FACULTY
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Masaryk University

Carbohydrate and lipid metabolism

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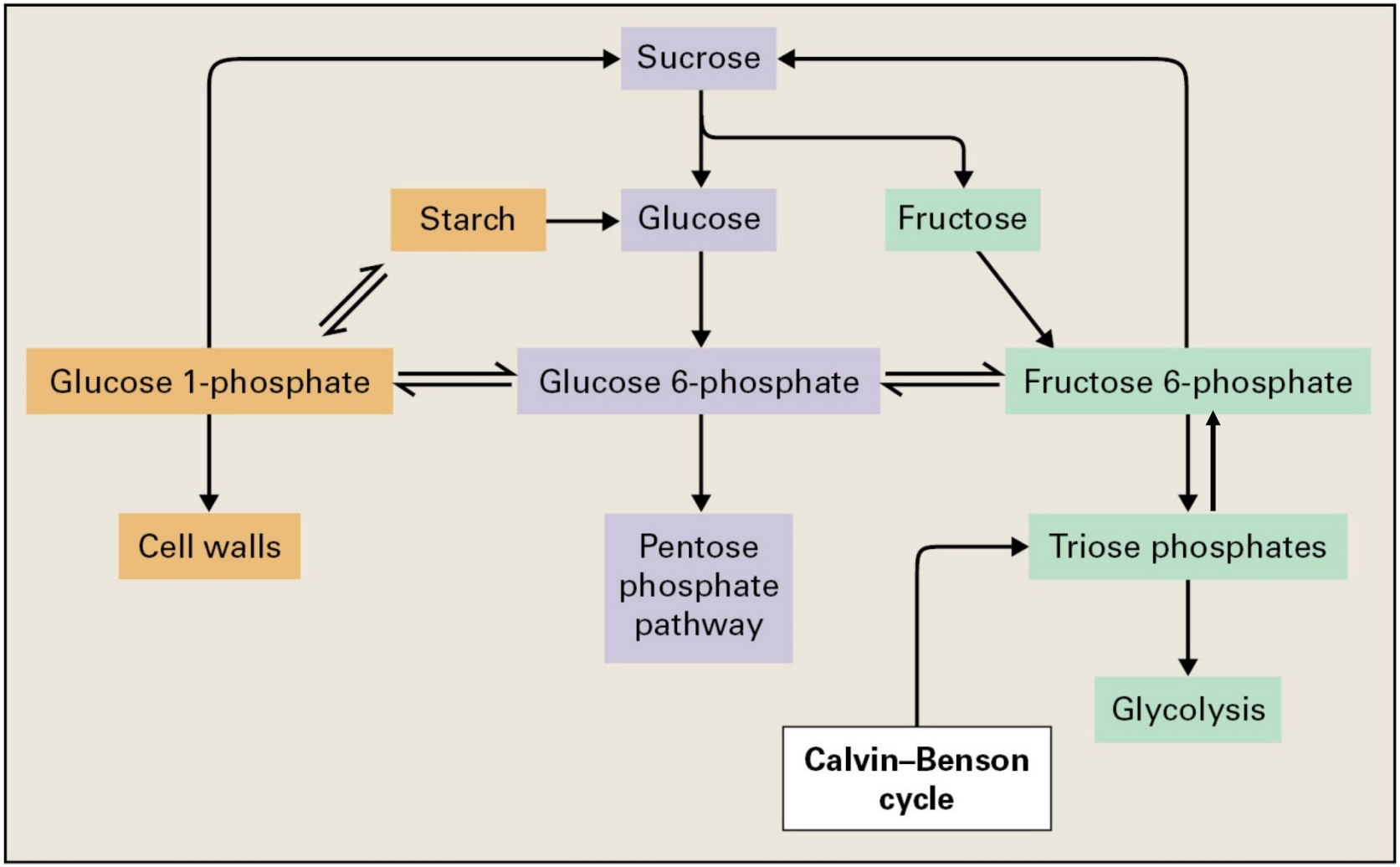
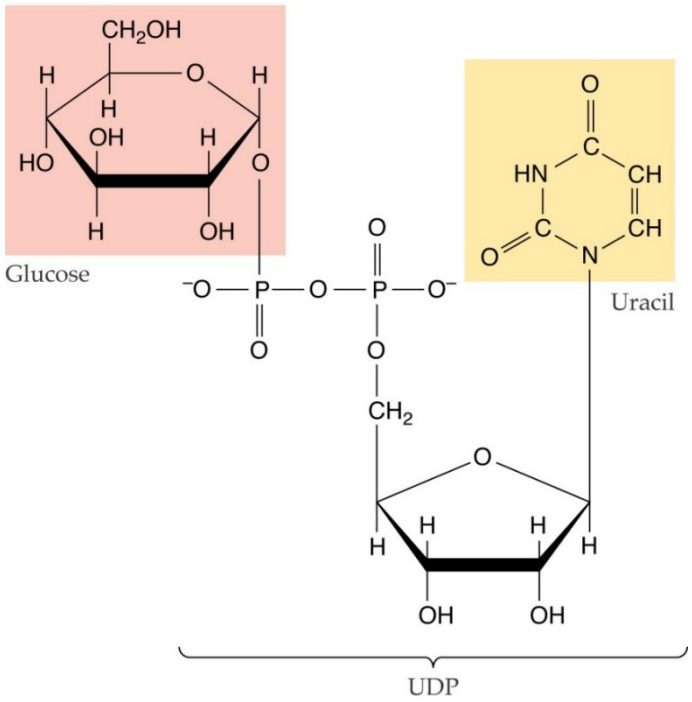
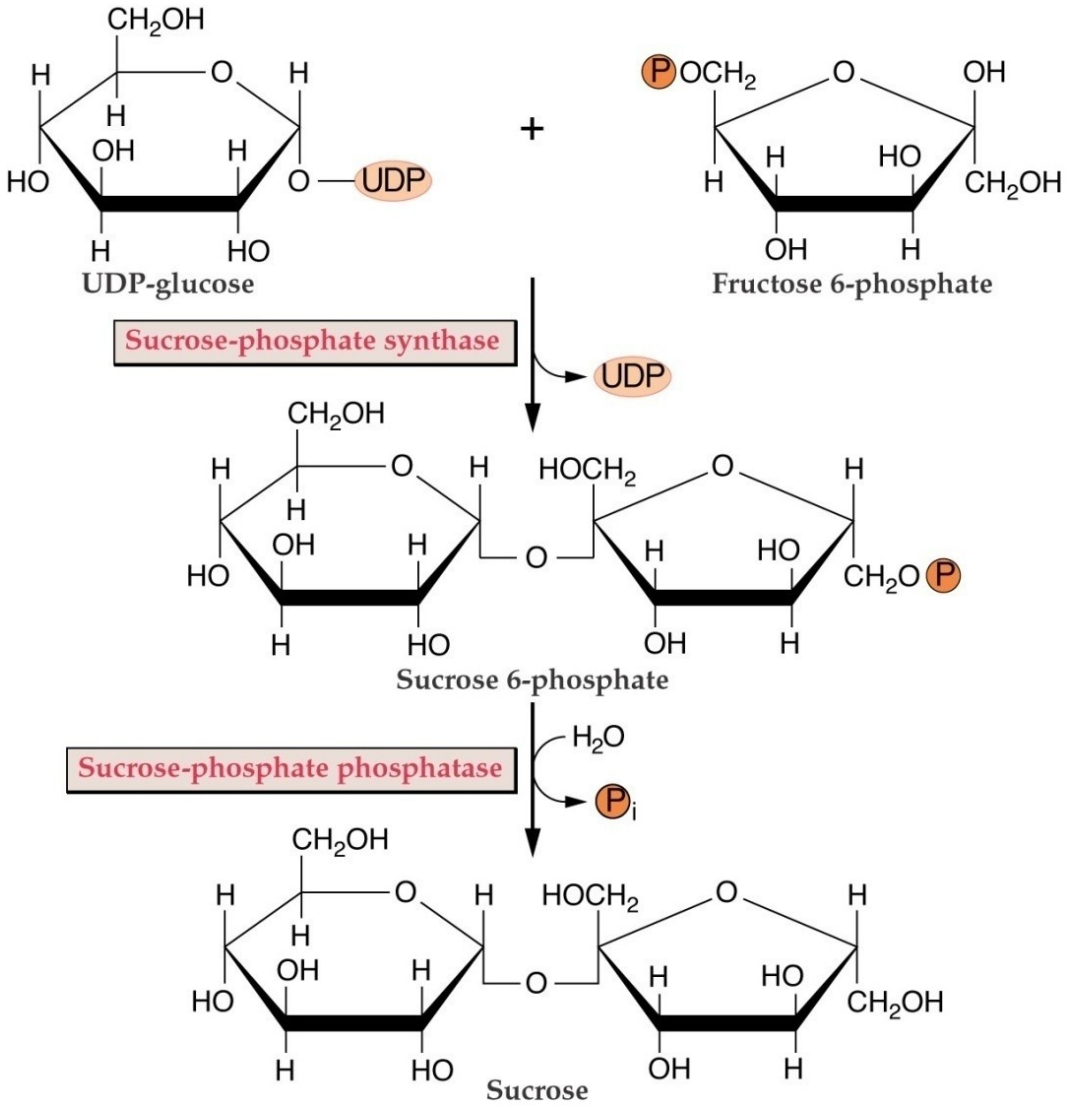
Figures adopted from Buchanan et al., Biochemistry & molecular biology of plants


Sucrose
Starch
Glucose
Fructose
Glucose 1-phosphate
Glucose 6-phosphate
Fructose 6-phosphate
Cell walls
Pentose phosphate pathway
Triose phosphates
Glycolysis
Calvin–Benson cycle

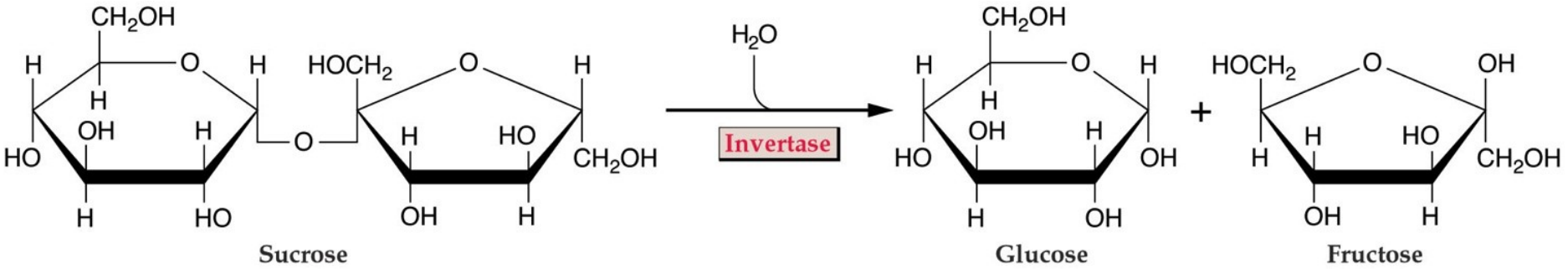
Sucrose synthesis

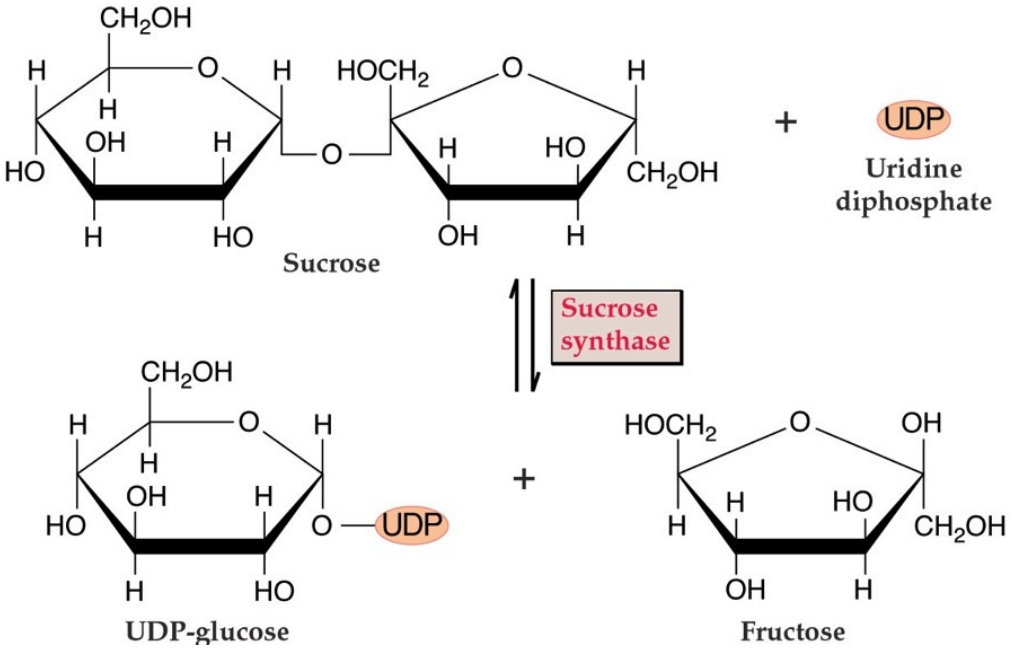
UDP-glucose



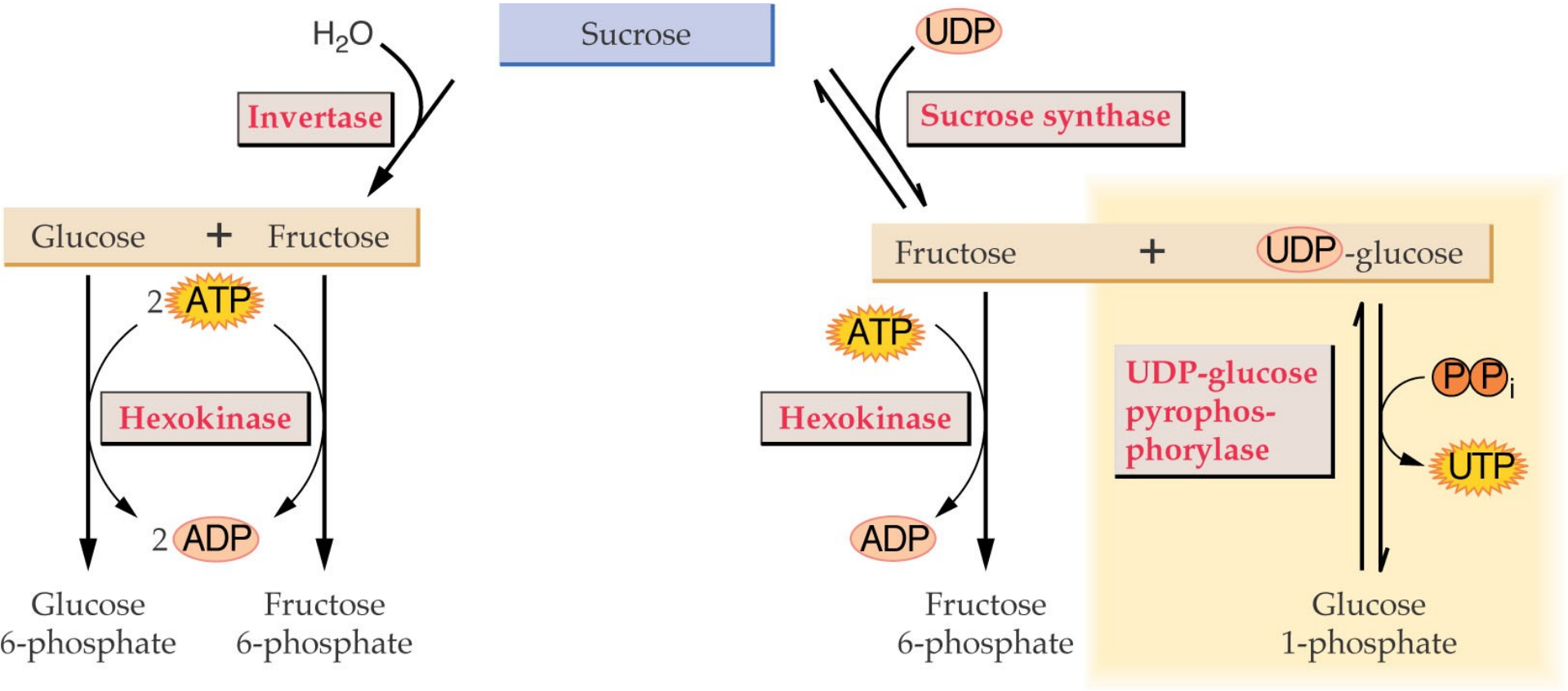


Sucrose degradation





Sucrose degradation

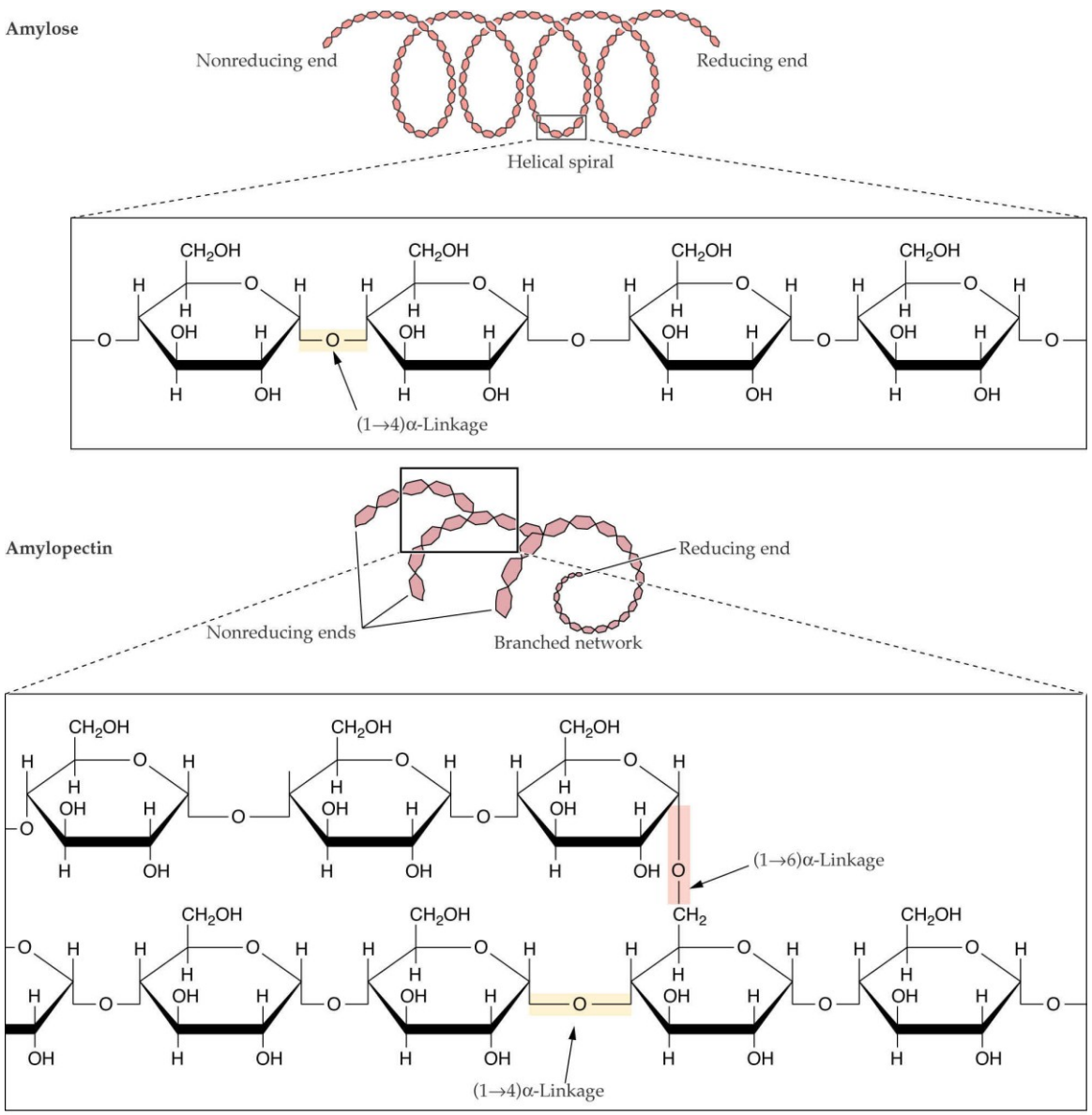


Starch

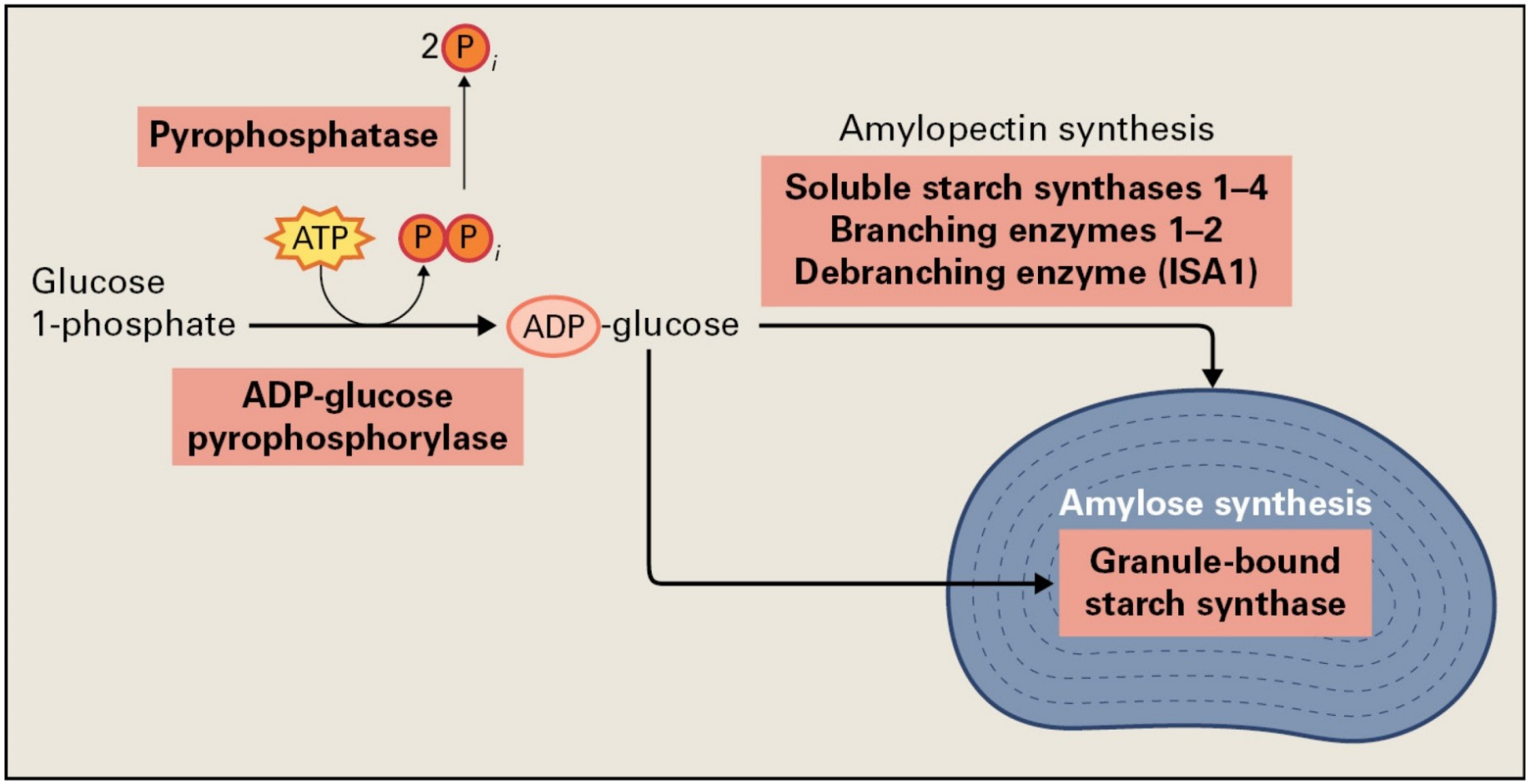
Starch, a polymer of glucose, is synthesized and stored in plastids.

Starch synthesis protects plastids from osmotic disruption.

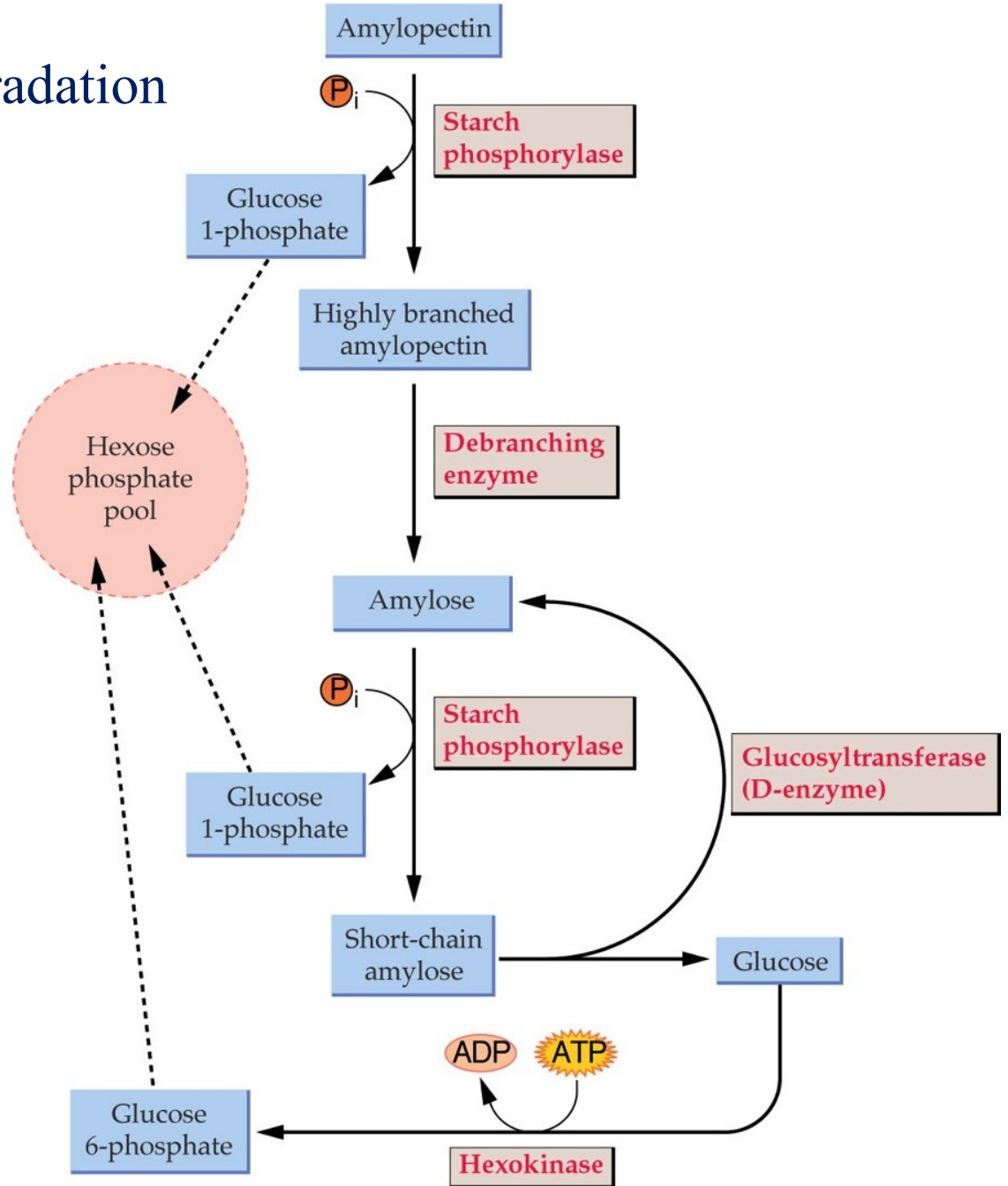
Starch is organized into grains that grow by adding layers.



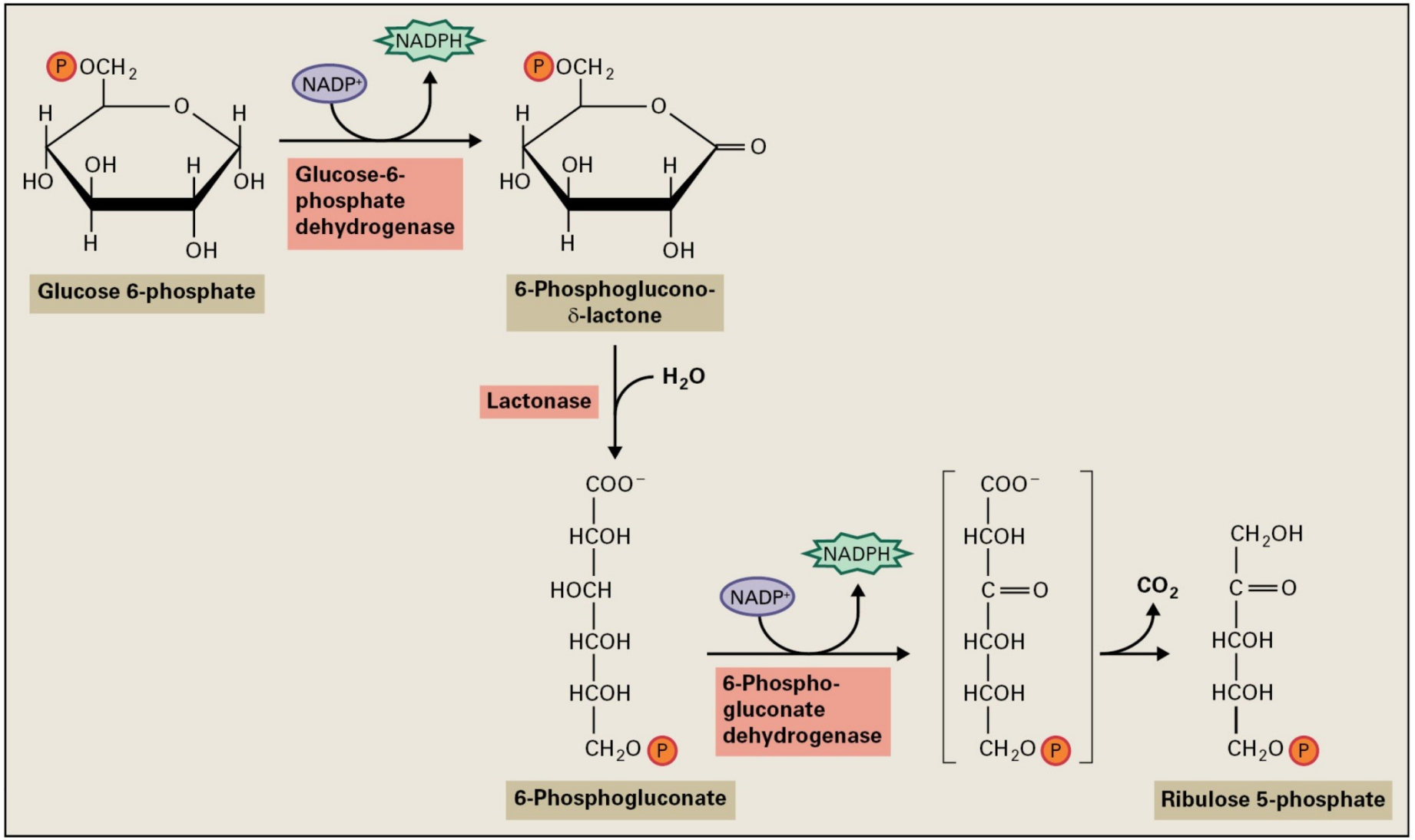
Starch synthesis



Starch degradation

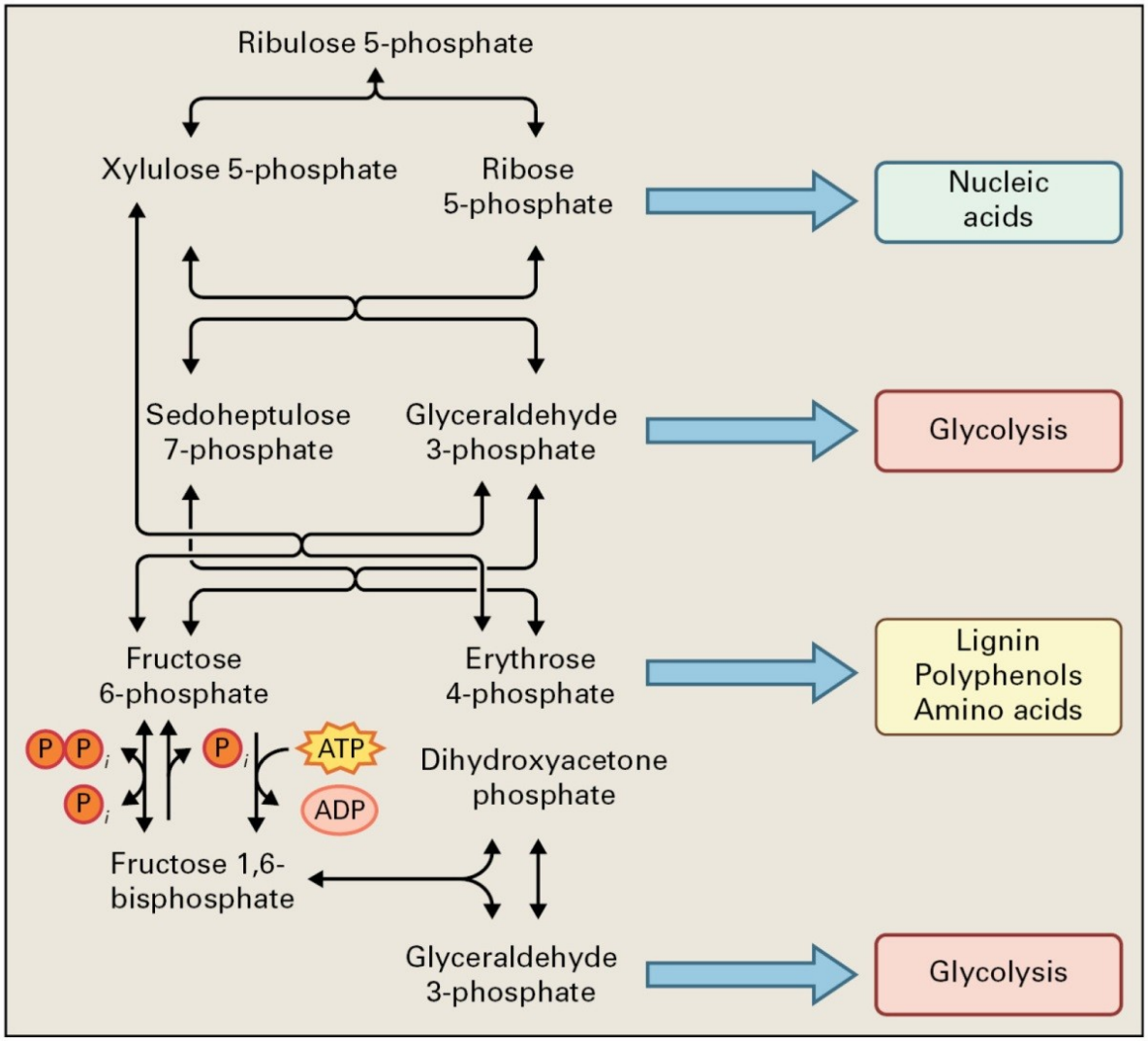


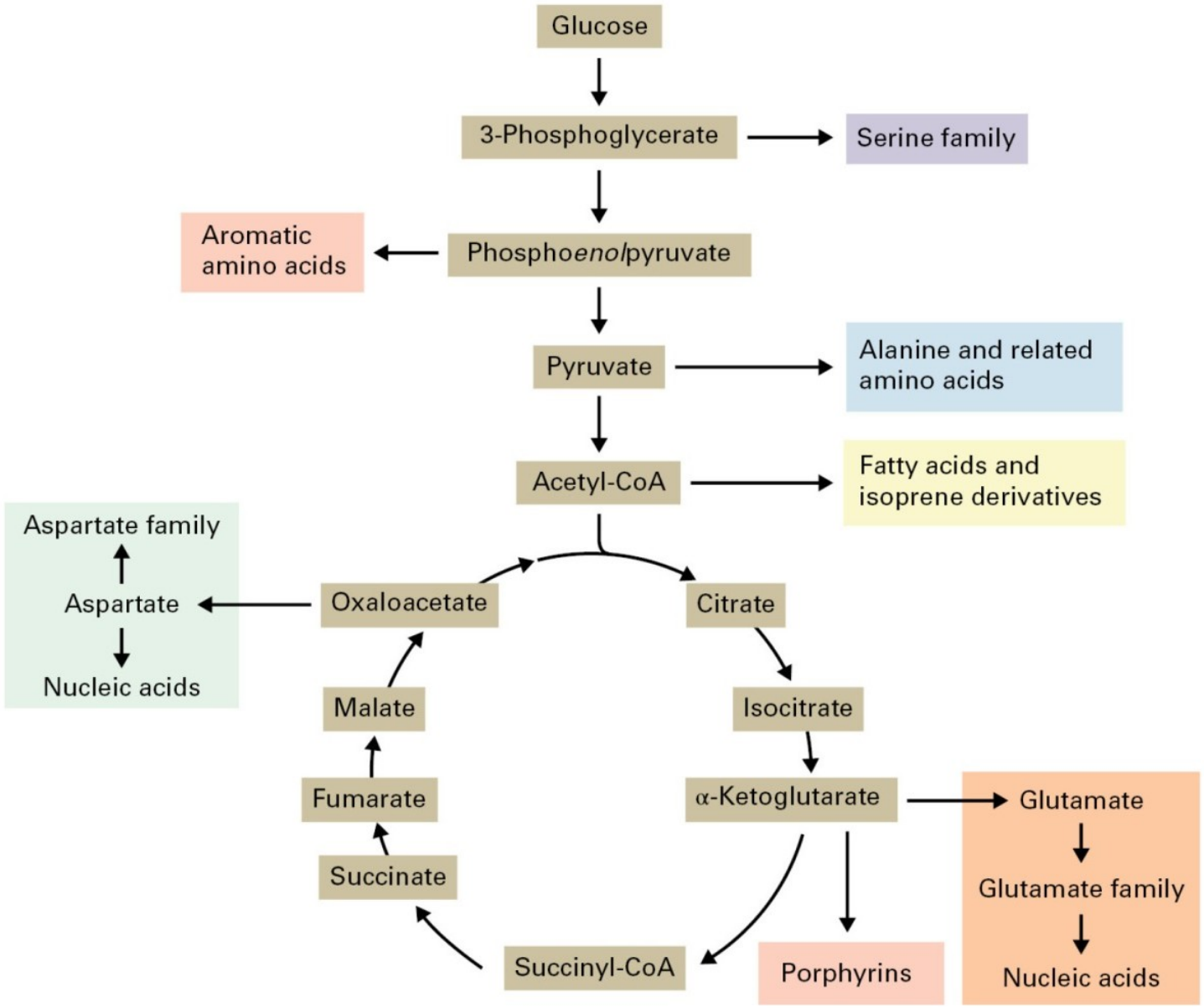
Pentose phosphate pathway – oxidative reactions



Pentose phosphate pathway – reversible reactions

Glycolysis, the pentose phosphate pathway, and various biosynthetic pathways are interconnected in plants



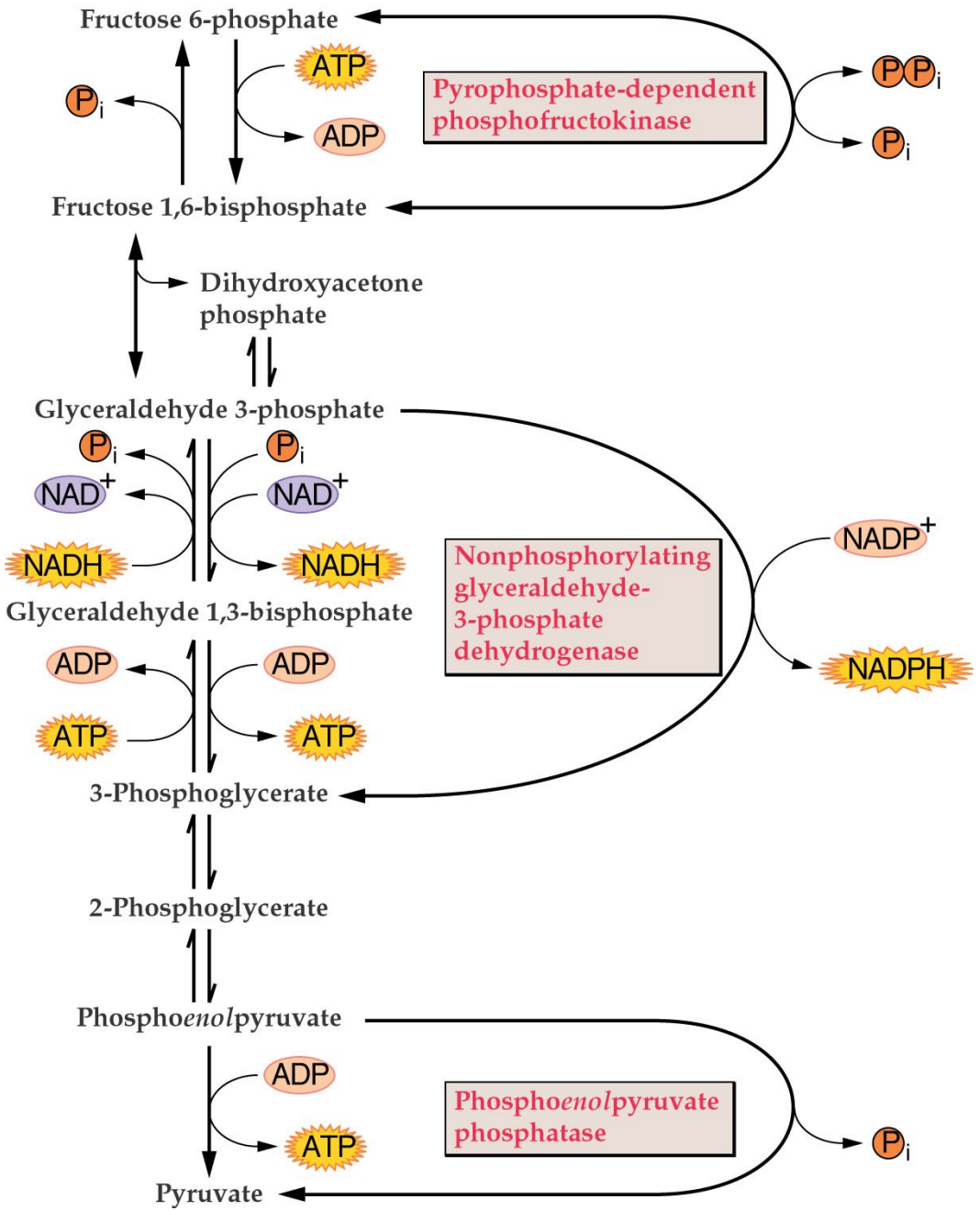

Glucose
3-Phosphoglycerate
Serine family
Aromatic amino acids
Phosphoenolpyruvate
Pyruvate
Alanine and related amino acids
Acetyl-CoA
Fatty acids and isoprene derivatives
Aspartate family
Aspartate
Nucleic acids
Oxaloacetate
Citrate
Malate
Isocitrate
Fumarate
α-Ketoglutarate
Glutamate
Glutamate family
Nucleic acids
Succinate
Succinyl-CoA
Porphyrins

Glycolysis

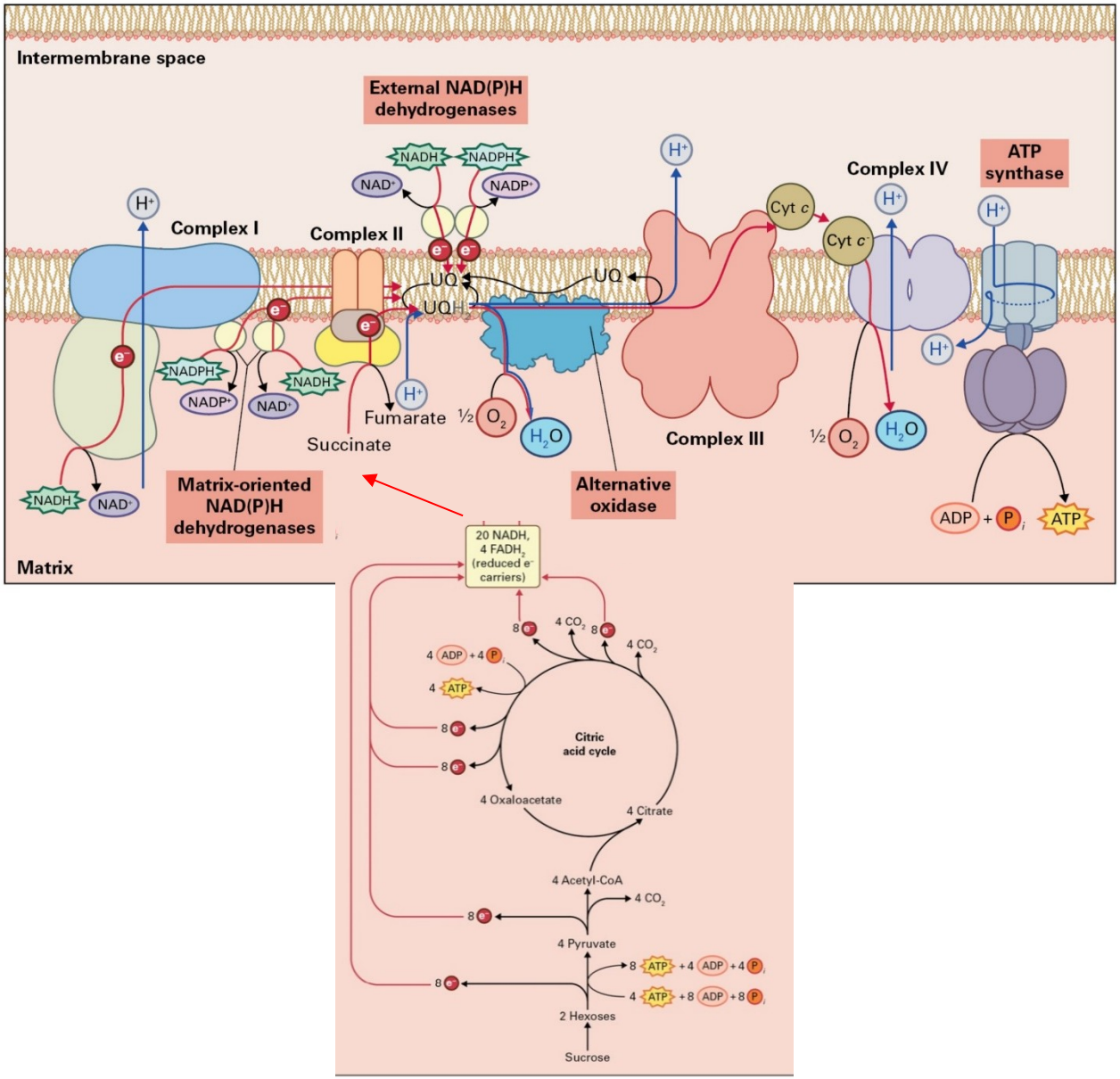
Functions:

- ATP production
- Supply of reducing power
- Funneling carbon for oxidative phosphorylation
- Production of biosynthetic precursors

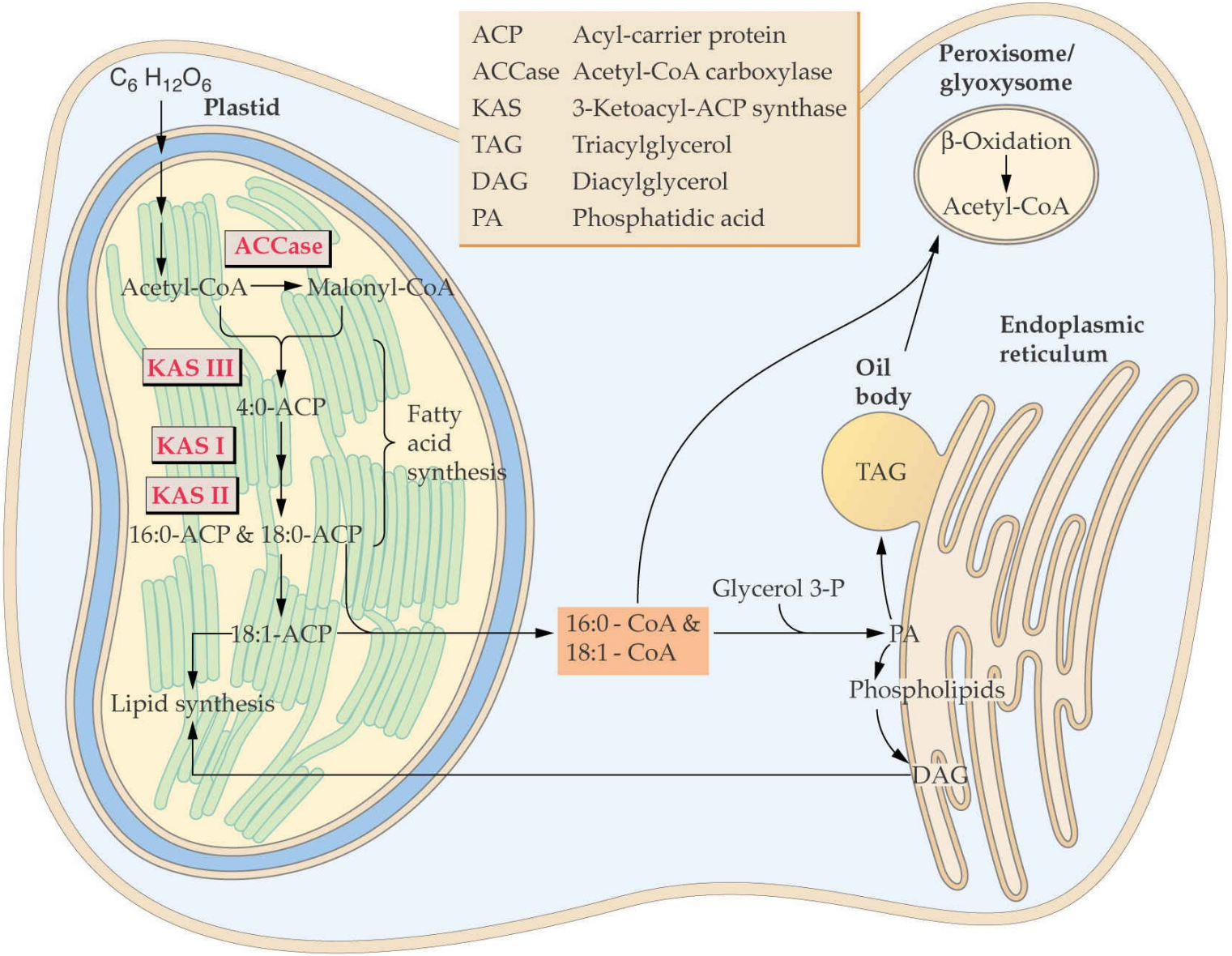
Bypass reactions give plants metabolic flexibility



Respiration



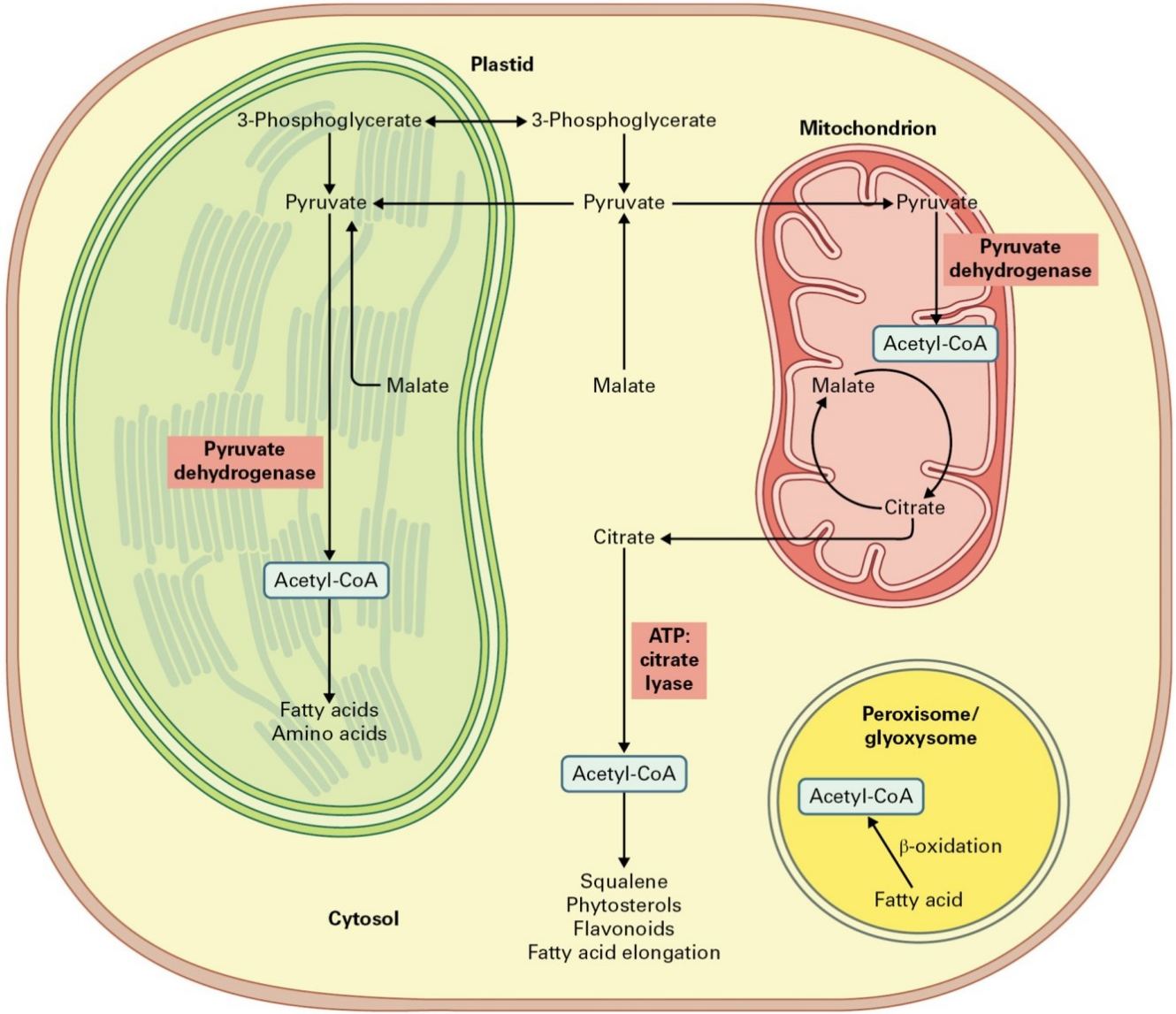
Lipids


ACP Acyl-carrier protein
ACCase Acetyl-CoA carboxylase
KAS 3-Ketoacyl-ACP synthase
TAG Triacylglycerol
DAG Diacylglycerol
PA Phosphatidic acid
$C_6H_{12}O_6$
Plastid
ACCase
Acetyl-CoA
Malonyl-CoA
KAS III
4:0-ACP
KAS I
KAS II
16:0-ACP & 18:0-ACP
Fatty acid synthesis
18:1-ACP
Lipid synthesis
16:0 - CoA & 18:1 - CoA
Peroxisome/ glyoxysome
β-Oxidation
Acetyl-CoA
Endoplasmic reticulum
Oil body
TAG
Glycerol 3-P
PA
Phospholipids
DAG

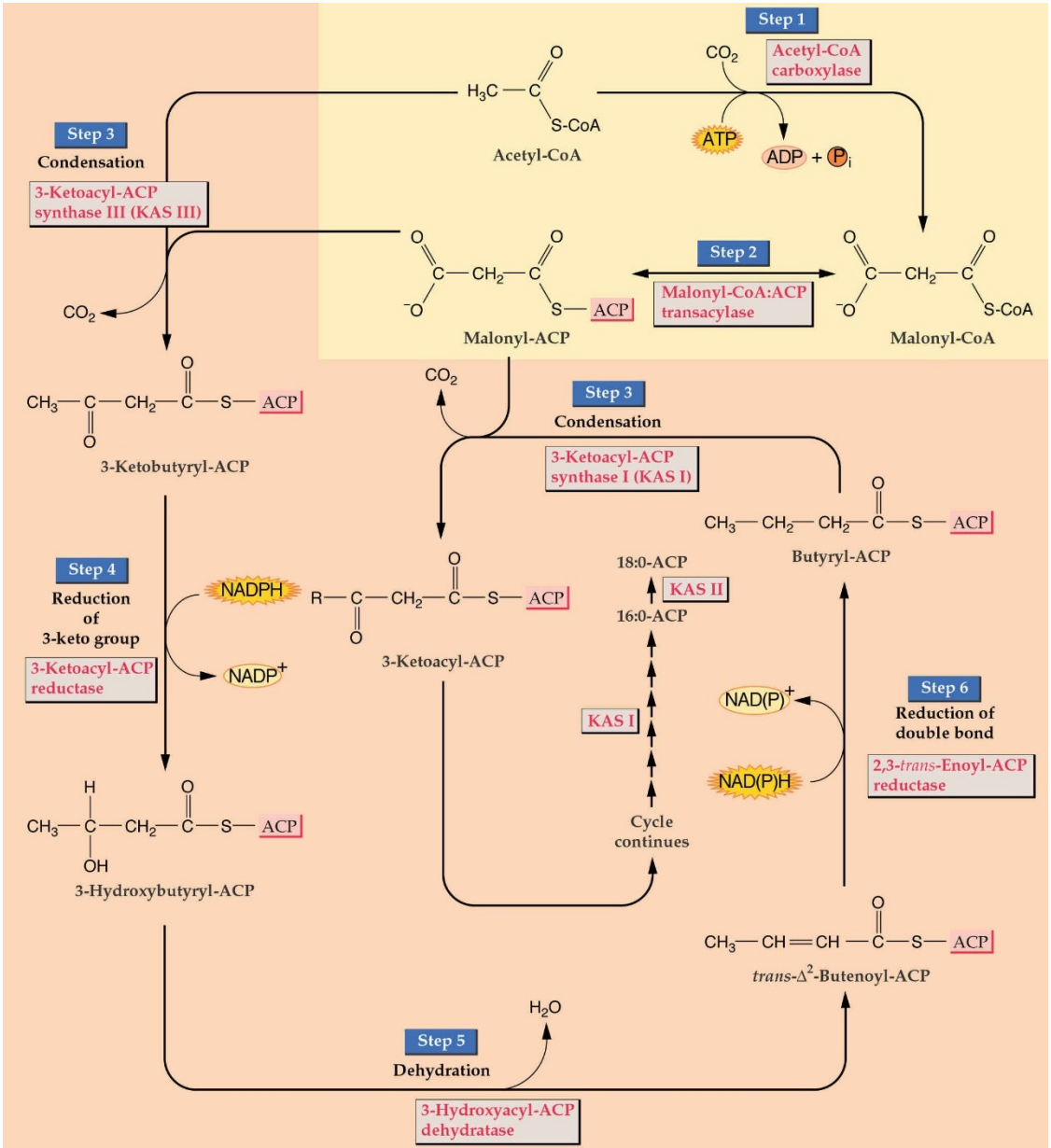
Lipid functions

Function	Lipid types involved[a]
Membrane structural components	Glycerolipids Sphingolipids Sterols
Storage compounds	Triacylglycerols Waxes
Compounds active in electron transfer reactions	Chlorophyll and other pigments Ubiquinone, plastoquinone
Photoprotection	Carotenoids (xanthophyll cycle)
Protection of membranes against damage from free radicals	Tocopherols
Waterproofing and surface protection	Long-chain and very-long-chain fatty acids and their derivatives (cutin, suberin, surface waxes) Triterpenes
Protein modification	
Addition of membrane anchors	
Acylation	Mainly 14:0 and 16:0 fatty acids
Prenylation	Farnesyl and geranylgeranyl pyrophosphate
Other membrane anchor components	Phosphatidylinositol, ceramide
Glycosylation	Dolichol
Signaling	
Internal	Abscisic acid, gibberellins, brassinosteroids 18:3 Fatty acid precursors of jasmonate Inositol phosphates Diacylglycerols
External	Jasmonate Volatile insect attractants
Defense and antifeeding compounds	Essential oils Latex components (rubber, etc.) Resin components (terpenes)

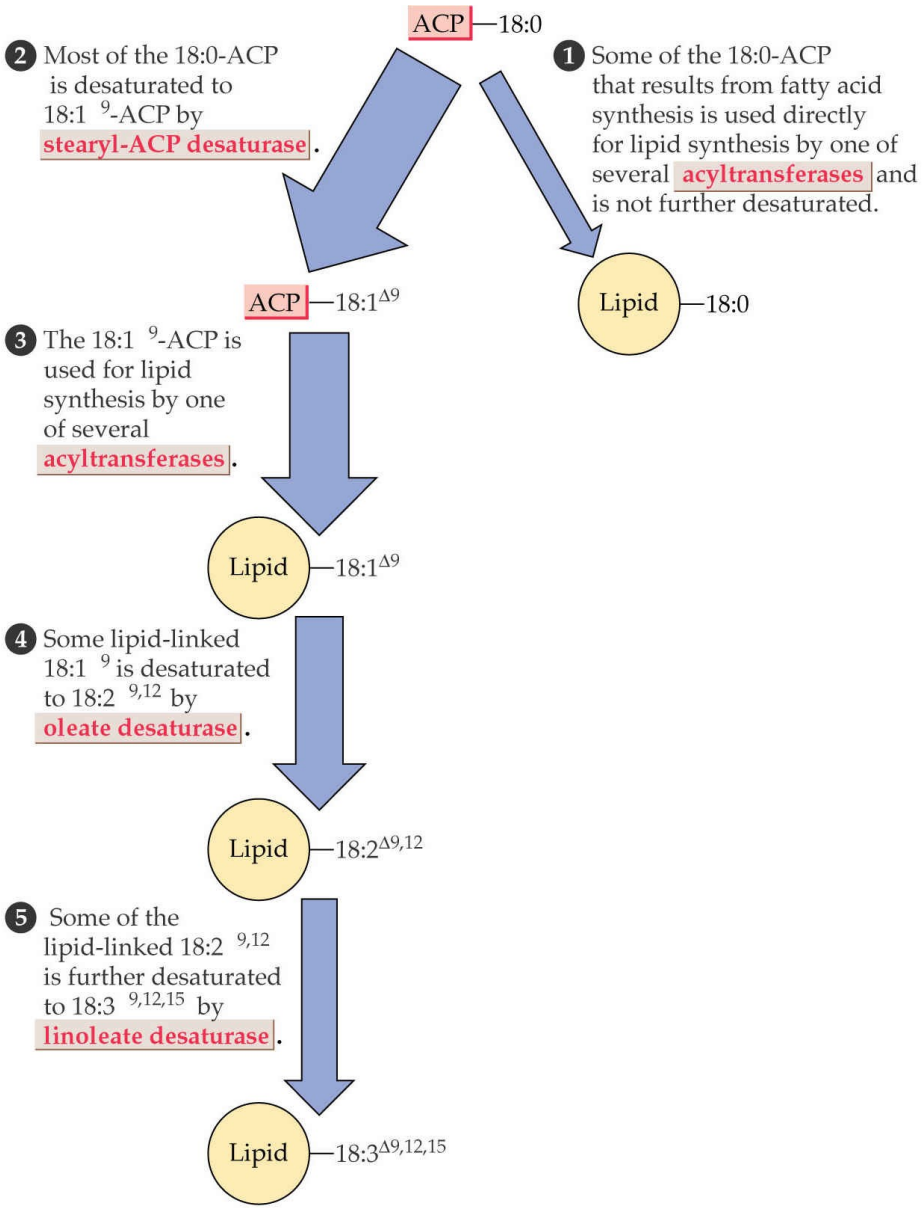
The central role of acetyl-CoA in metabolism

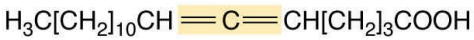


Fatty acid synthesis

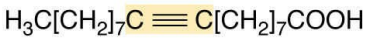


Fatty acid synthesis

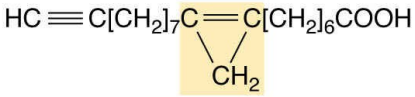




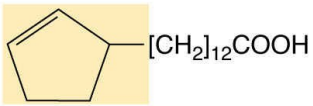
Laballenic acid, an allenic acid



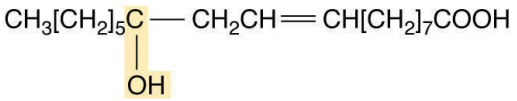
Stearolic acid, a monoacetylenic acid



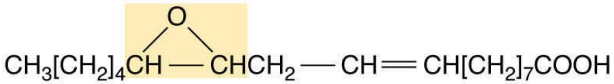
Sterculynic acid, a cyclopropene-containing acid



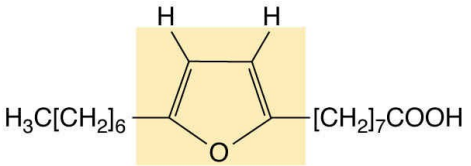
Chaulmoogric acid, a cyclopentenyl acid



Ricinoleic acid, a hydroxy fatty acid

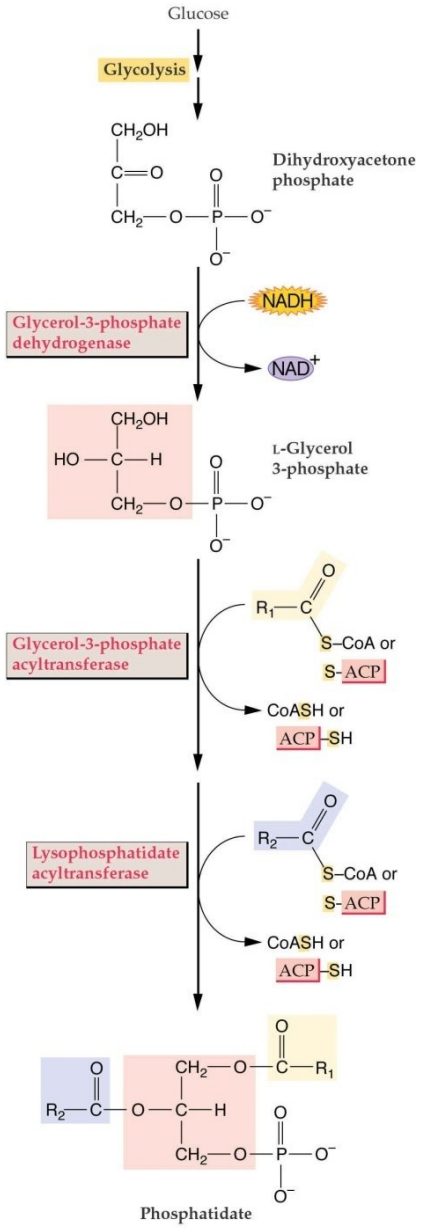


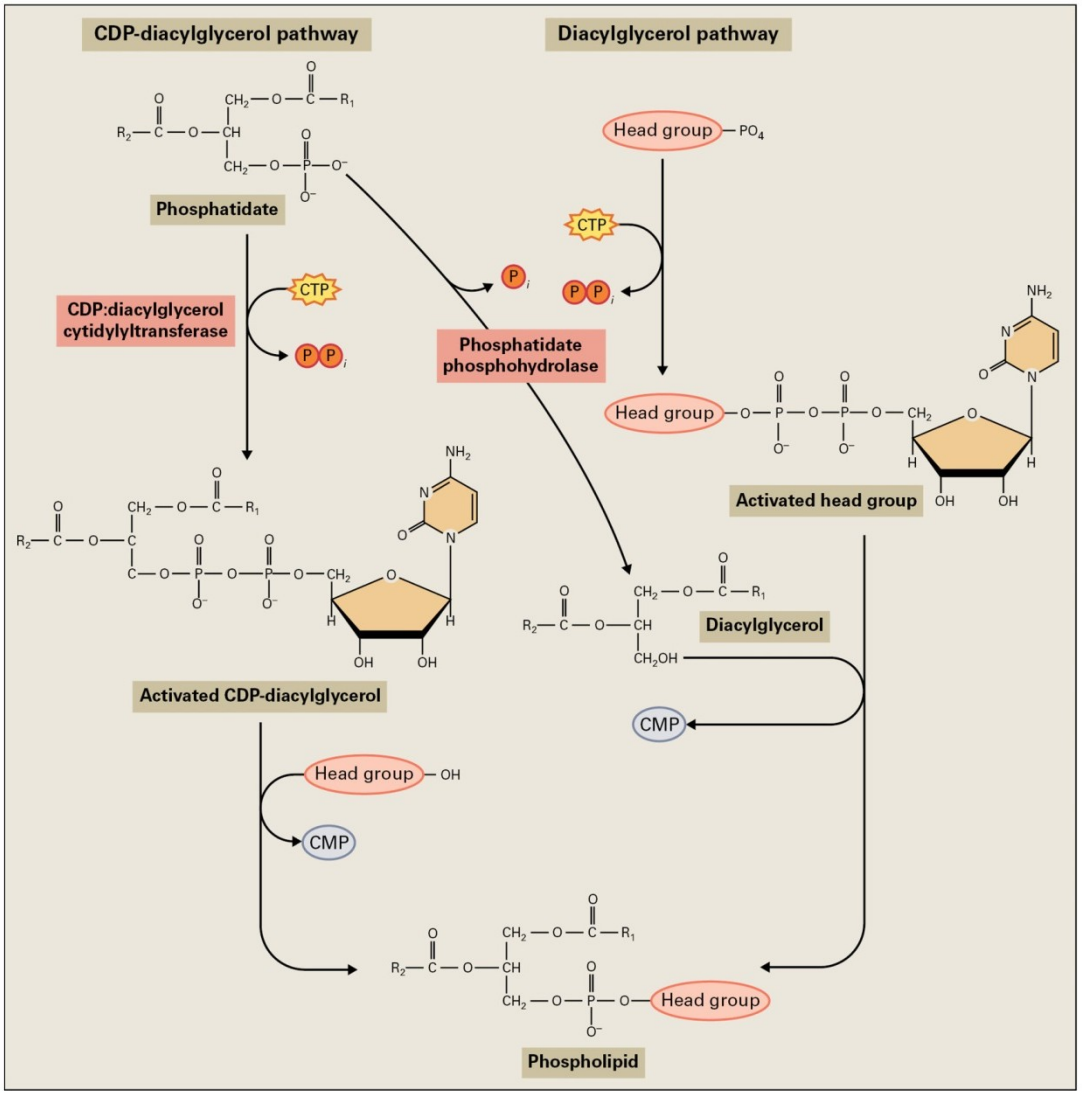
Vernolic acid, an epoxy fatty acid



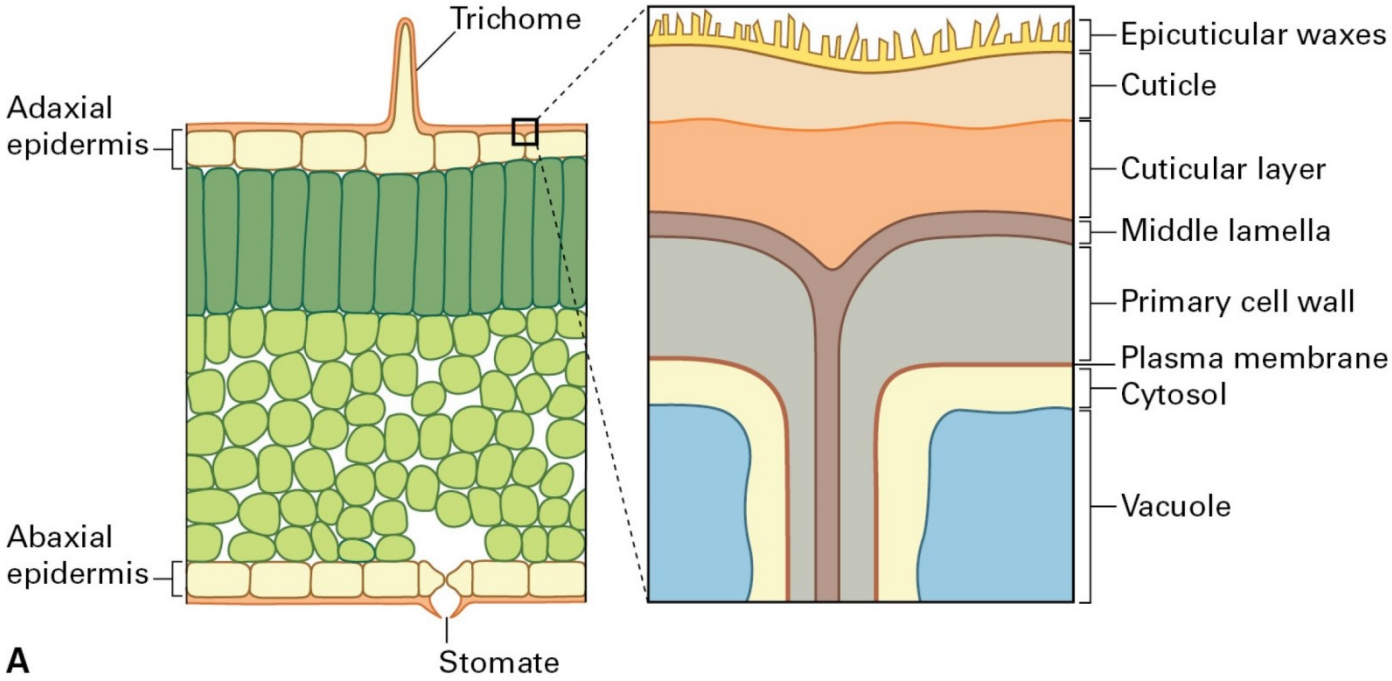
A furan-containing fatty acid

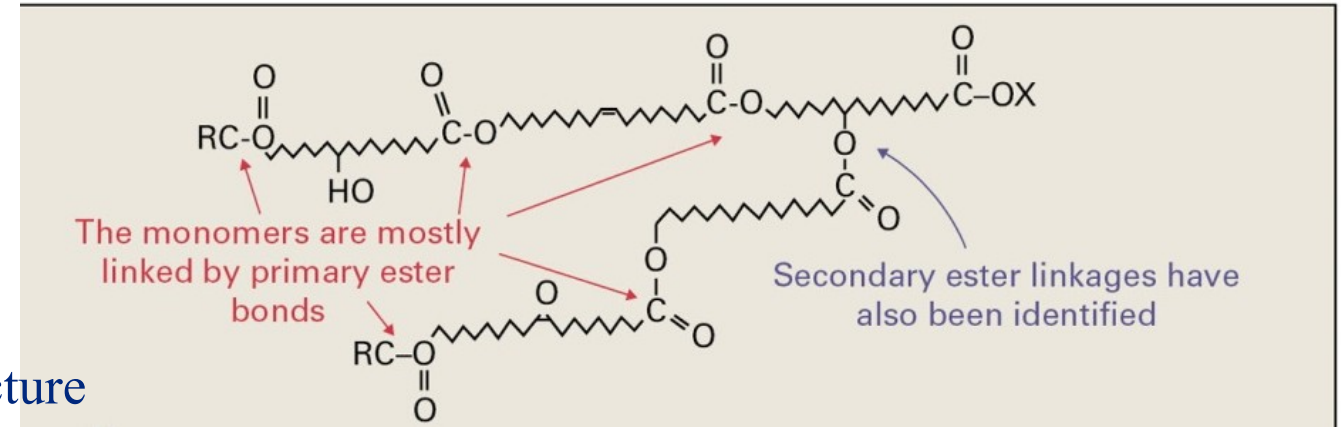
Membrane lipids





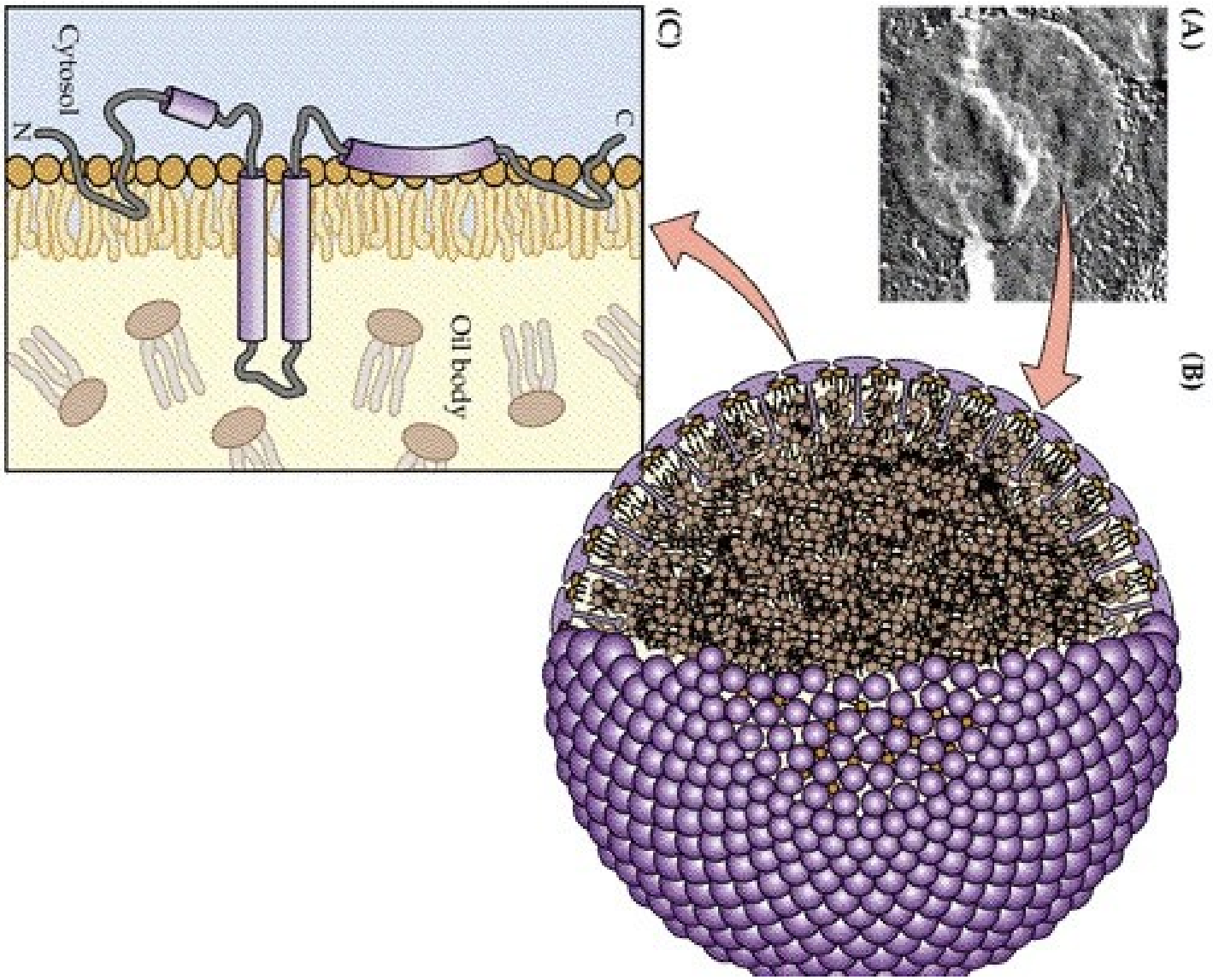
Structural lipids



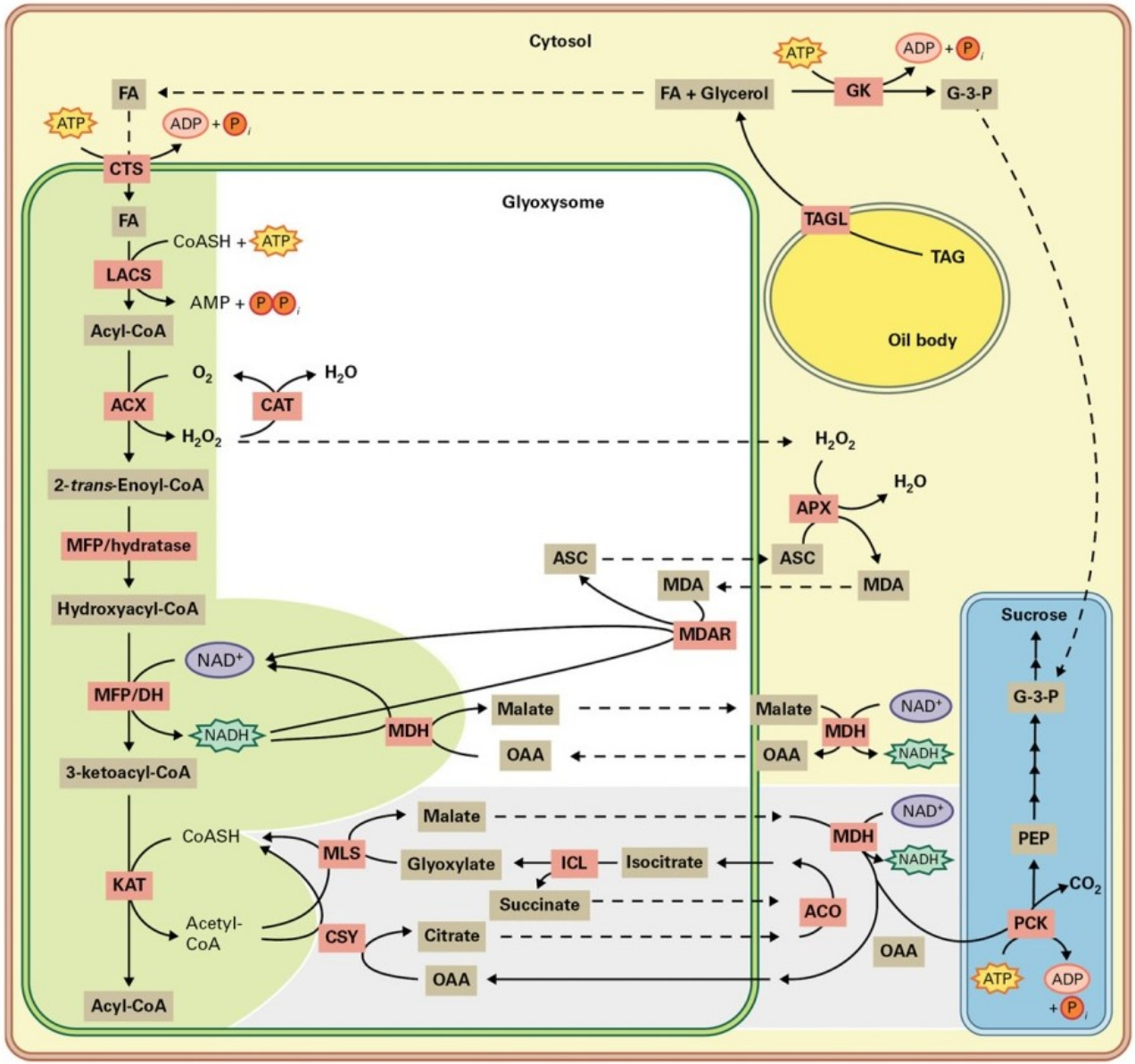


Cutin structure

Storage lipids



Storage lipid mobilization



Genetic engineering of lipids