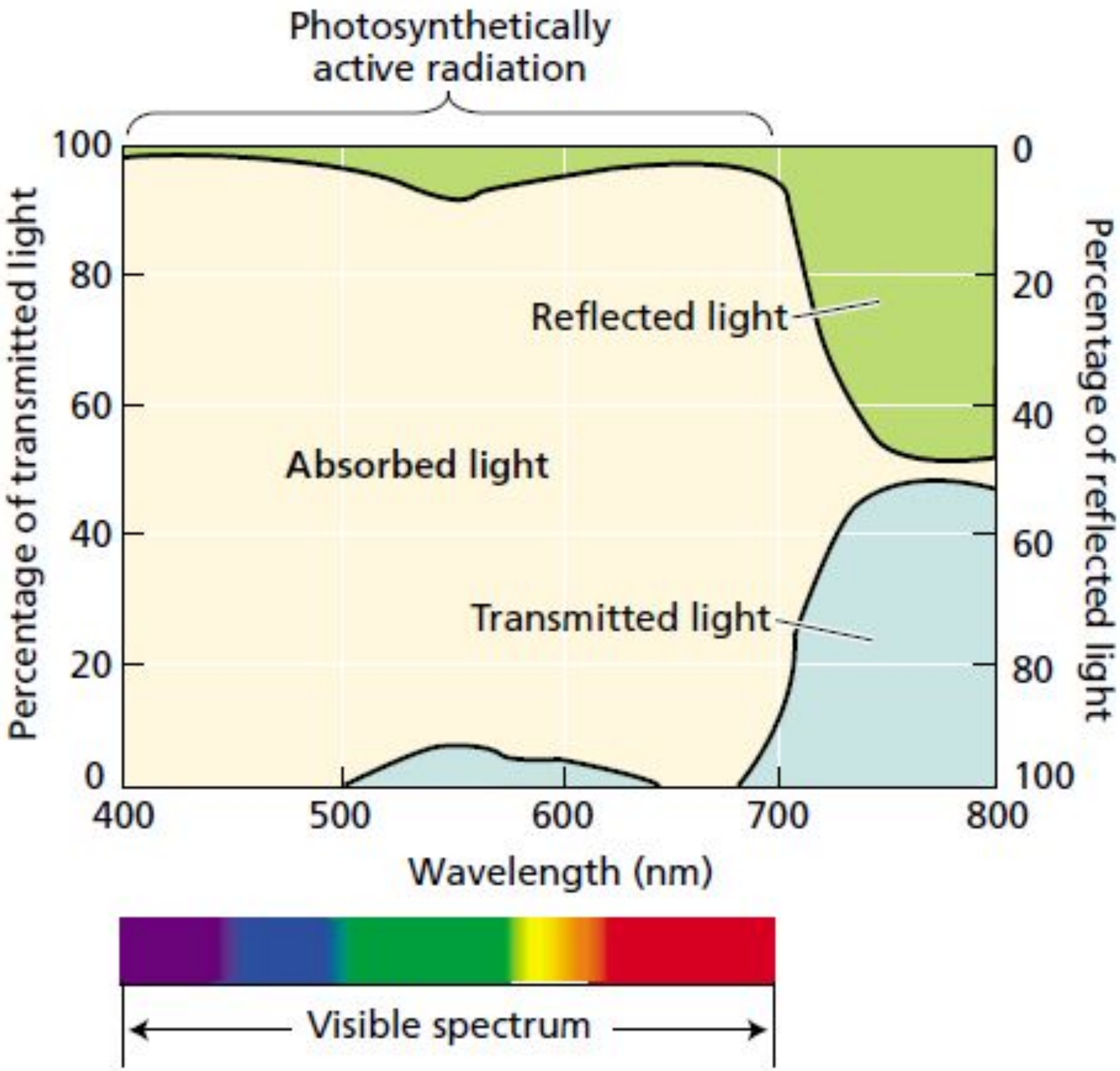
Бетаин

(триметилглицин)

Conversion of solar energy into carbohydrates by a leaf.



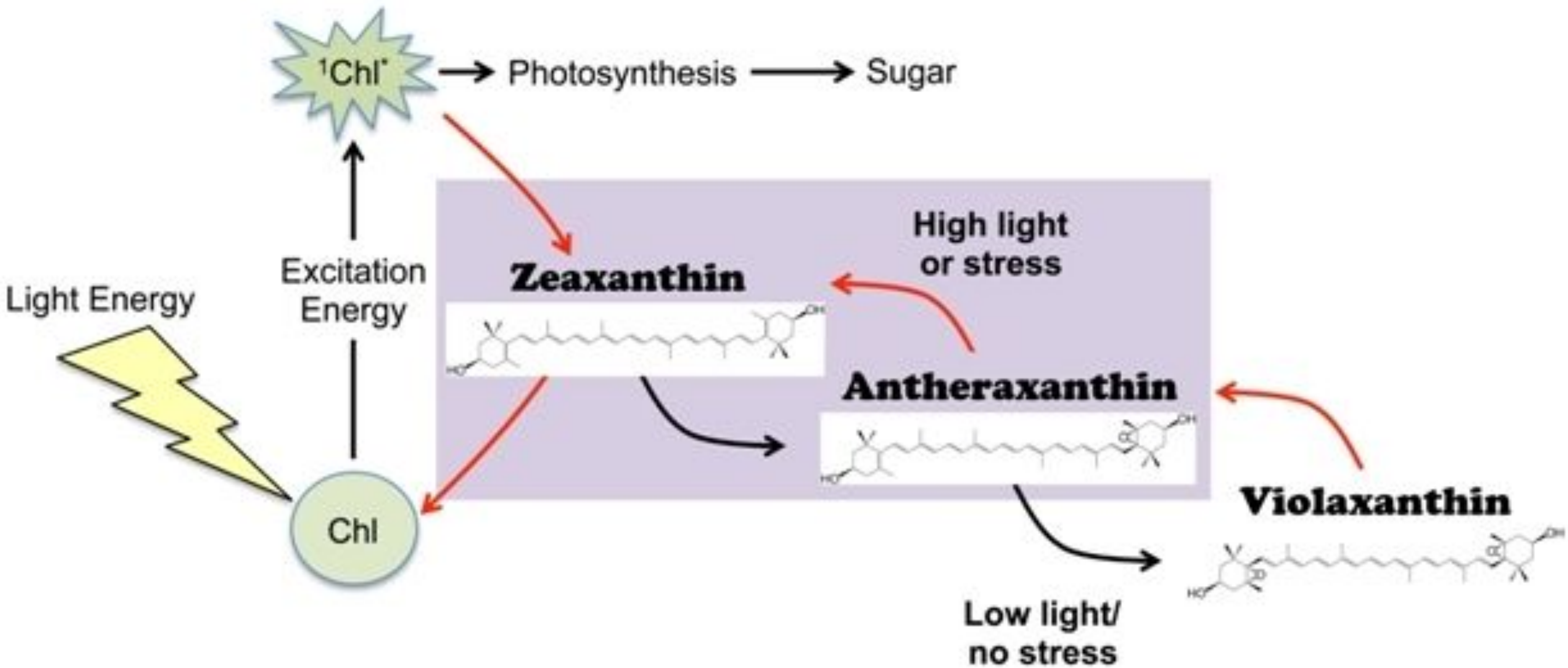
Optical properties of a bean leaf.



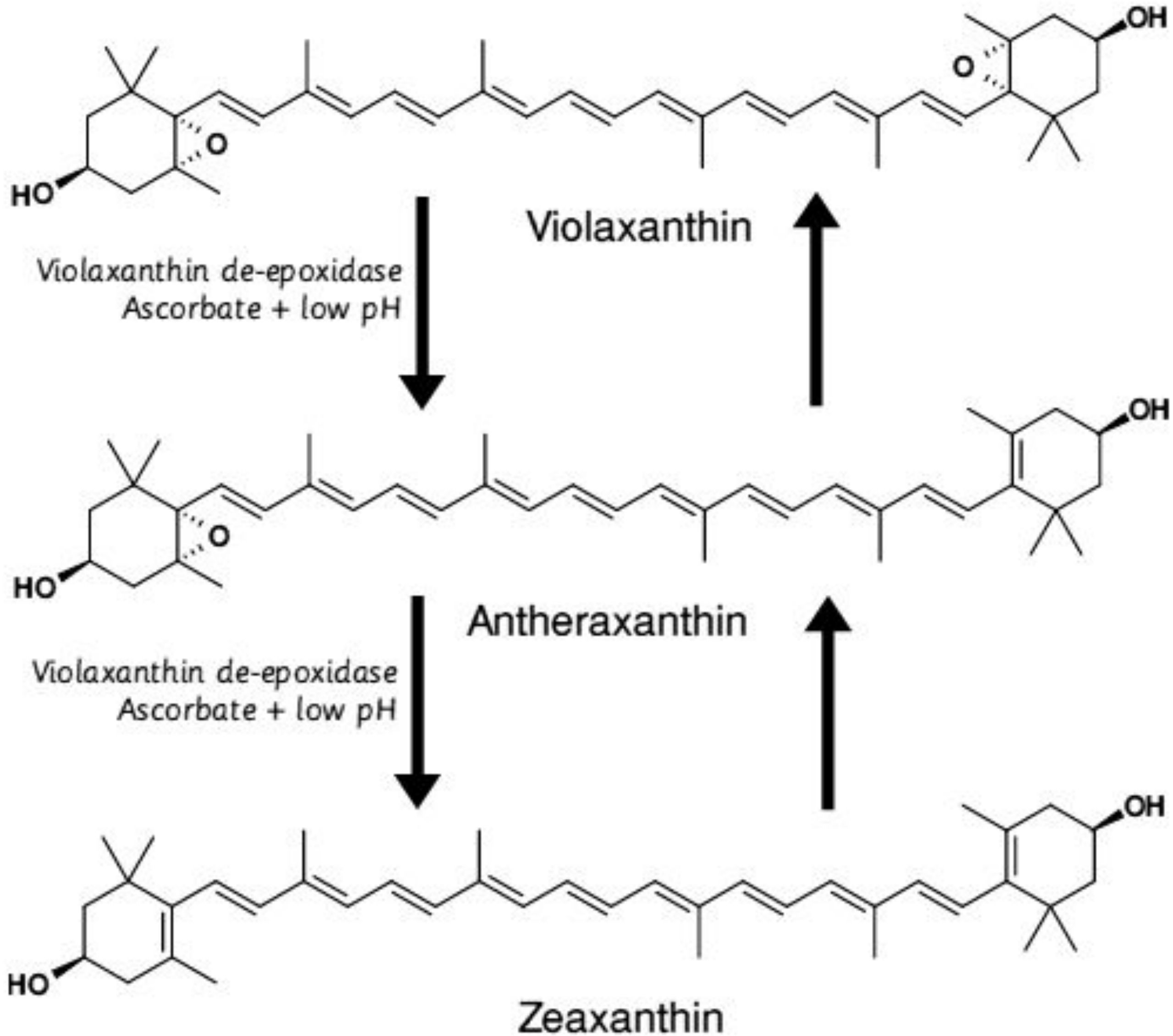
Shown here are the percentages of light absorbed, reflected, and transmitted, as a function of wavelength. The transmitted and reflected green light in the wave band at 500 to 600 nm gives leaves their green color. Note that most of the light above 700 nm is not absorbed by the leaf.

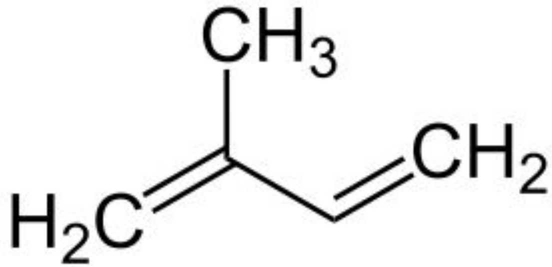
(From Smith 1986.)

Photoprotection by dissipation of excess light energy aided by xanthophyll cycle carotenoids

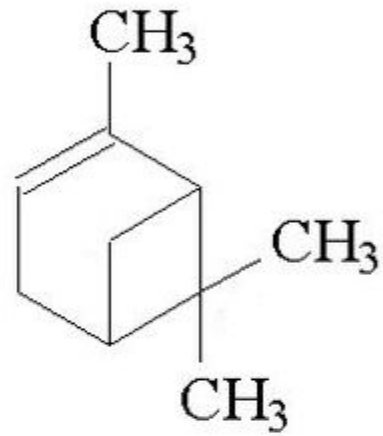


Xanthophyll cycle

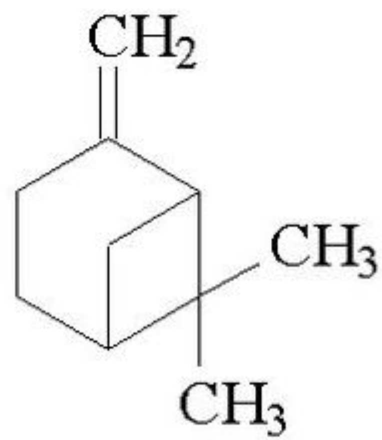




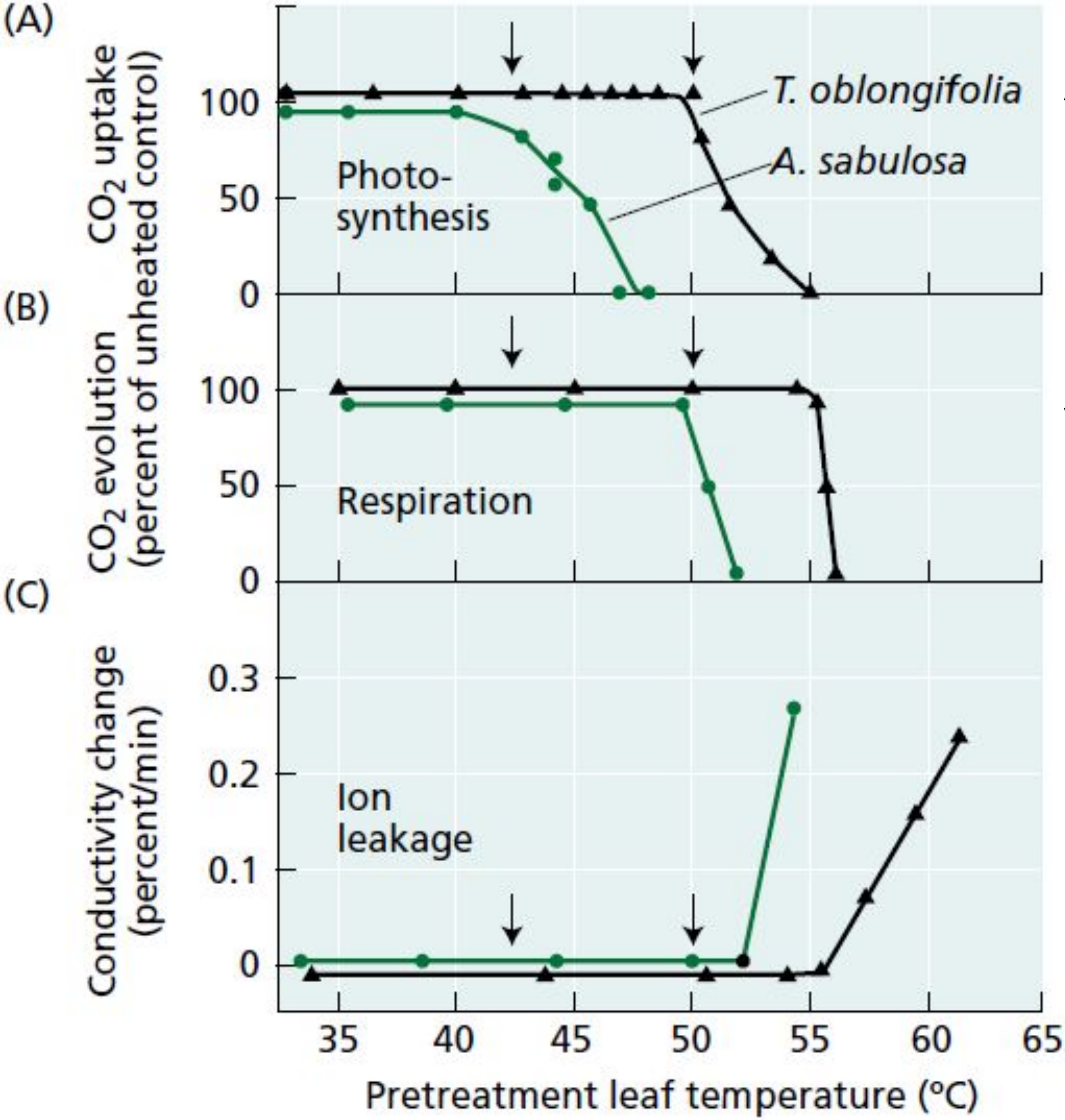
isoprene



α-pinene



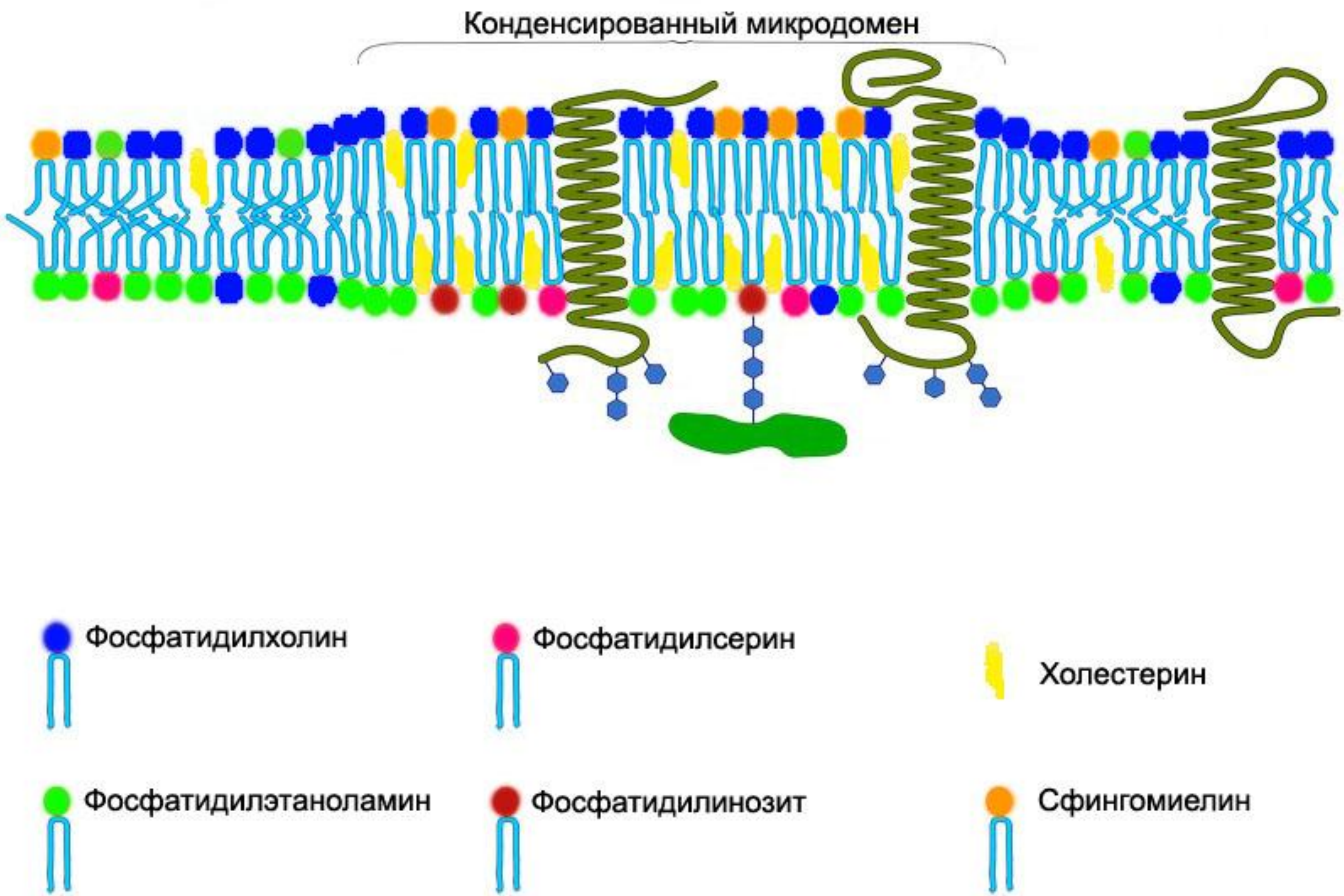
β-pinene



Response of frosted orache (*Atriplex sabulosa*) and Arizona honeysweet (*Tidestromia oblongifolia*) to heat stress.

Photosynthesis (A) and respiration (B) were measured on attached leaves, and ion leakage (C) was measured in leaf slices submerged in water.
(From Bjorkman et al. 1980.)

Организация мембранных микродоменов (рафтов)



Fatty acid composition of mitochondria isolated from chilling-resistant and chilling-sensitive species

	Percent weight of total fatty acid content					
	Chilling-resistant species			Chilling-sensitive species		
Major fatty acids[a]	Cauliflower bud	Turnip root	Pea shoot	Bean shoot	Sweet potato	Maize shoot
Palmitic (16:0)	21.3	19.0	12.8	24.0	24.9	28.3
Stearic (18:0)	1.9	1.1	2.9	2.2	2.6	1.6
Oleic (18:0)	7.0	12.2	3.1	3.8	0.6	4.6
Linoleic (18:2)	16.4	20.6	61.9	43.6	50.8	54.6
Linolenic (18:3)	49.4	44.9	13.2	24.3	10.6	6.8
Ratio of unsaturated to saturated fatty acids	3.2	3.9	3.8	2.8	1.7	2.1

[a] Shown in parentheses are the number of carbon atoms in the fatty acid chain and the number of double bonds.

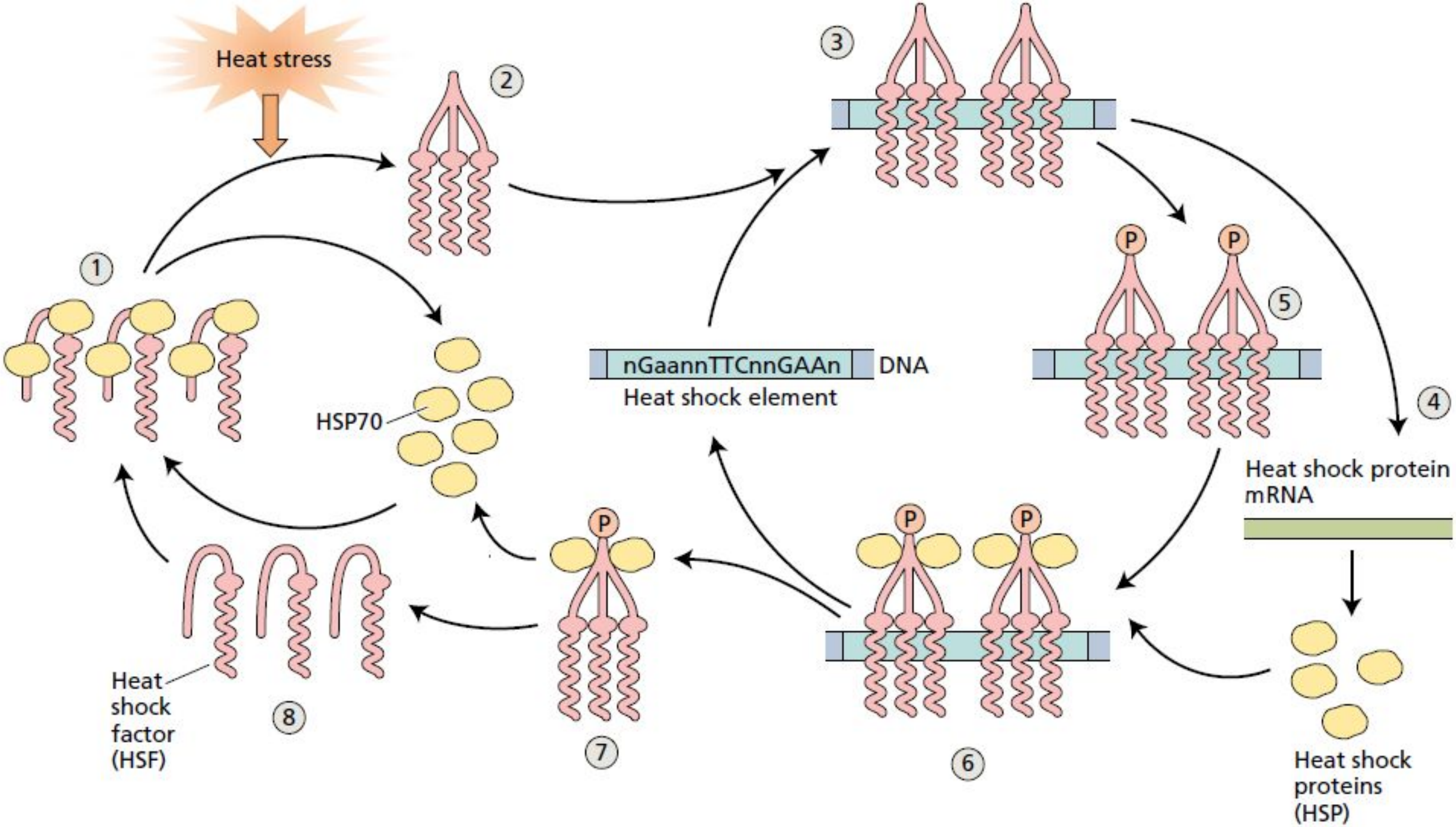
Source: After Lyons et al. 1964.

The five classes of heat shock proteins found in plants

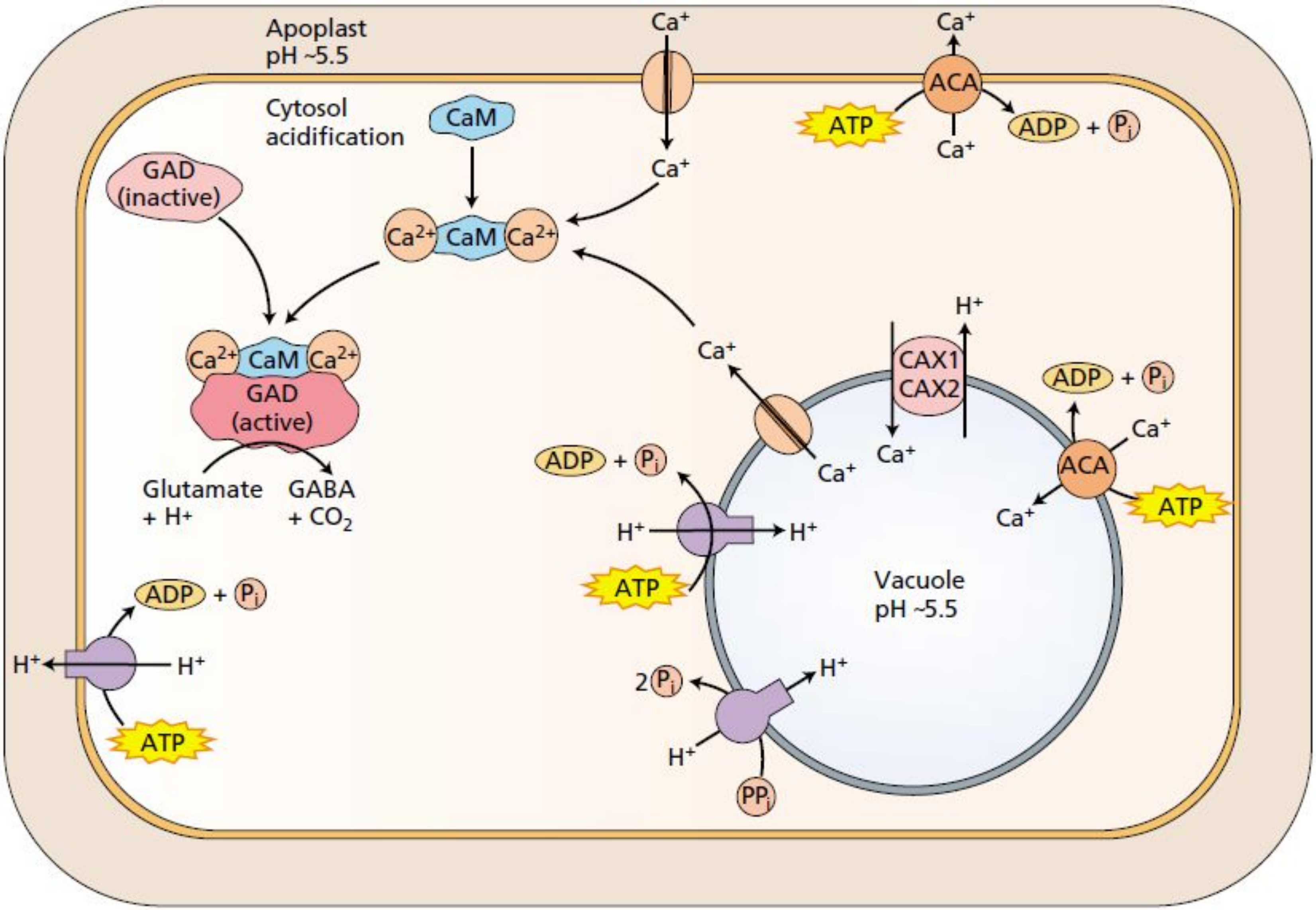
HSP class	Size (kDa)	Examples (Arabidopsis / prokaryotic)	Cellular location
HSP100	100–114	AtHSP101 / ClpB, ClpA/C	Cytosol, mitochondria, chloroplasts
HSP90	80–94	AtHSP90 / HtpG	Cytosol, endoplasmic reticulum
HSP70	69–71	AtHSP70 / DnaK	Cytosol/nucleus, mitochondria, chloroplasts
HSP60	57–60	AtTCP-1 / GroEL, GroES	Mitochondria, chloroplasts
smHSP	15–30	Various AtHSP22, AtHSP20, AtHSP18.2, AtHSP17.6 / IBPA/B	Cytosol, mitochondria, chloroplasts, endoplasmic reticulum

Source: After Boston et al. 1996.

Heat shock factor (HSF) cycle

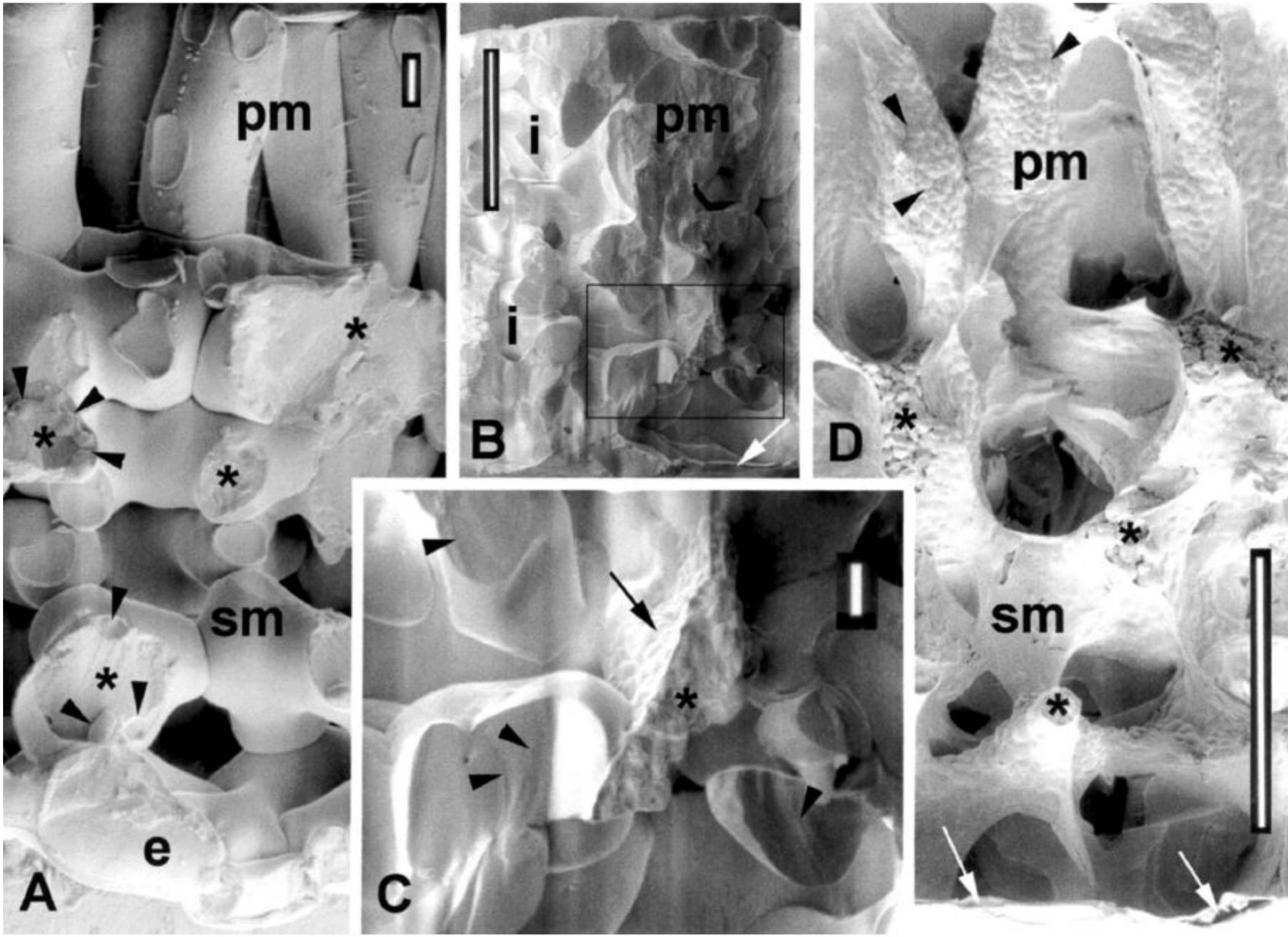


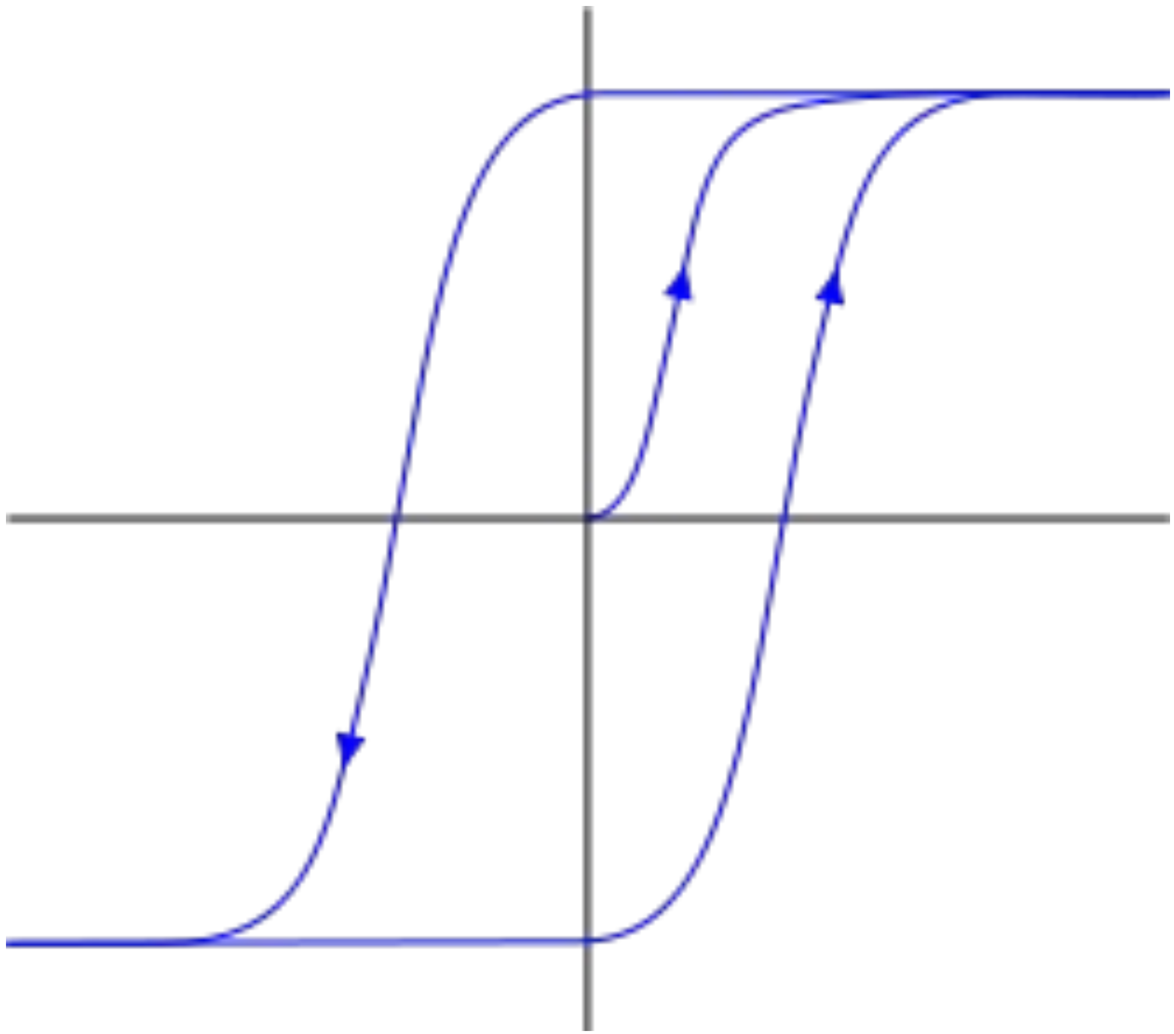
Heat stress Ca-mediated response



- Low temperature scanning electron microscopy of contro (A) and freezing – stressed tobacco leaves (B-D) (Ashworth and Pearce, unpubl. res.). Themicrographs show transverse fractures through the leaves.
- Youngpottedplantsweregrowninawarmgreenhouseandweretestedatthetwo-to-fourleafstage.
- Theplantsweresprayedwithwaterandcooledat28Chÿ1toÿ208Cthenfreeze-®xedinmeltingfreon12.DTAshowedtheleavesfrozebetweenÿ2.08Candÿ3.08C.DetailsofthemicroscopicalmethodsareasinPearceandAshworth(1992).A,Controlsampleshowingturgidcellsandabsenceofextracellulariceinalltissues(e,epidermis;pm,palisademesophyll;sm,spongymesophyll).Notethatorganellepro®leswerevisiblewherethefractureplanehadcutthroughthecells(starsindicatecross-fracturedcellsinthespongymesophyll;arrowheadsindicateorganellesintwoexamplecells).Theepidermalcells(e)werealsocross-fractured.BandC,Samplefrozentoÿ208Cshowingextensiveextracellularice(i).CisanenlargementoftheareaboxedinB.Inthisexampleicerami®edextensivelythroughthegasspacesbutdidnotfullyoccludethem.Thewhitearrow(B)indicatesthecollapsedepidermis.Atlowmagni®cation(B)theiceappearedsuper®ciallysimilartoturgidcells.However,whenenlarged(C)thecross-fractureofthesestructuresshowedthemtocontainnoorganellepro®lesandinsteadthefracturedsurfacehadsteps(arrowheads)typicaloffracturedice.Thecellsweremostlyhiddenbytheice.However,intheareaenlargedinCacollapsedcell(star)waseasilyidenti®edbytheorganellesitcontained:thearrowindicatestheimpressonthecellwalloforganellesinacell.D,Samplefrozentoÿ208C.Icewasremovedfromthespecimenbysublimationinthemicroscope,thusrevealingthecollapsed,dehydratedcells.Themesophyllcells(pm,palisademesophyll;sm,spongymesophyll)andepidermis(whitearrows)werecollapsed.Theoutersurfaceofcellwallsshowedanimpressoftheorganelleswithinthecells(examplesindicatedbyarrowheads).Starsindicatewherethefractureplanehascutthroughthecells,againrevealingorganelles.Allgold-coated.2kV.Bars‹10mm(AandC)or100mm(BandD).

Low temperature scanning electron microscopy of control (A) and freezing – stressed tobacco leaves (B-D) (Ashworth and Pearce, unpubl. res.).

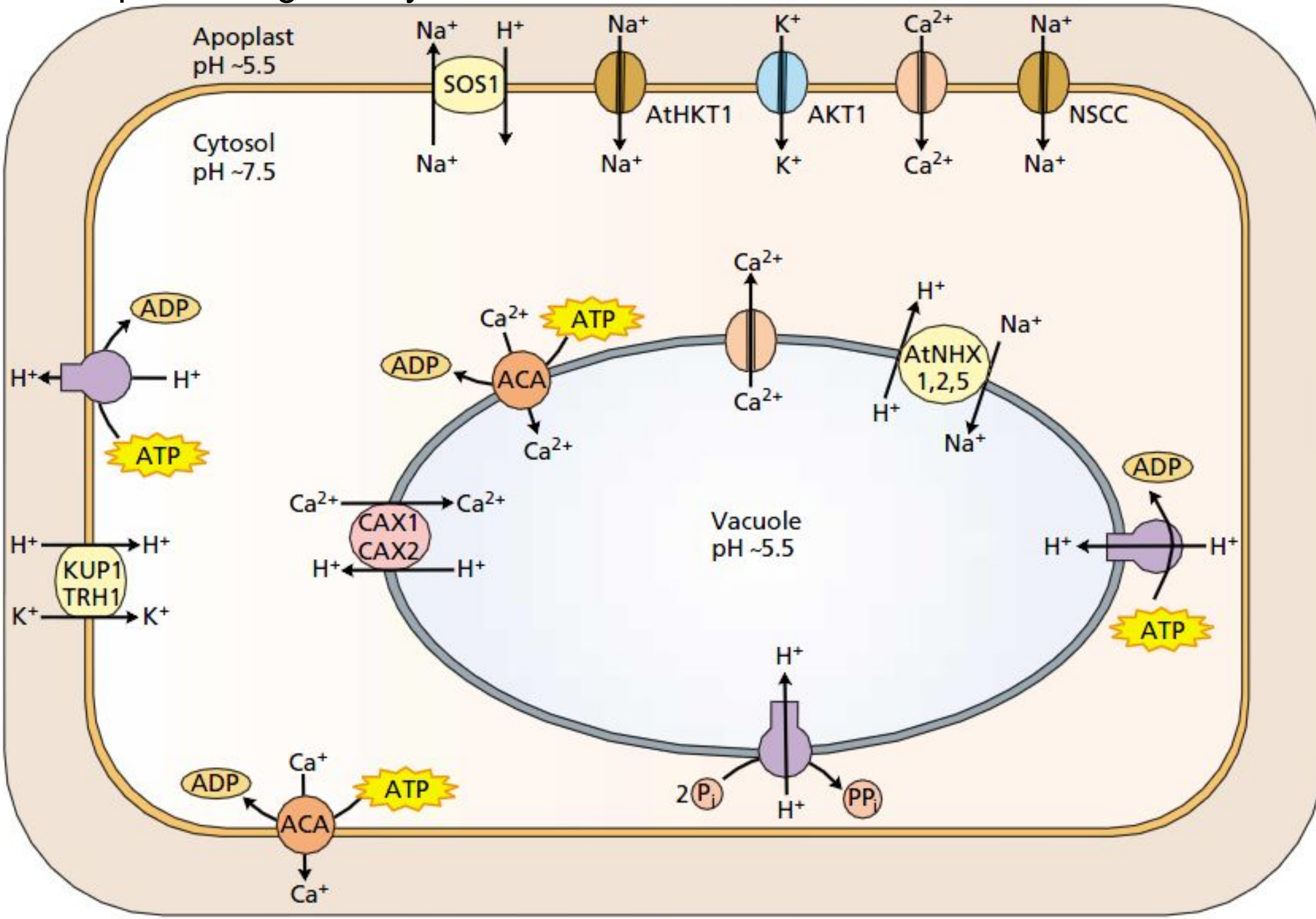




Properties of seawater and of good quality irrigation water

Property	Seawater	Irrigation water
Concentration of ions (m*M*)		
Na^+	457	<2.0
K^+	9.7	<1.0
Ca^{2+}	10	0.5–2.5
Mg^{2+}	56	0.25–1.0
Cl^-	536	<2.0
SO_4^{2-}	28	0.25–2.5
HCO_3^-	2.3	<1.5
Osmotic potential (MPa)	–2.4	–0.039
Total dissolved salts (mg L^{-1} or ppm)	32,000	500

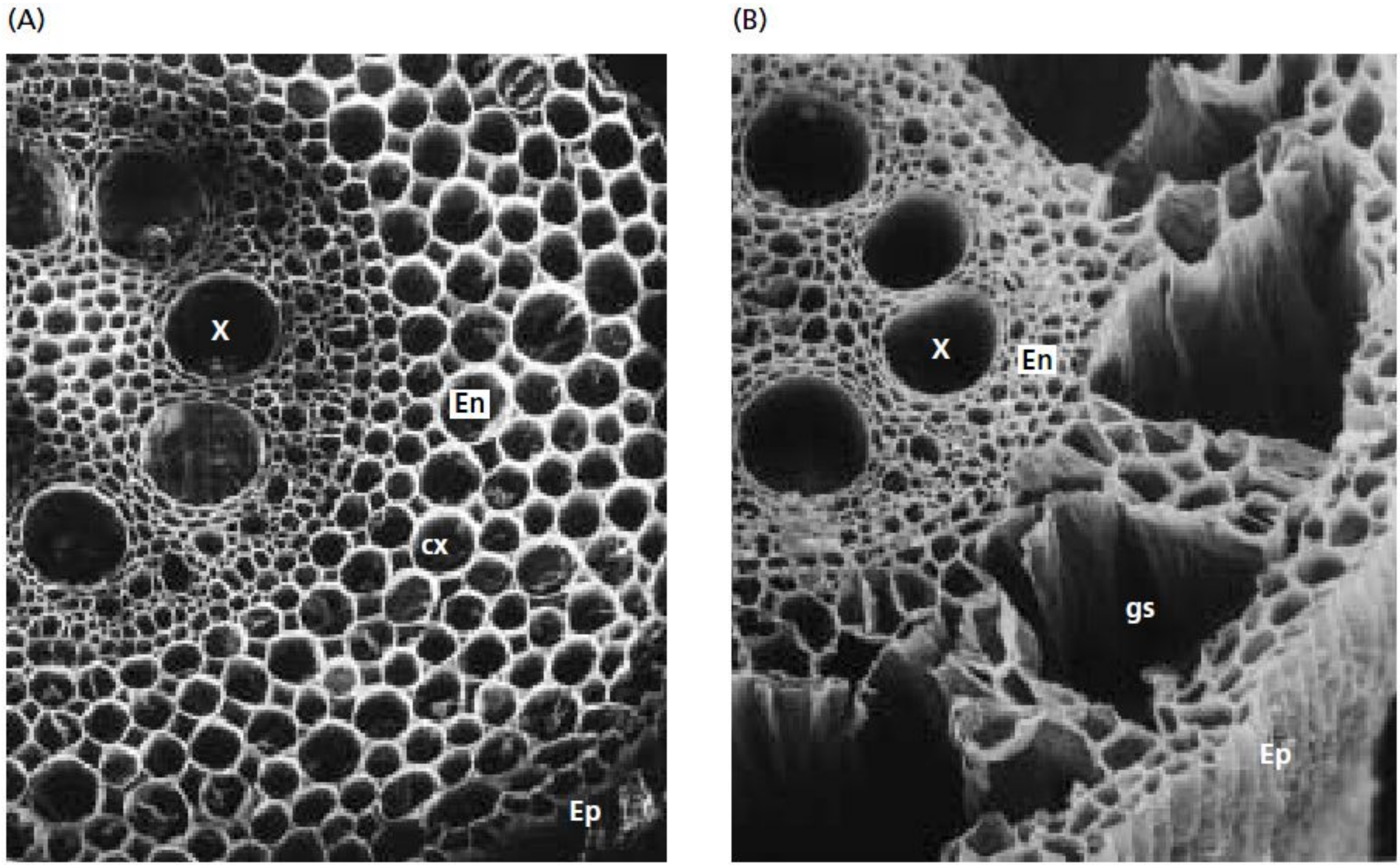
Membrane transport proteins mediating sodium, potassium, and calcium transport during salinity stress

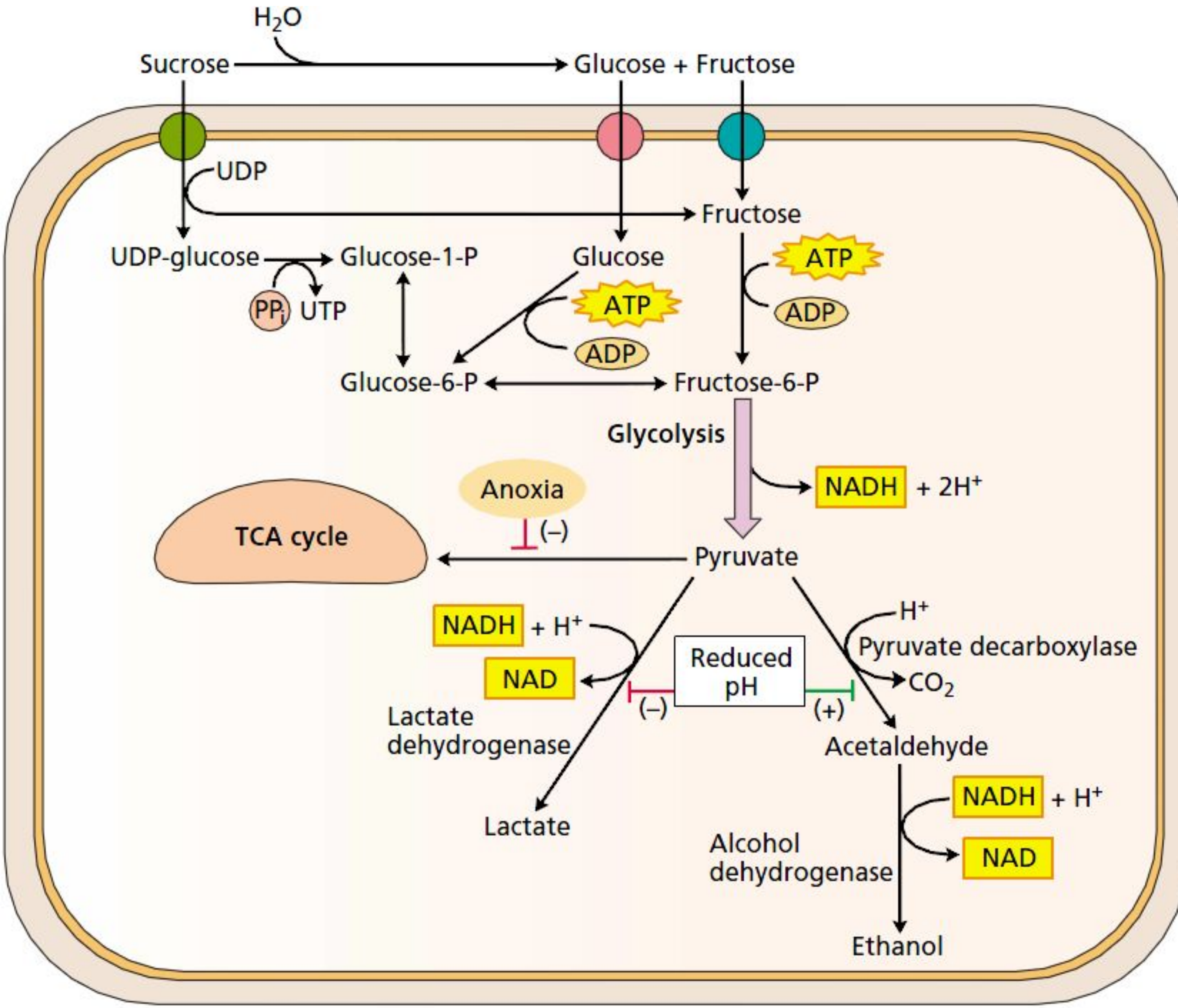


Roots of maize. Scanning electron micrographs (150×).

(A) Control root, supplied with air, with intact cortical cells. (B) Oxygen-deficient root.

Note the prominent gas-filled spaces (gs) in the cortex (cx), formed by degeneration of cells. The stele (all cells interior to the endodermis, En) and the epidermis (Ep) remain intact. X, xylem. (Courtesy of J. L. Basq and M. C. Drew.)

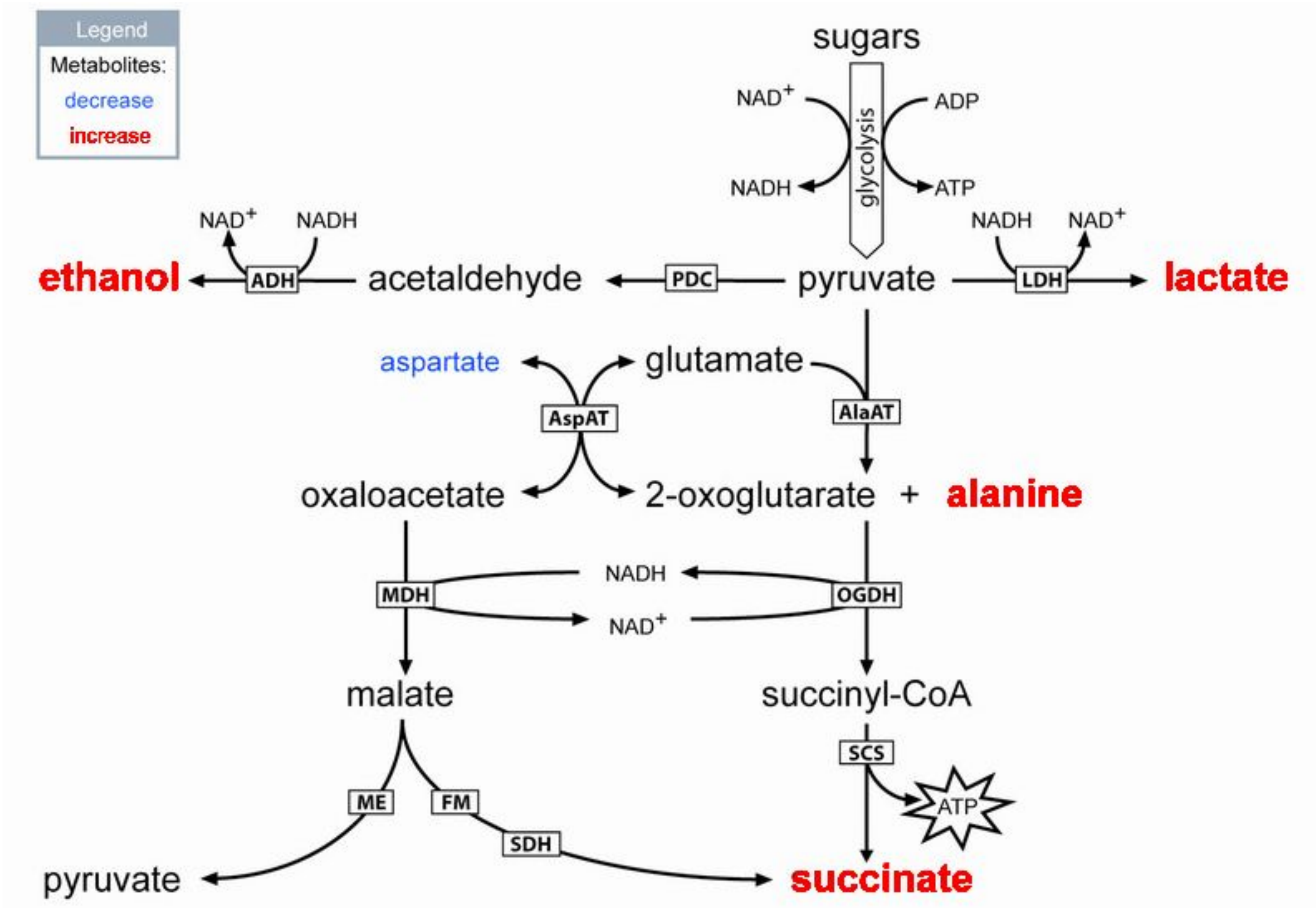




H2O
Sucrose
Glucose + Fructose
UDP
Fructose
UDP-glucose
Glucose-1-P
Glucose
ATP
PPi
UTP
ATP
ADP
ADP
Glucose-6-P
Fructose-6-P
Glycolysis
NADH + 2H+
Anoxia
(–)
TCA cycle
Pyruvate
NADH + H+
H+
Pyruvate decarboxylase
Reduced pH
NAD
CO2
(–)
(+)
Lactate dehydrogenase
Acetaldehyde
NADH + H+
Lactate
Alcohol dehydrogenase
NAD
Ethanol

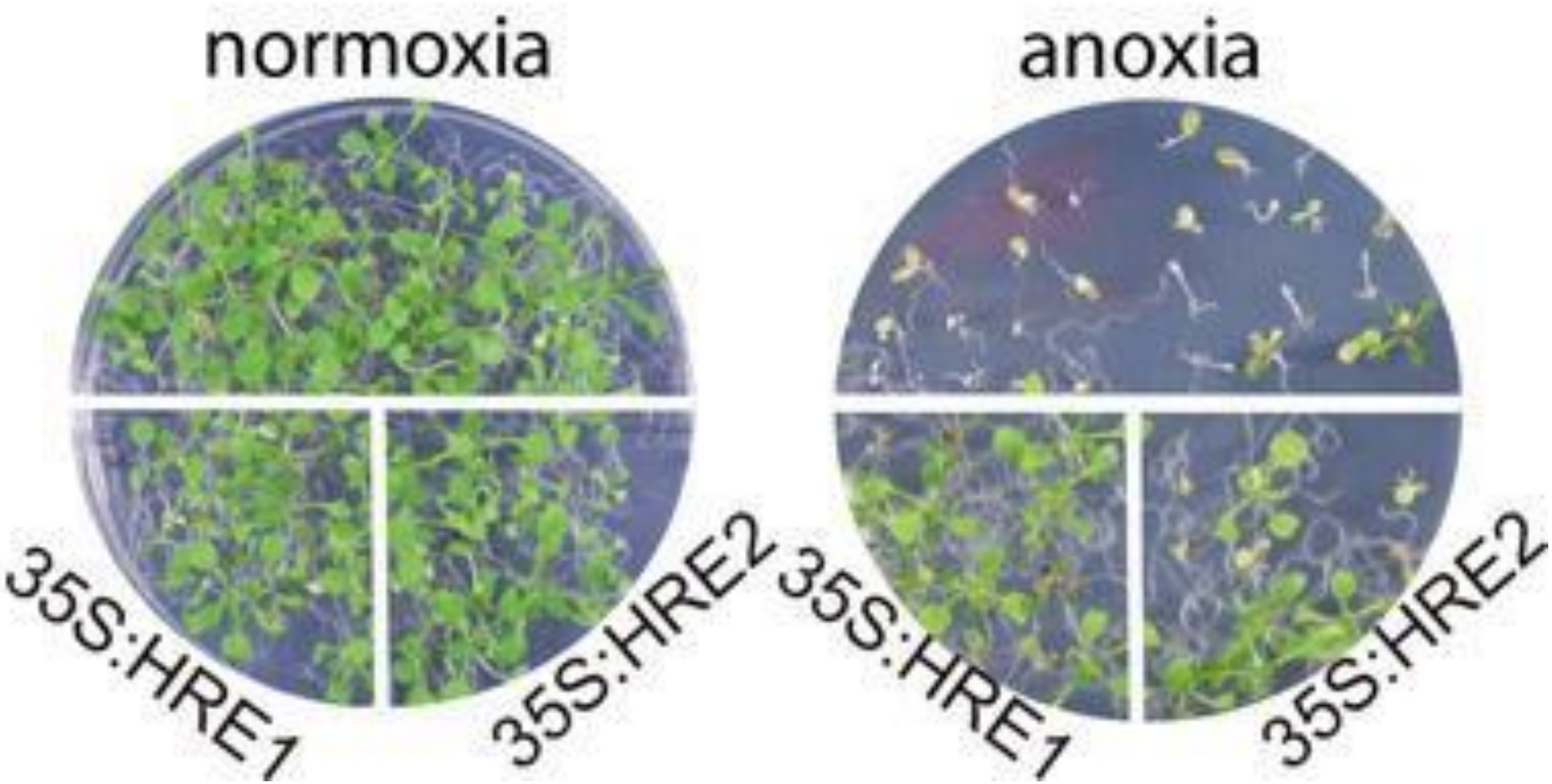
Metabolic pathways that are active during hypoxia in plants

Narsai et al. 2011

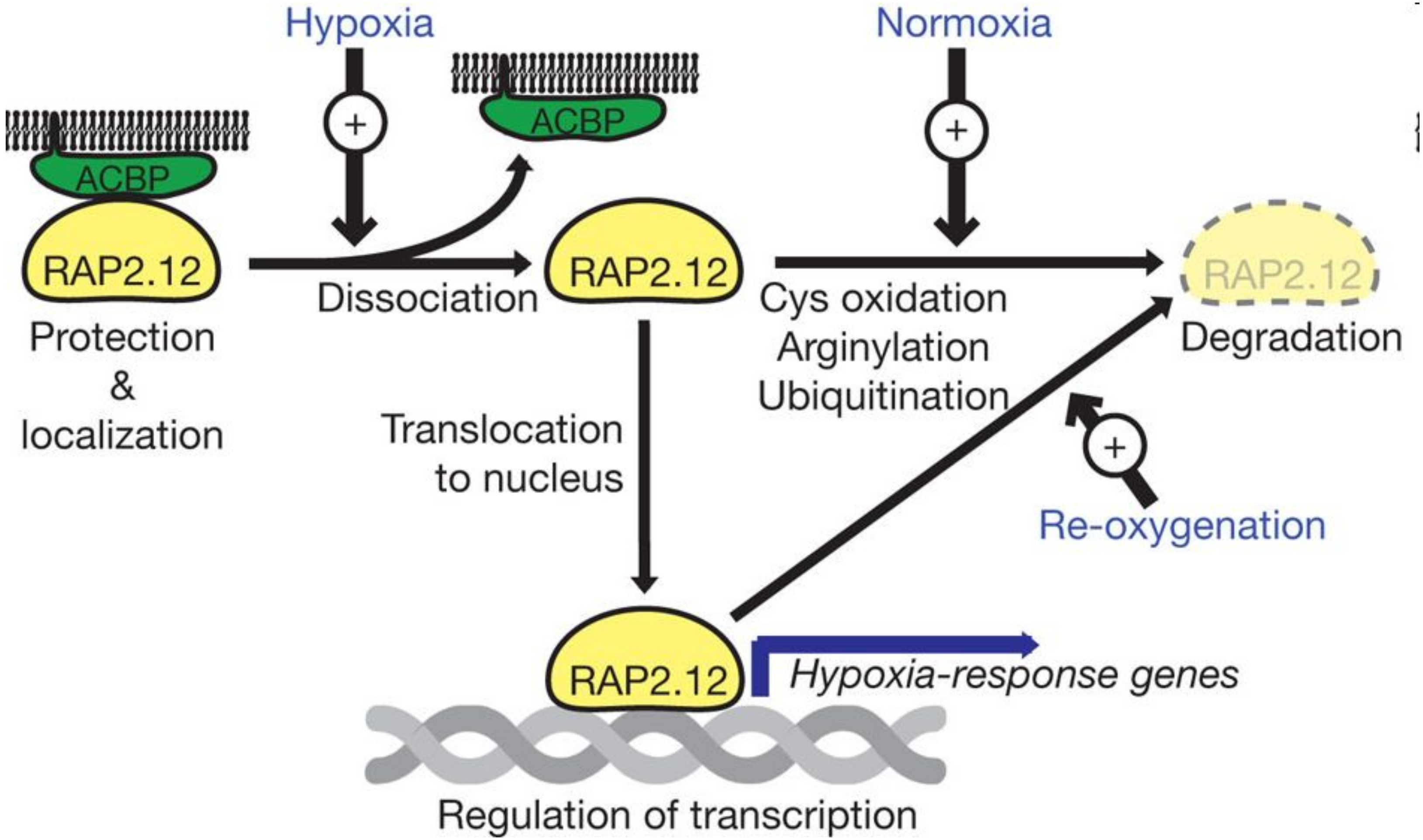


The transcription factors HRE1 and HRE2 were shown to play a crucial role in inducing adaptive responses of plants to hypoxia. Overexpression of these transcription factors improved the survival rate of plants that were exposed to anoxia for 10 hours.

Licausi, 2011

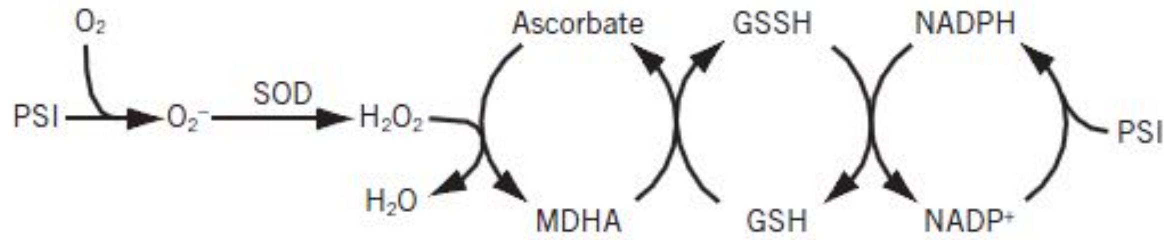


Oxygen sensing in plants is mediated by an N-end rule pathway for protein destabilization

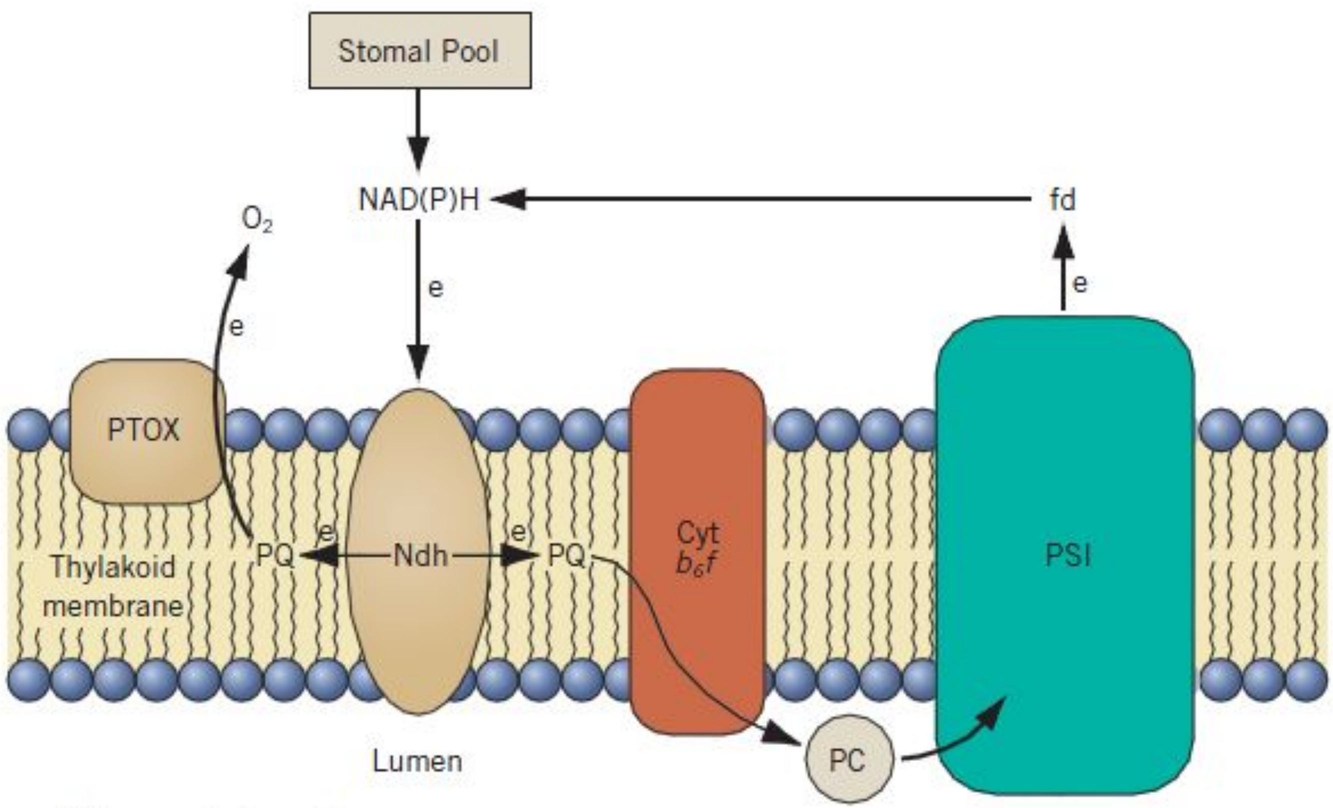


The transcription factor *RAP2.12* is constitutively expressed under aerobic conditions. RAP2.12 protein is always present, bound to ACBP to prevent RAP2.12 from moving into the nucleus under aerobic conditions and to protect it against proteasomal degradation in air. Upon hypoxia, RAP2.12 moves into the nucleus, where it activates anaerobic-gene expression. Upon re-oxygenation, RAP2.12 is rapidly degraded via the N-end rule pathway and proteasome-mediated proteolysis to downregulate the hypoxic response.

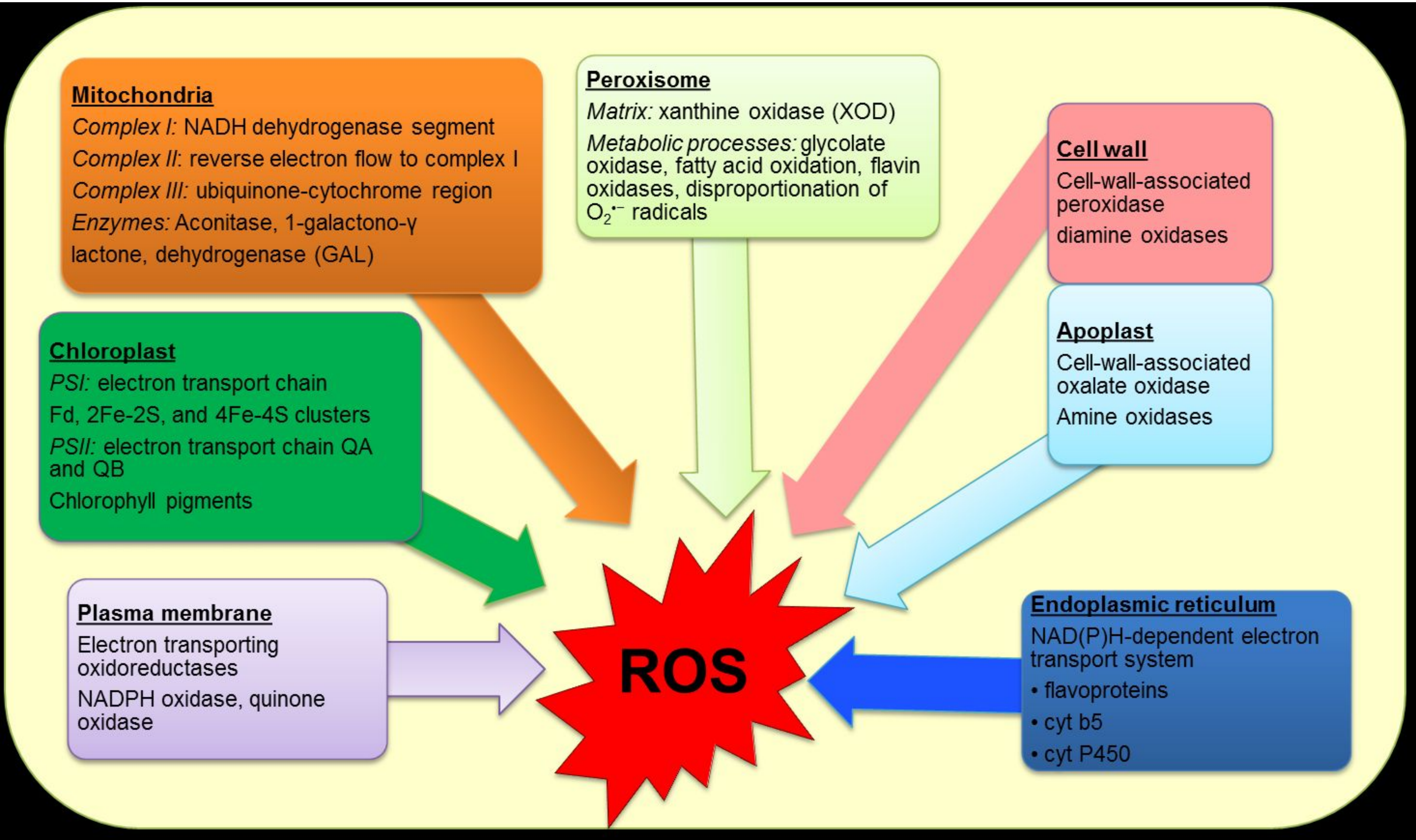
Oxygen as an alternative electron acceptor in chloroplasts.



A. Asada-Halliwell pathway



B. Chlororespiratory pathway



Mitochondria
Complex I: NADH dehydrogenase segment
Complex II: reverse electron flow to complex I
Complex III: ubiquinone-cytochrome region
Enzymes: Aconitase, 1-galactono-γ lactone, dehydrogenase (GAL)
Peroxisome
Matrix: xanthine oxidase (XOD)
Metabolic processes: glycolate oxidase, fatty acid oxidation, flavin oxidases, disproportionation of $O_2^{\bullet -}$ radicals
Cell wall
Cell-wall-associated peroxidase
diamine oxidases
Chloroplast
PSI: electron transport chain
Fd, 2Fe-2S, and 4Fe-4S clusters
PSII: electron transport chain QA and QB
Chlorophyll pigments
Apoplast
Cell-wall-associated oxalate oxidase
Amine oxidases
Plasma membrane
Electron transporting oxidoreductases
NADPH oxidase, quinone oxidase
ROS
Endoplasmic reticulum
NAD(P)H-dependent electron transport system
• flavoproteins
• cyt b5
• cyt P450

Outline of Known Major Osmotic Stress Responsive Signal Transduction Pathways in Plants