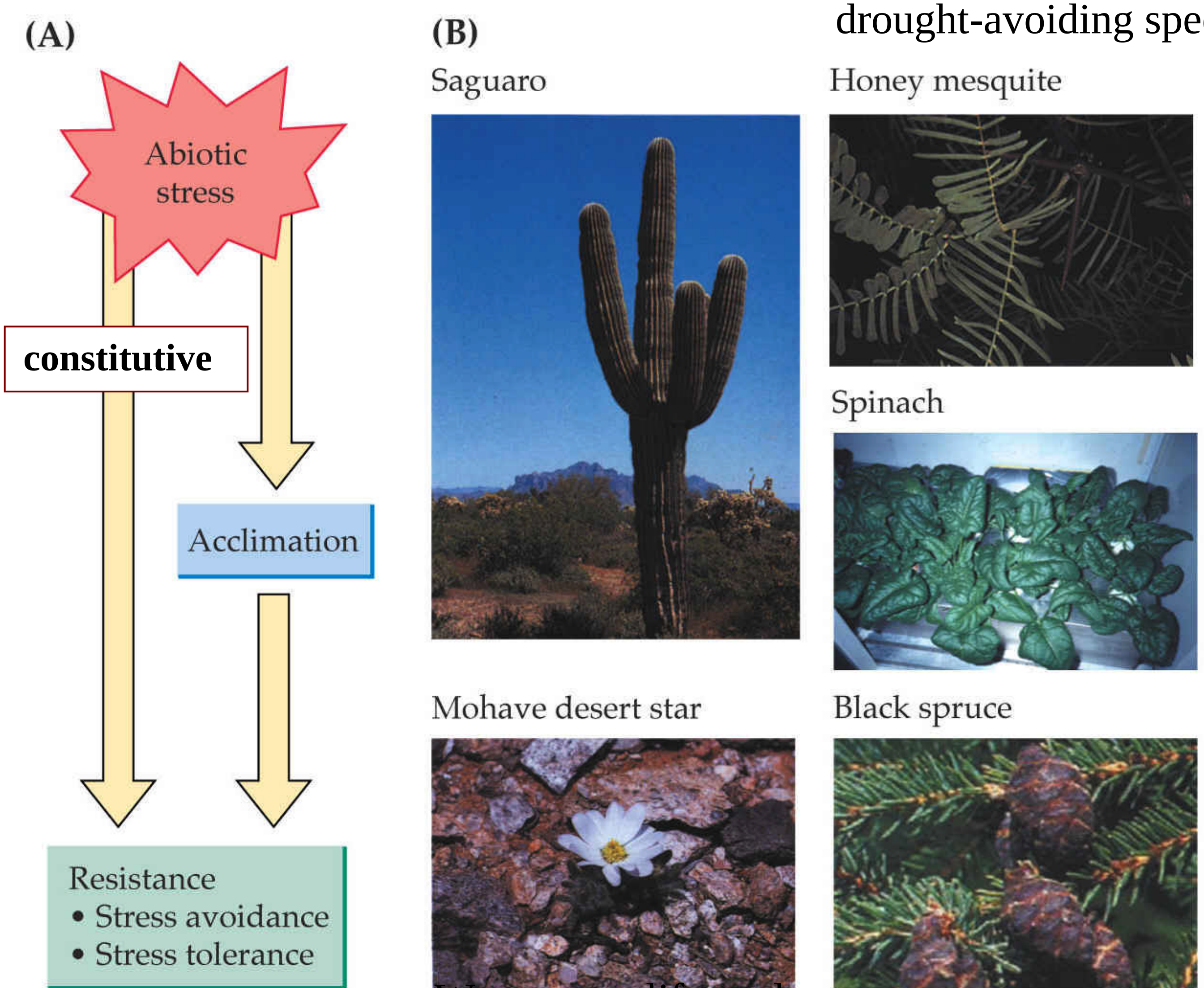
Fig. 22.2

Succulent stem

Deep root
drought-avoiding species



<u>Acclimation:</u>
Osmotic
Adjustment

Freezing
tolerance

Wet-season life cycle

Read 1158-1177

Many environmental conditions can lead to water deficit

-drought
-saline habitat
-low temperature (cold)
  because water leaves cell and forms ice crystals in intercellular spaces
-transpirational water loss

$$U_w = U_s + U_p$$

U_w water potential

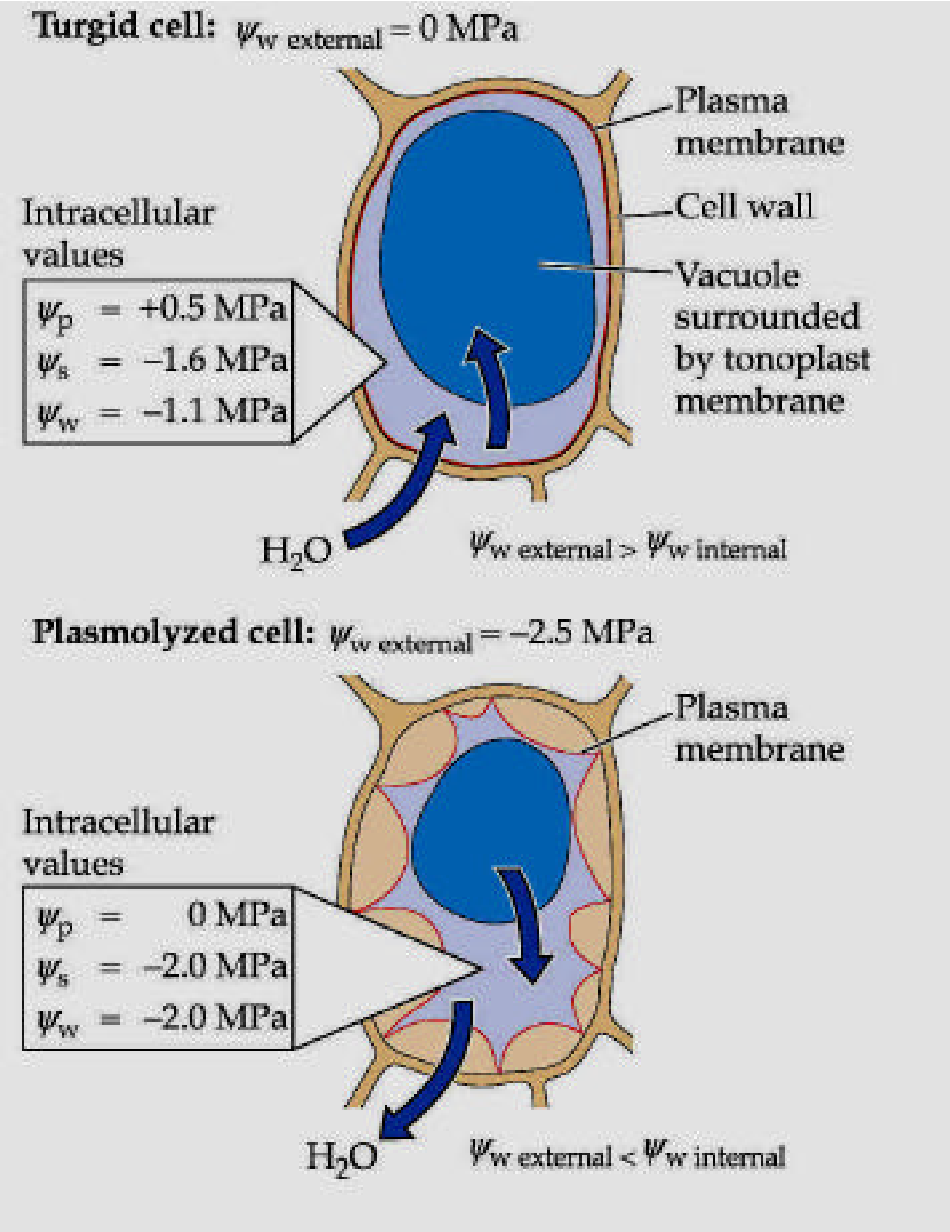
U_s solute potential, higher salt conc., lower the U_s

U_p pressure potential,

physical force exerted on water to its environment

Water moves from high U_w to low U_w

Fig. 22.4



lethal

Osmotic adjustment

Increase in number of solute particles in a cell

Critical role in helping plants to acclimate to drought ot saline conditions

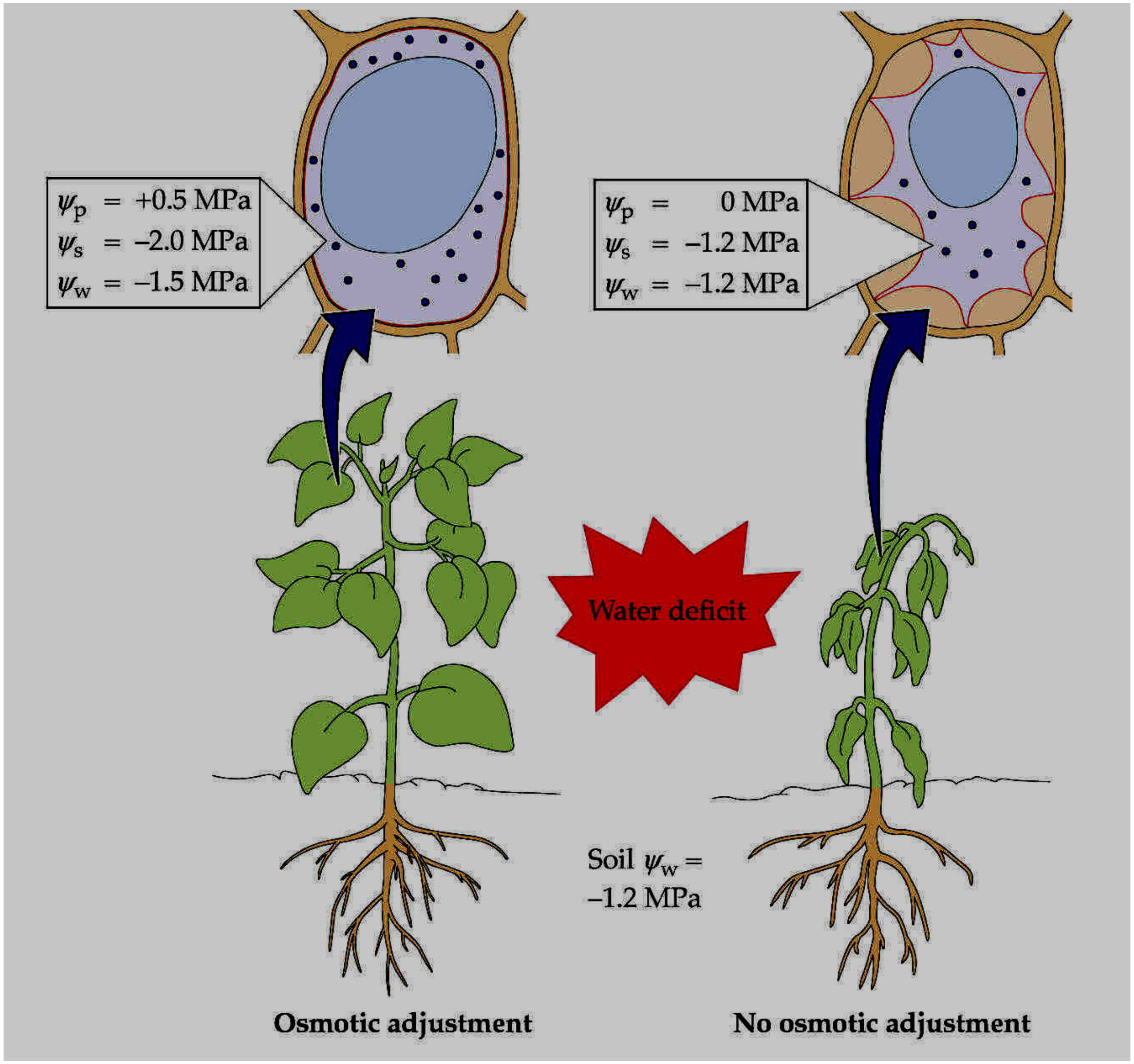


Fig. 22.6 Compatible osmolytes

Organic compound, that is highly soluble and non-toxic

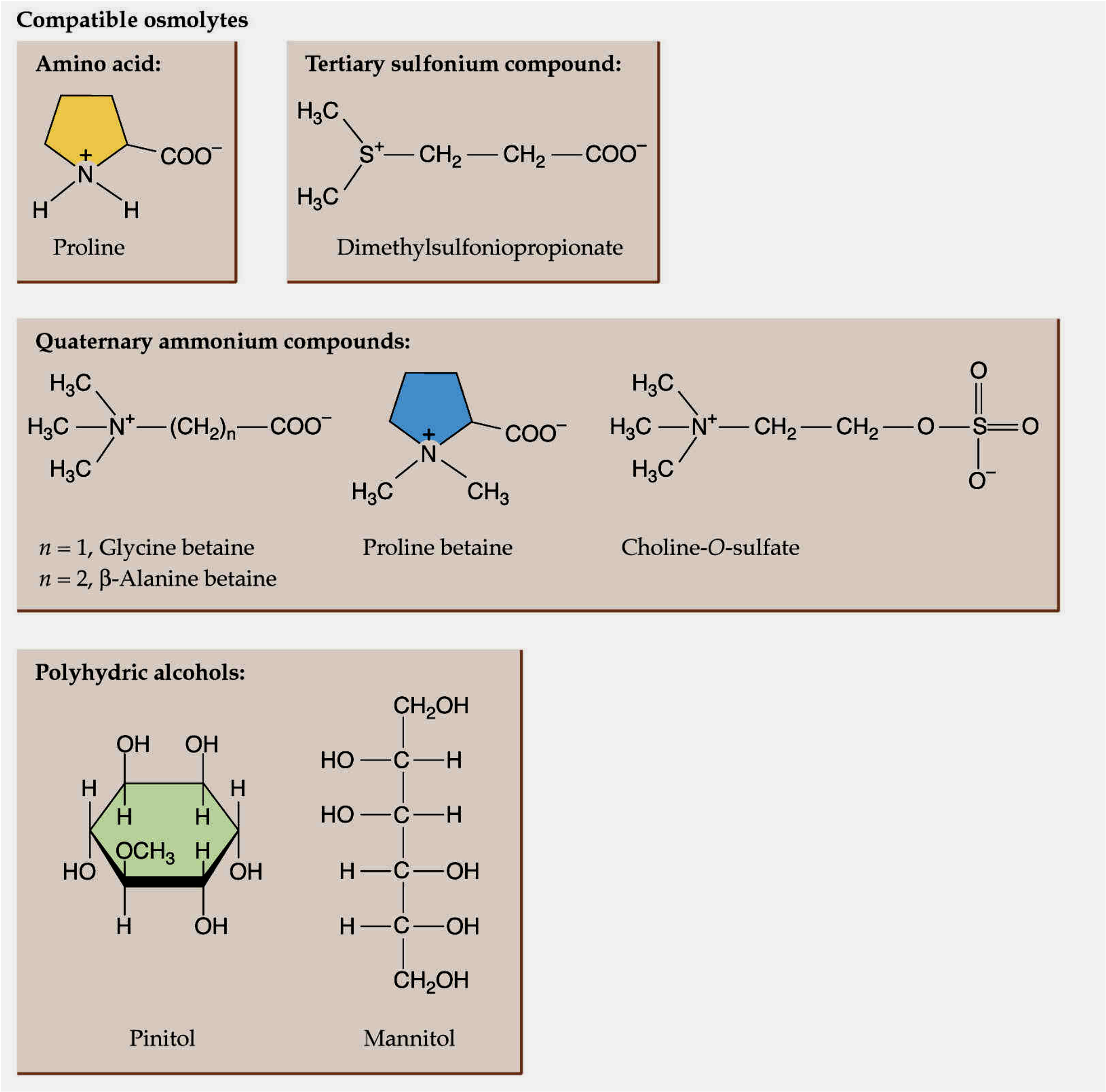
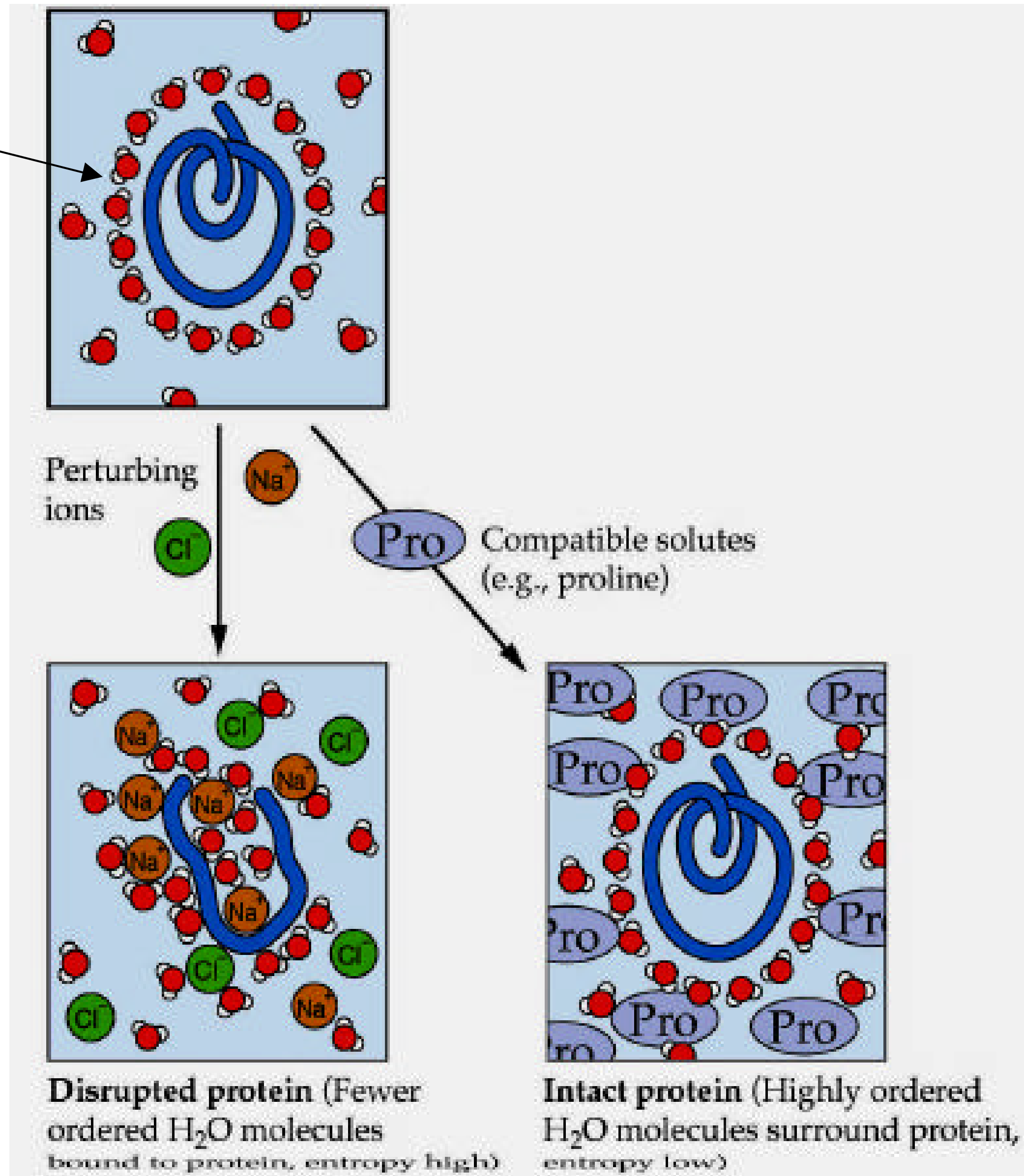


Fig. 22.7

hydration shell



Distribution vary in order to support osmotic equilibrium among membrane bound organelles

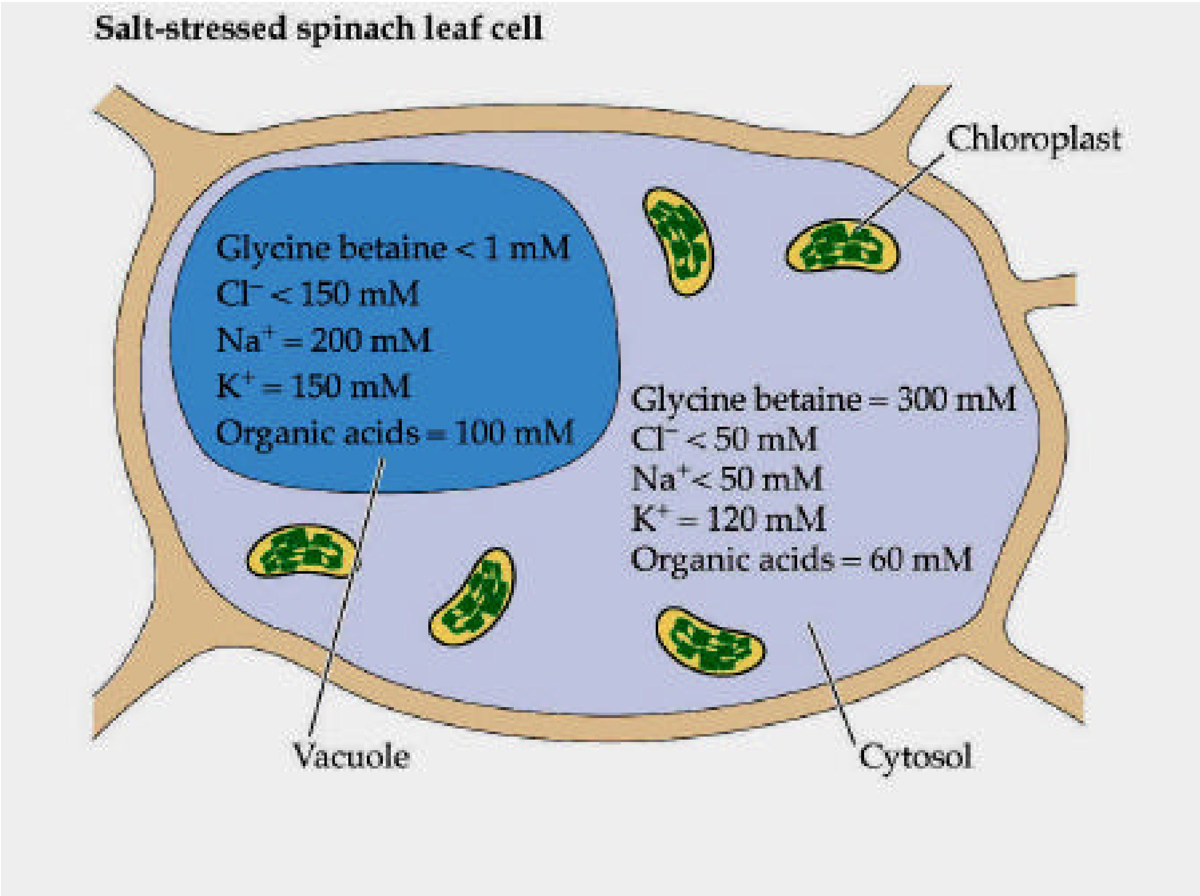


Fig. 22.8 spinach, high cytosolic glycine betaine allows the cytosol to achieve osmotic balance with vacuole which contains toxic ion and solutes

Genetic engineering of drought-tolerant plants

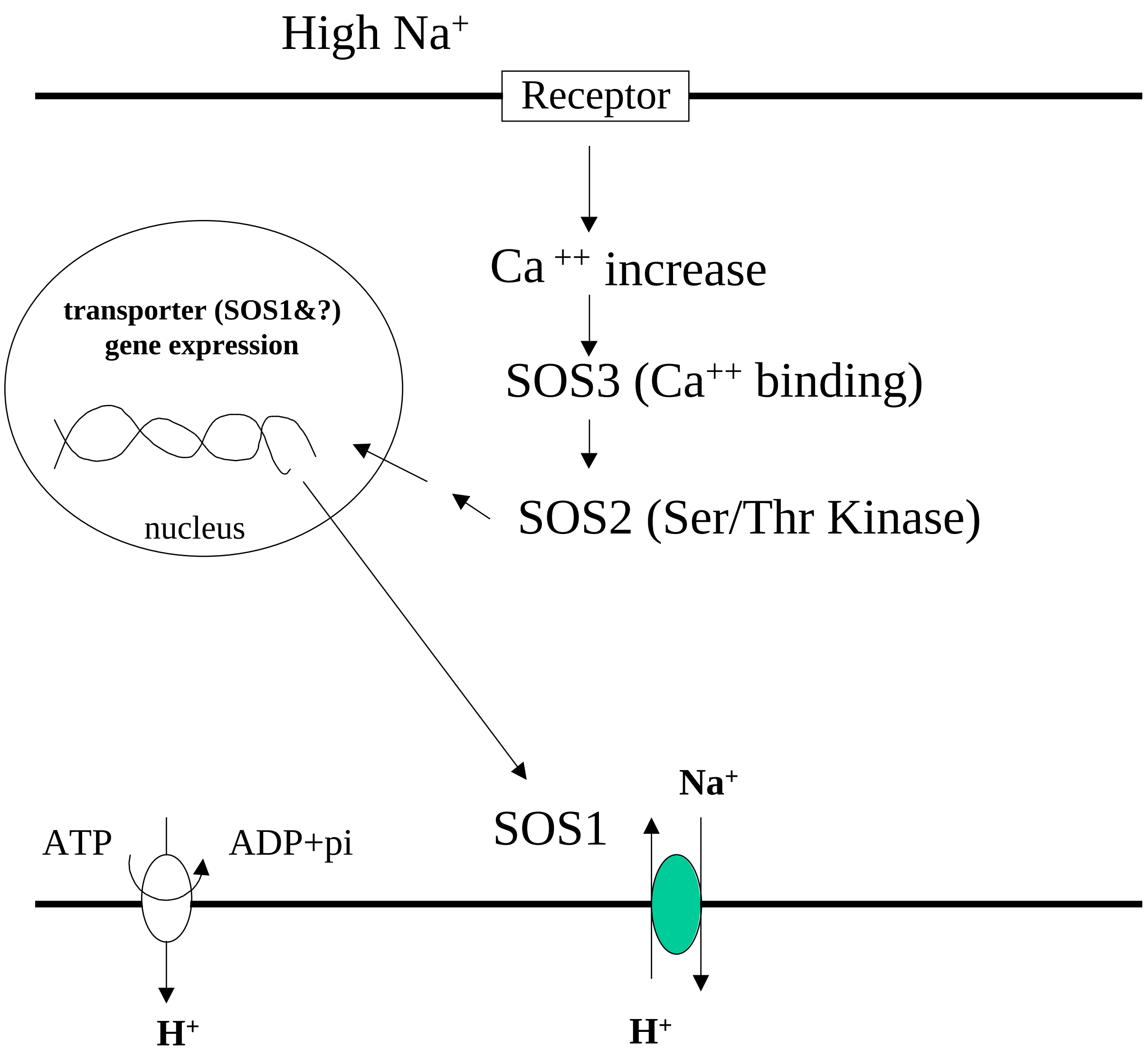
-Introducing biosynthetic enzyme for osmolytes

i.e. tobacco and Arabidopsis expressing mannitol-1-phosphate are more salt-tolerant

-Over-expression of Na^+/H^+ antiporter

Arabidopsis with such transgene can grow at 200mM NaCl (50% of sea salt conc.)

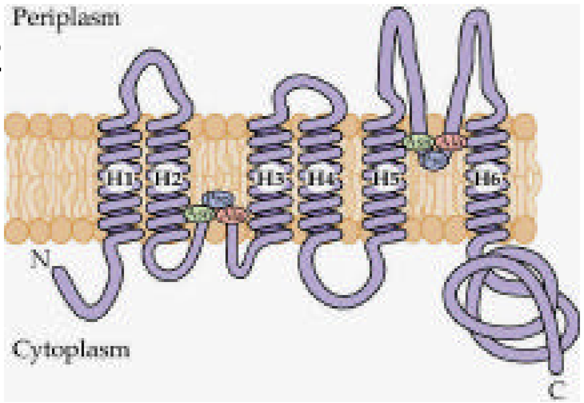
- Change of aquaporin gene expression


High Na+
Receptor
Ca ++ increase
SOS3 (Ca++ binding)
SOS2 (Ser/Thr Kinase)
transporter (SOS1&?)
gene expression
nucleus
SOS1
Na+
ATP
ADP+pi
H+
H+

Aquaporin: water channels

Members of MIP (major intrinsic protein) family located in plasma membrane

Fig. 3.52



Loss of tugor

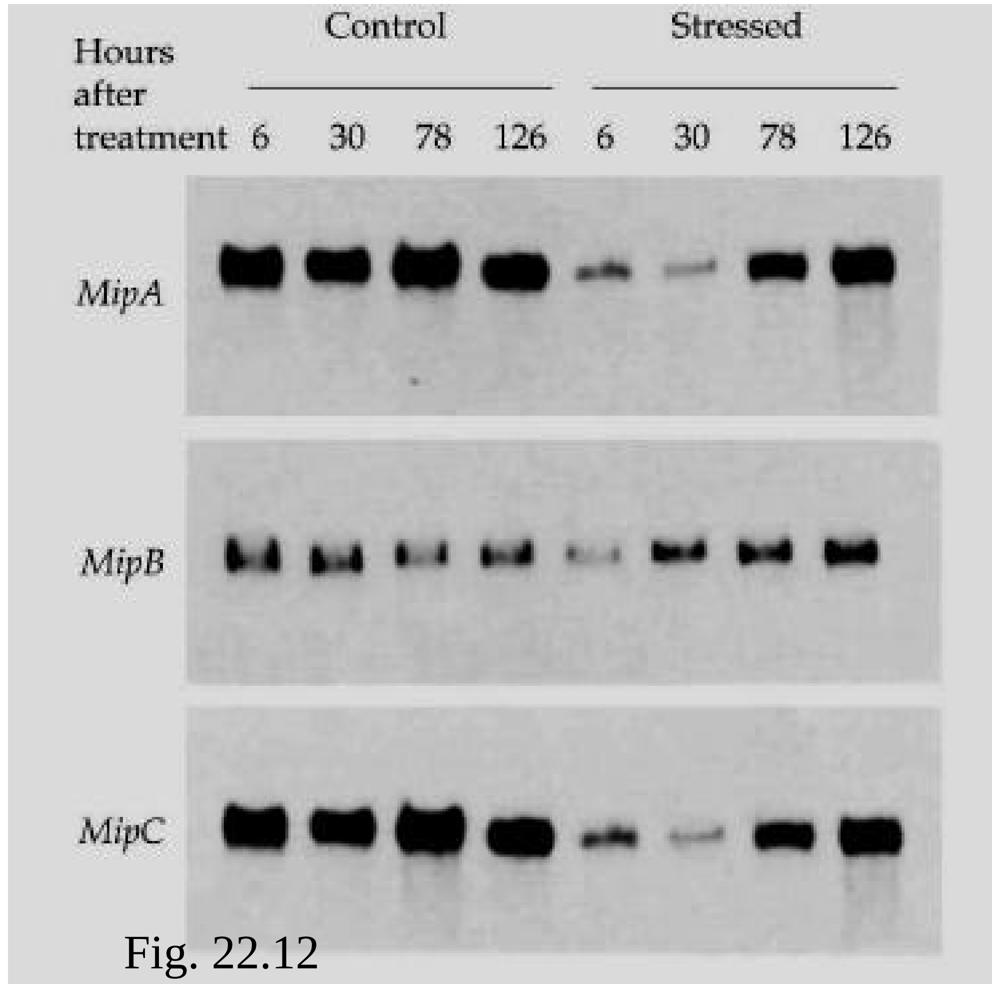
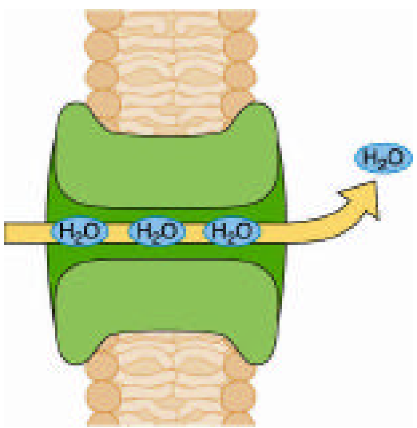


Fig. 22.12

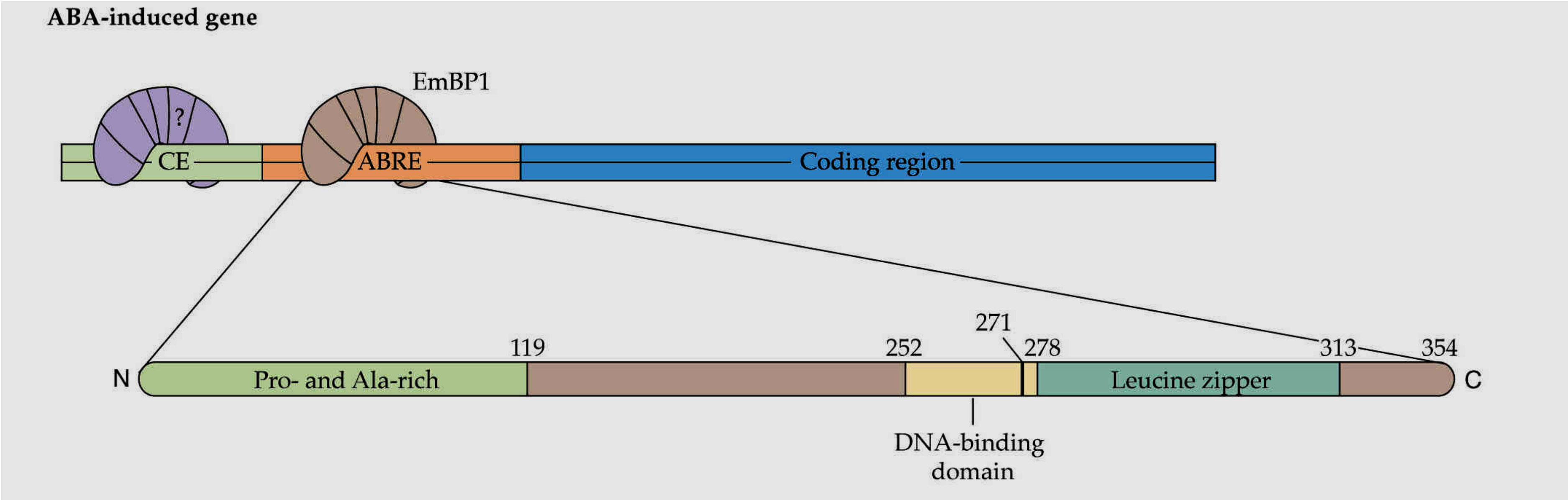
Fig. 3. 50



Regulation of MIP expression can regulate permeability of plant cells to water

ABA plays a role in responses to water stress

by regulating stomatal closure and induction of gene expression
but not all water-deficit-responsive genes are induced by ABA



Freezing stress

Chemical potential of ice is less than liquid water
Vapor pressure of extracellular ice is less than that of water in cytoplasm
As ice is initiated in intercellular spaces, water moves out of cytoplasm toward extracellular space

Freezing tolerant plants:

1. promote extracellular ice formation, preventing ice crystal in cytoplasm
2. Accumulate antifreezing proteins in apoplast, slowing ice formation

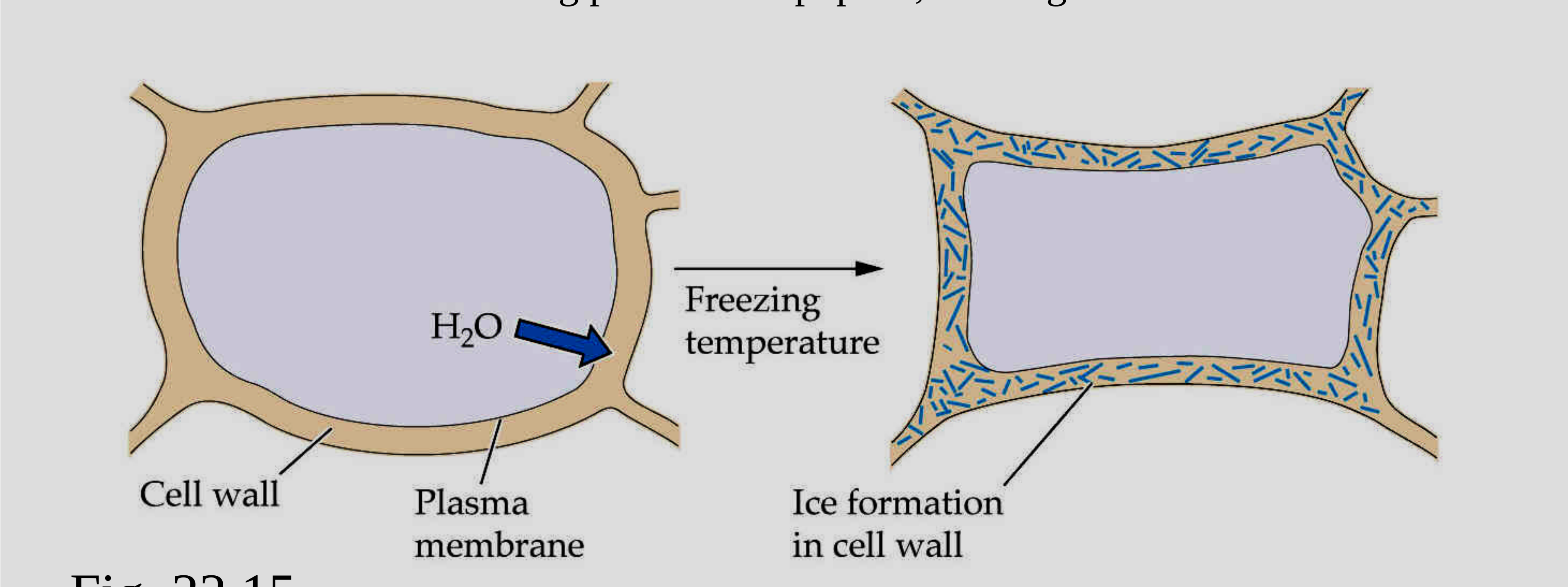


Fig. 22.15

Cold acclimation

1. membrane stablization:
   change in membrane lipid composition,
   fatty acid desaturation in membrane phospholipids
   change in abundance of membrane sterols and cerebroside

2. osmolytes and antifreeze proteins accumulate
   antifreeze proteins form oligomeric complexes, whose large surfaces
   interact with ice and inhibit its growth ans recrystalization

3. changes in gene expression
   still poorly understood

Oxidative stress

Read 1189-1197

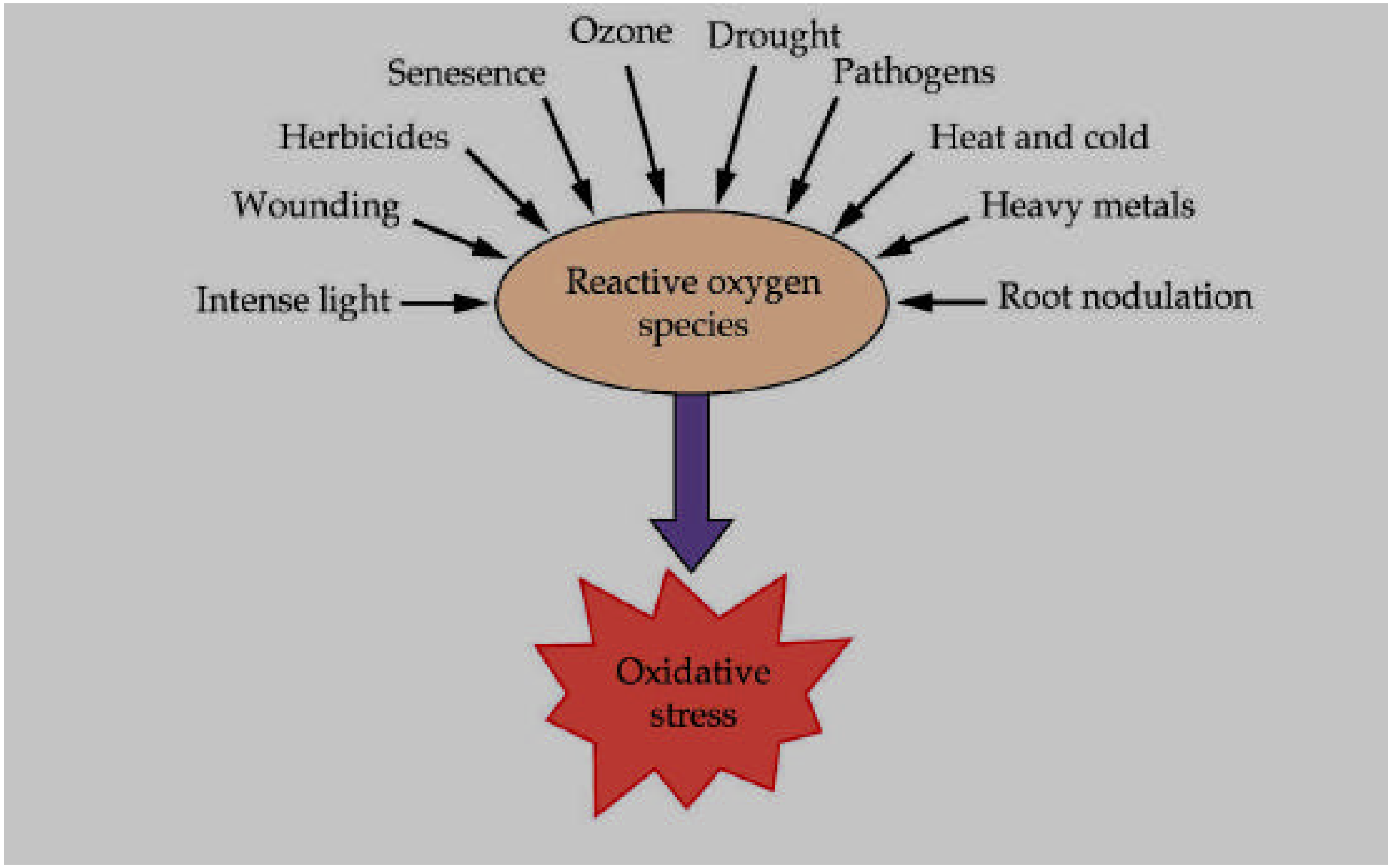


Fig. 22.35

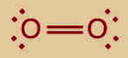
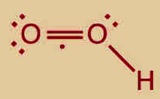
Compound	Shorthand notation(s)	Structural representation(s)	Sources
Molecular oxygen (triplet ground state)	O_2 ; $^3\Sigma$	 $1s^22s^2(\sigma_s)^2(\sigma_s^*)^2(\sigma_x)^2(\pi_y)^2(\pi_z)^2(\pi_y^*)^1(\pi_z^*)^1$	Most common form of dioxygen gas
Singlet oxygen (first excited singlet state)	$^1O_2$; $^1\Delta$	 $1s^22s^2(\sigma_s)^2(\sigma_s^*)^2(\sigma_x)^2(\pi_y)^2(\pi_z)^2(\pi_y^*)^2$	UV irradiation, photoinhibition, photosystem II e^- transfer reactions (chloroplasts)
Superoxide anion	$O_2^{\bullet-}$		Mitochondrial e^- transfer reactions, Mehler reaction in chloroplasts (reduction of O_2 by iron–sulfur center F_X of Photosystem I), glyoxysomal photorespiration, peroxisome activity, plasma membrane, oxidation of paraquat, nitrogen fixation, defense against pathogens, reaction of O_3 and OH^- in apoplastic space
Hydrogen peroxide	H_2O_2		Photorespiration, β-oxidation, proton-induced decomposition of $O_2^{\bullet-}$, defense against pathogens
Hydroxyl radical	$OH^\bullet$		Decomposition of O_3 in presence of protons in apoplastic space, defense against pathogens
Perhydroxyl radical	$O_2H^\bullet$		Reaction of O_3 and OH^- in apoplastic space
Ozone	O_3		Electrical discharge or UV radiation in stratosphere, reactions involving combustion products of fossil fuels and UV radiation in troposphere

Fig. 22.38

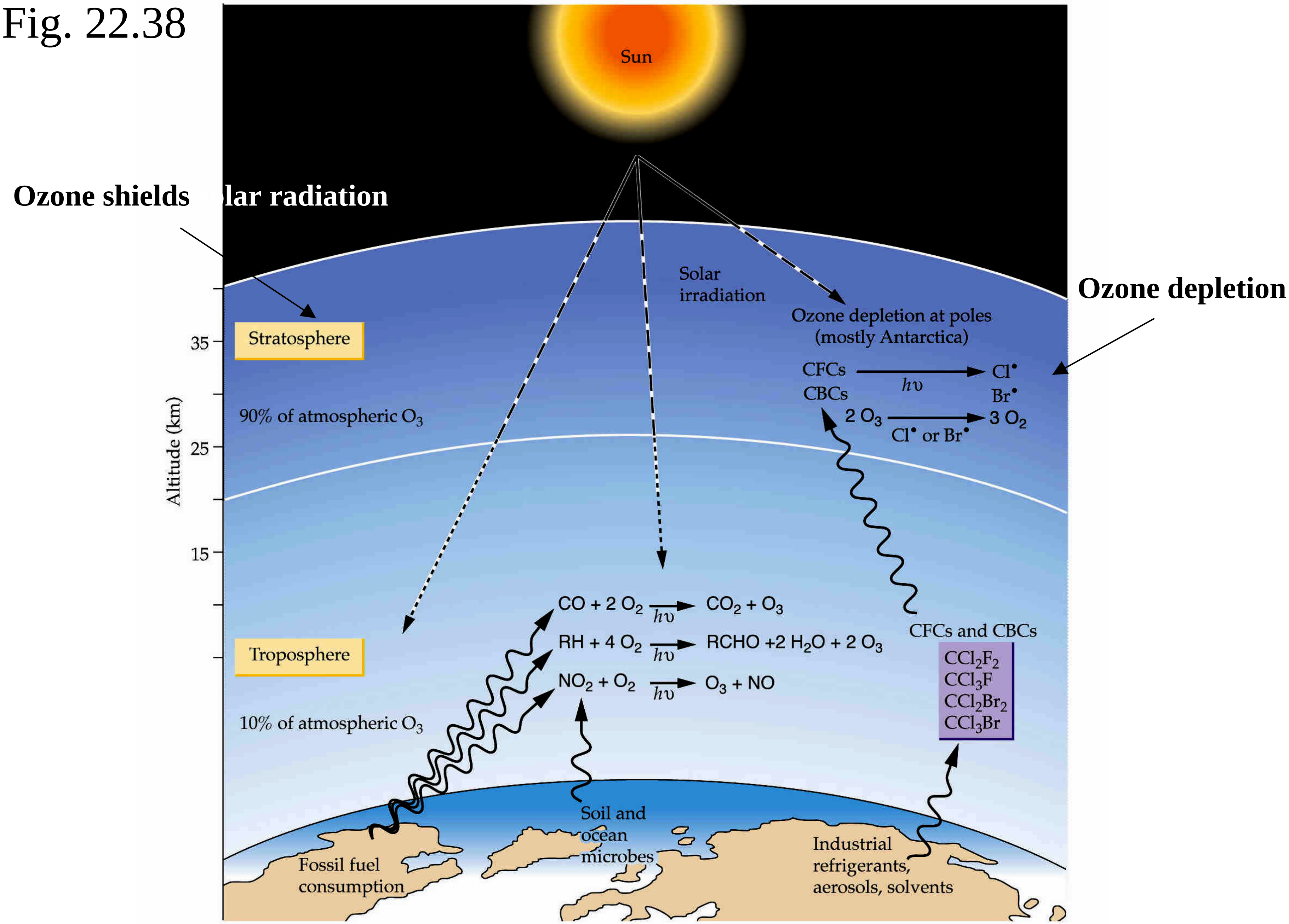
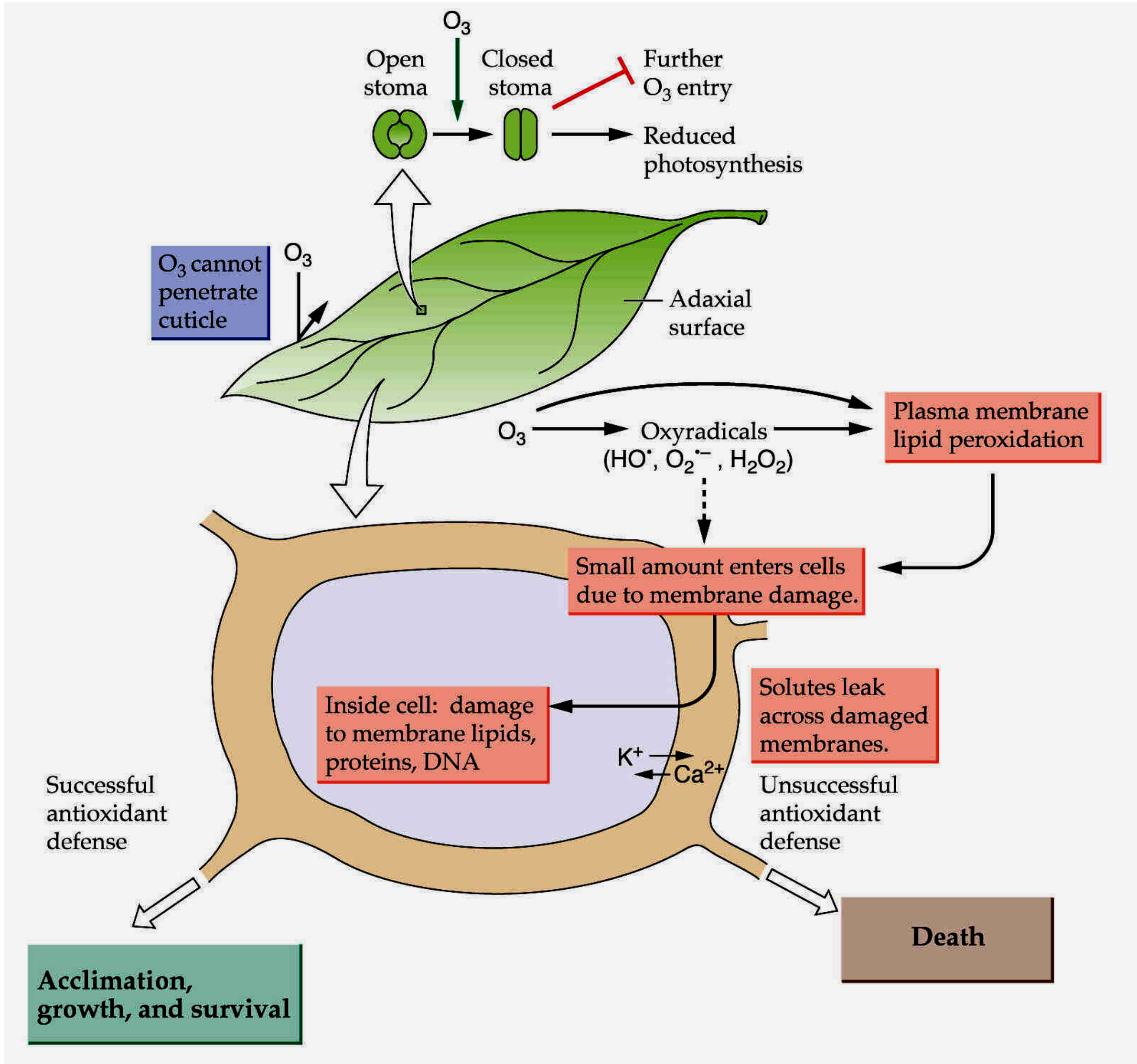

Ozone shields lar radiation
Ozone depletion
Sun
Solar
irradiation
Ozone depletion at poles
(mostly Antarctica)
CFCs
CBCs
$h\upsilon$
$Cl^{\bullet}$
$Br^{\bullet}$
$2\ O_3 \rightarrow 3\ O_2$
$Cl^{\bullet}$ or $Br^{\bullet}$
Stratosphere
35
25
15
Altitude (km)
90% of atmospheric O_3
Troposphere
10% of atmospheric O_3
$CO + 2\ O_2 \xrightarrow{h\upsilon} CO_2 + O_3$
$RH + 4\ O_2 \xrightarrow{h\upsilon} RCHO + 2\ H_2O + 2\ O_3$
$NO_2 + O_2 \xrightarrow{h\upsilon} O_3 + NO$
CFCs and CBCs
CCl_2F_2
CCl_3F
CCl_2Br_2
CCl_3Br
Fossil fuel
consumption
Soil and
ocean
microbes
Industrial
refrigerants,
aerosols, solvents

Fig. 22.40

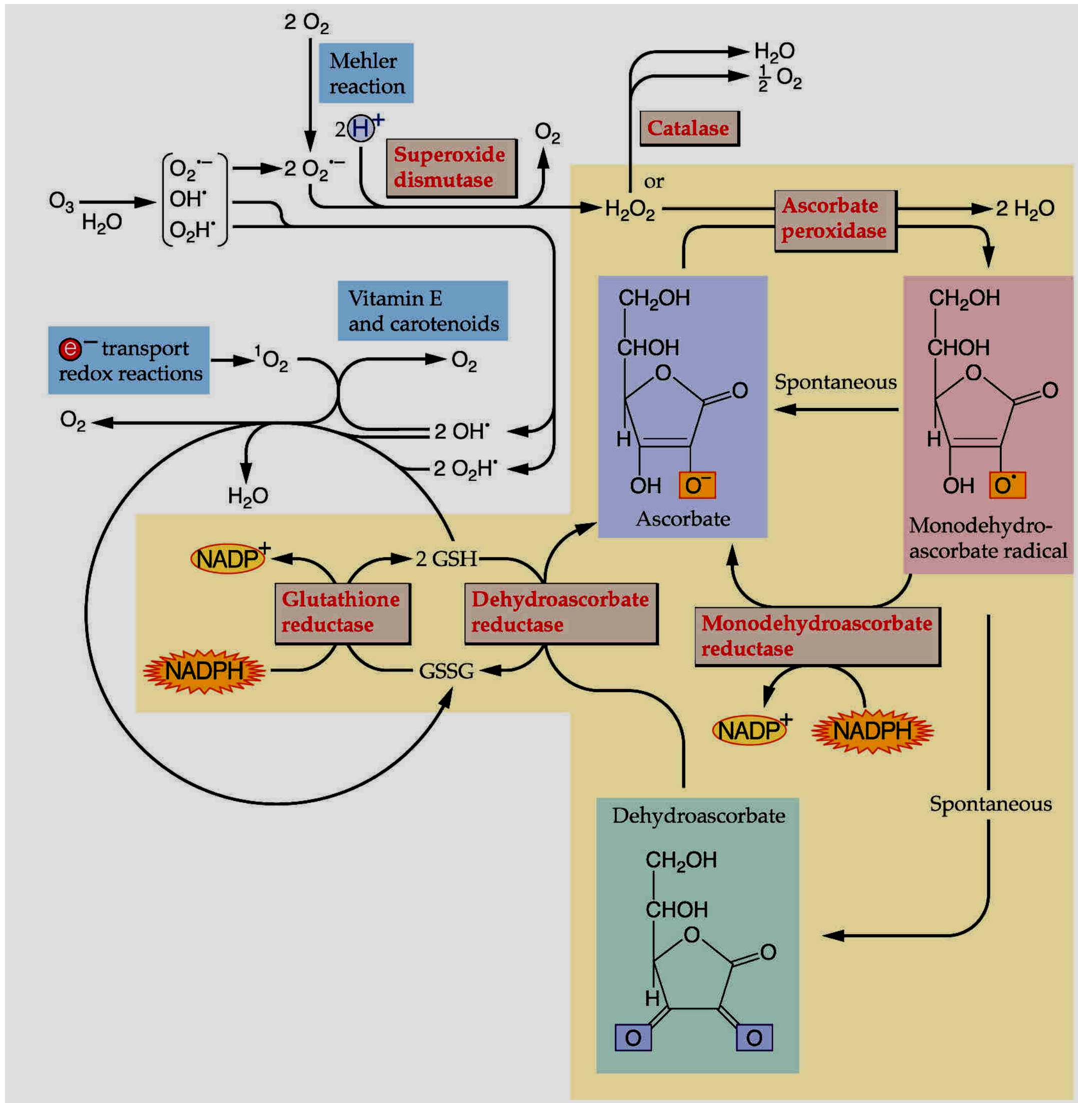

O_3
Open stoma
Closed stoma
Further O_3 entry
Reduced photosynthesis
O_3 cannot penetrate cuticle
O_3
Adaxial surface
O_3
Oxyradicals ($HO^{\cdot}$, $O_2^{\cdot-}$, H_2O_2)
Plasma membrane lipid peroxidation
Small amount enters cells due to membrane damage.
Inside cell: damage to membrane lipids, proteins, DNA
K^+
Ca^{2+}
Solutes leak across damaged membranes.
Successful antioxidant defense
Unsuccessful antioxidant defense
Acclimation, growth, and survival
Death

Antioxidants	Subcellular location
Ascorbate (Vit. C)	Apoplast, cytosol, plastids, vacuole
β-carotene	plastids
Glutathione reduced (GSH)	cytosol, mitochondrion, plastid
Polyamine	cytosol, mitochondrion, plastid, nucleus
α−Tocopherol (Vit. E)	cell membrane, plastid membrane
Zeaxanthin	chloroplast

Antioxidant enzyme:	
Ascorbate peroxidase	cytosol, plastid stoma, plastid membrane root nodule
Catalase	cytosol, glyoxysome, peroxisome
Dehydroascorbatereductase	cytosol, plastid stoma, root nodule
Glutathione reductase	cytosol, mitochondrion, plastid stoma, root nodule
Monodehydroascorbate reductase	plastid stoma, root nodule
Superoxide dismutase	cytosol, plastid, peroxisome, root nodule

Table 22.6 and 22.7

Fig. 22.37



2 O2
Mehler reaction
2 H+
Superoxide dismutase
O2
Catalase
H2O
1/2 O2
or
O3
H2O
O2•−
OH•
O2H•
2 O2•−
H2O2
Ascorbate peroxidase
2 H2O
Vitamin E and carotenoids
e− transport redox reactions
1O2
O2
2 OH•
2 O2H•
H2O
CH2OH
CHOH
O
H
OH
O−
Ascorbate
Spontaneous
O•
Monodehydro-ascorbate radical
NADP+
2 GSH
Glutathione reductase
Dehydroascorbate reductase
Monodehydroascorbate reductase
NADPH
GSSG
Spontaneous
Dehydroascorbate