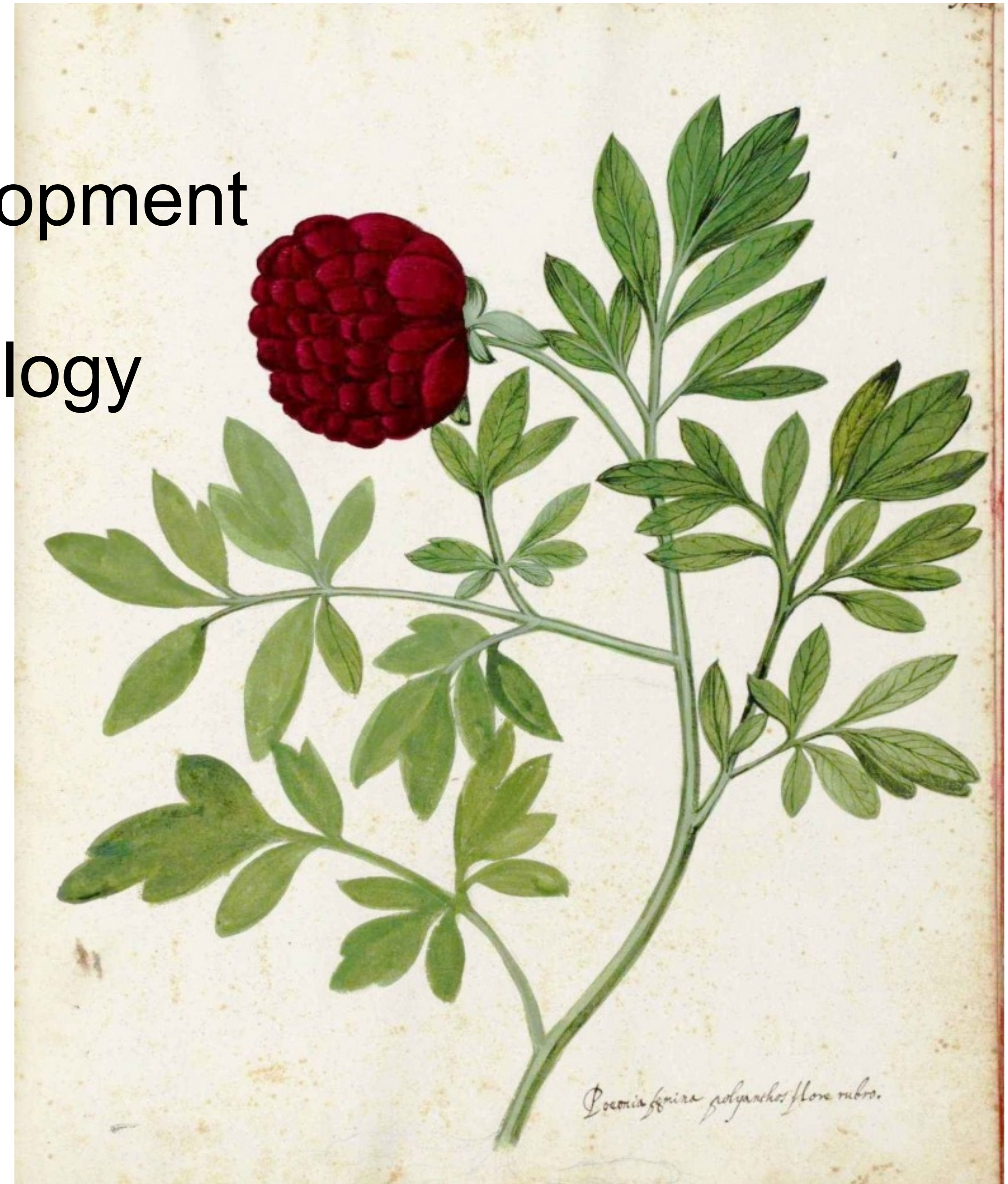
«Bioloģija nebiologiem»: plant physiology

- Plant growth and development
- Plant resistance physiology
- Plant movements



Differences of plant and animal organisms

Animals 

Plants 

Movement

Nutrition

Development

Regeneration capacity

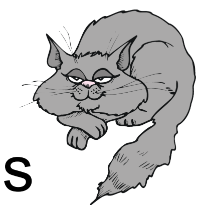
Differences of plant and animal organisms

Animals 

Plants 

Animals		Plants
+	**Movement**	-
	Nutrition	
	Development	
	Regeneration capacity	

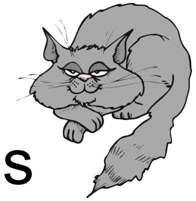
Differences of plant and animal organisms

Animals 

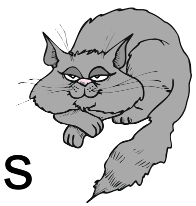
Plants 

Animals		Plants
+	**Movement**	-
heterotrophic	**Nutrition**	autotrophic
	Development	
	Regeneration capacity	

Differences of plant and animal organisms

Animals 		Plants 
+	**Movement**	-
heterotrofs	**Nutrition**	autotrofs
canalyzed development	**Development**	plastic development
	Regeneration capacity	

Differences of plant and animal organisms

Animals 		Plants 
+	**Movement**	-
heterotrofs	**Nutrition**	autotrofs
canalyzed development	**Development**	plastic development
low	**Regeneration capacity**	high

Specific properties of plants

Plastic development
high regeneration capacity
low movement capacity

→ **cell totipotence**

→ **Metameric structure**

→ **Phenotypic plasticity**

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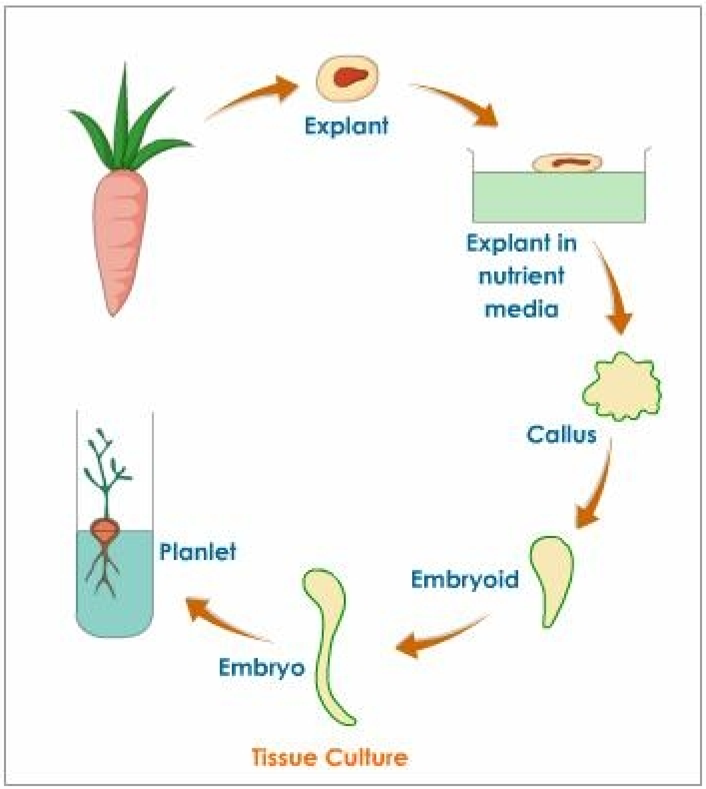
autotrophic nutrition → **Photosynthesis**

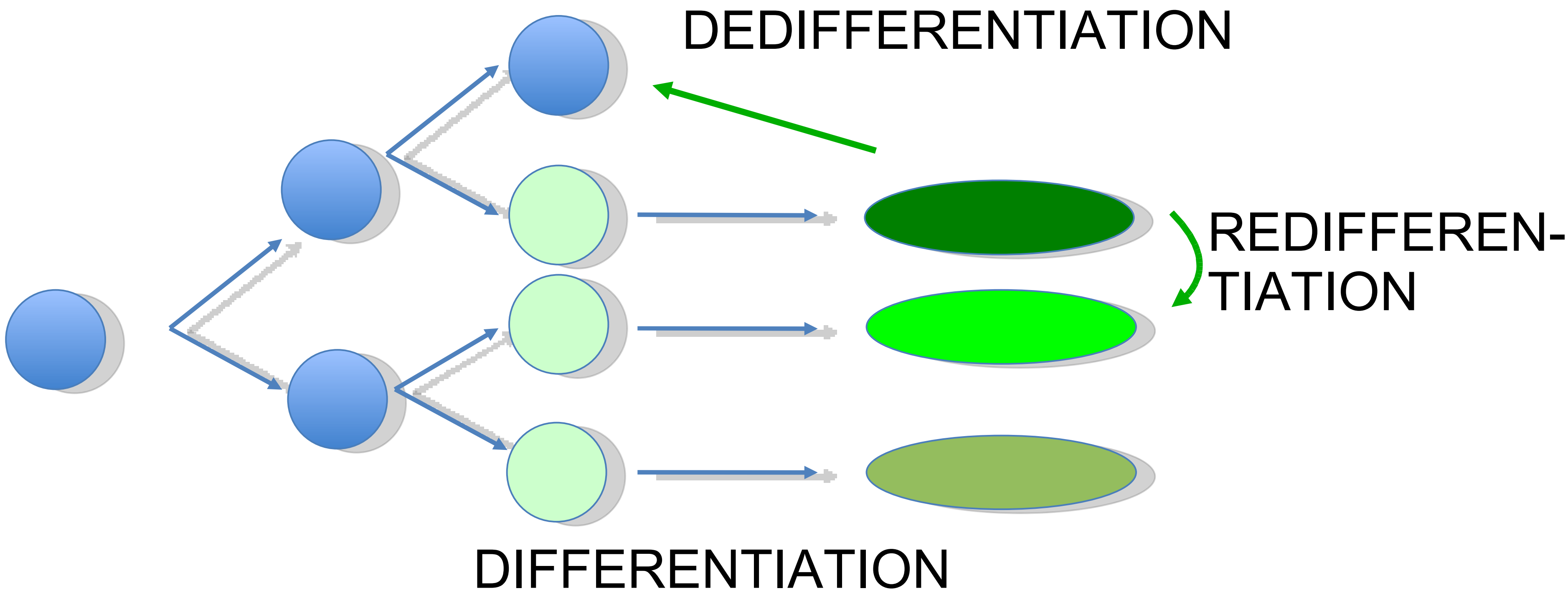
Cell totipotence

Totipotent cell — cell that through division and differentiation cal regenerate the whole organism or any of its cell types



Plant cells are totipotent or pluripotent

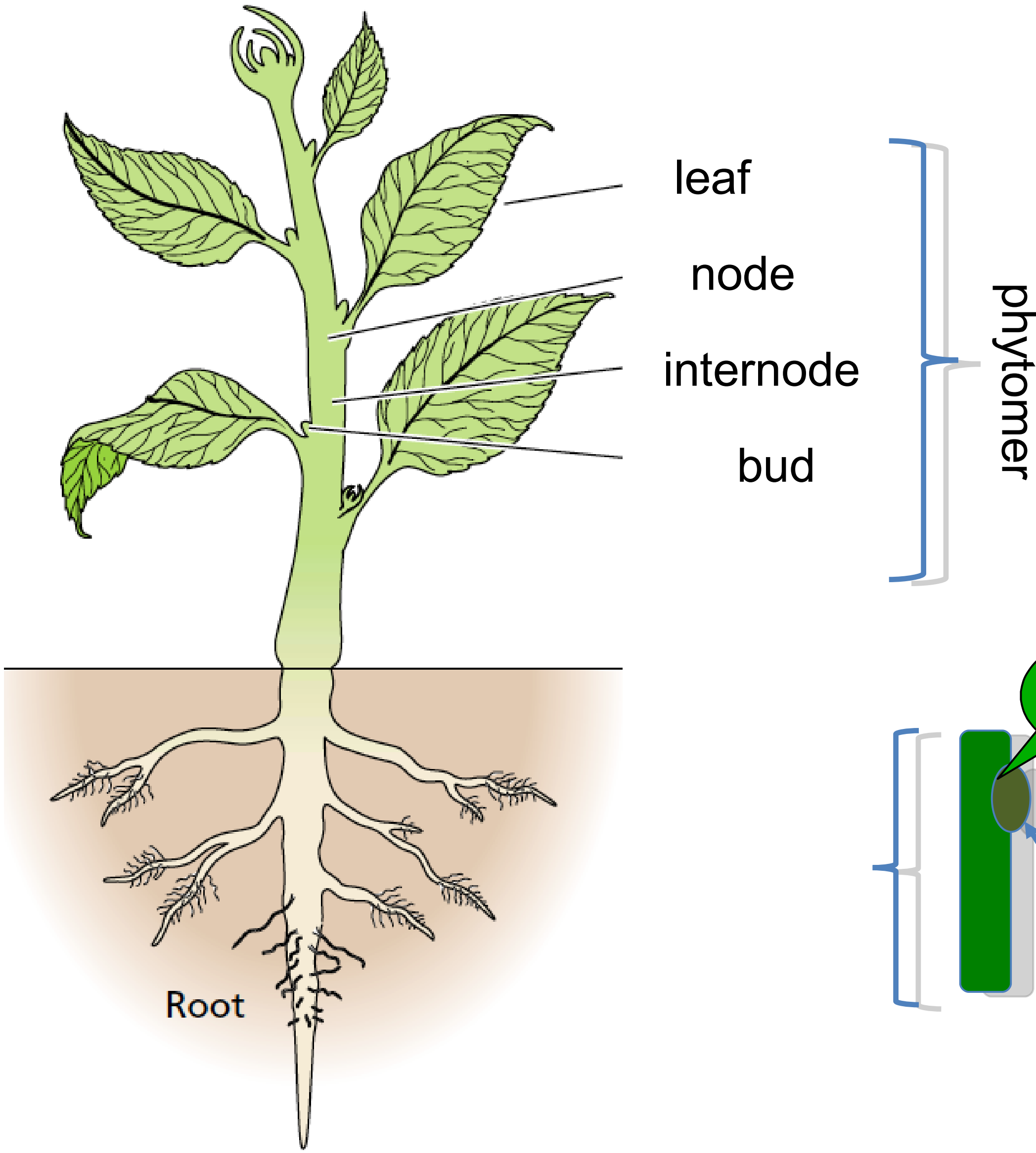
Cell totipotence

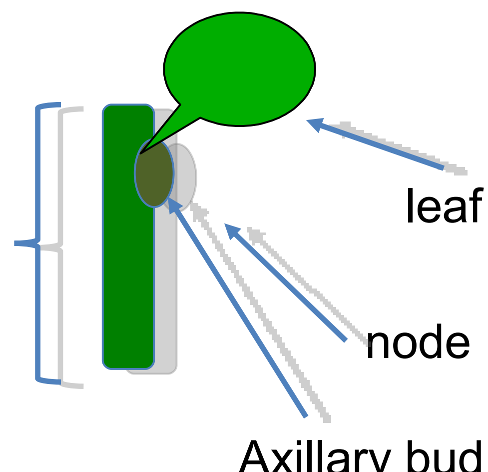


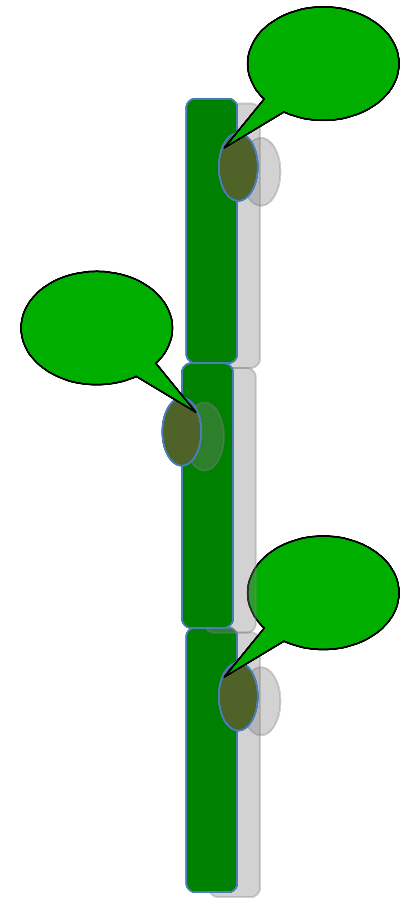
Non-differentiated cells can divide

Differentiated cells do not divide, they perform specific functions

Metamers


leaf
node
internode
bud
phytomer
Root


leaf
node
Axillary bud

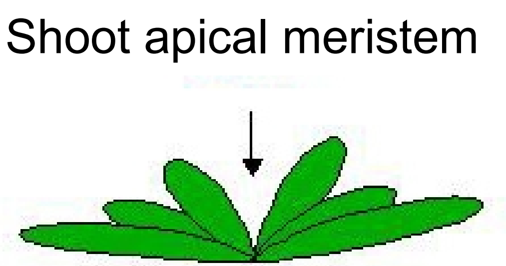


Meristem — localized embryonic tissues that produce phytomers

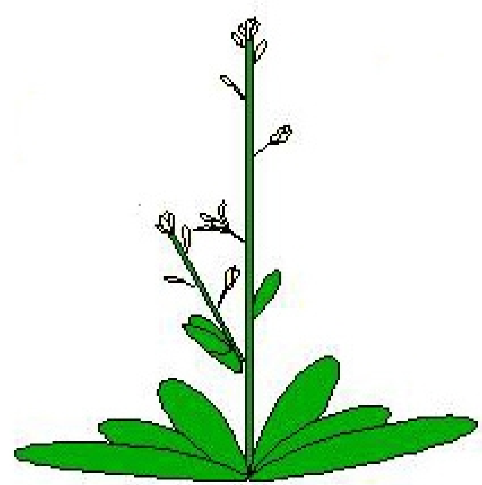
Meristems

Vegetative

- active (apex)
- inactive (axillary buds)



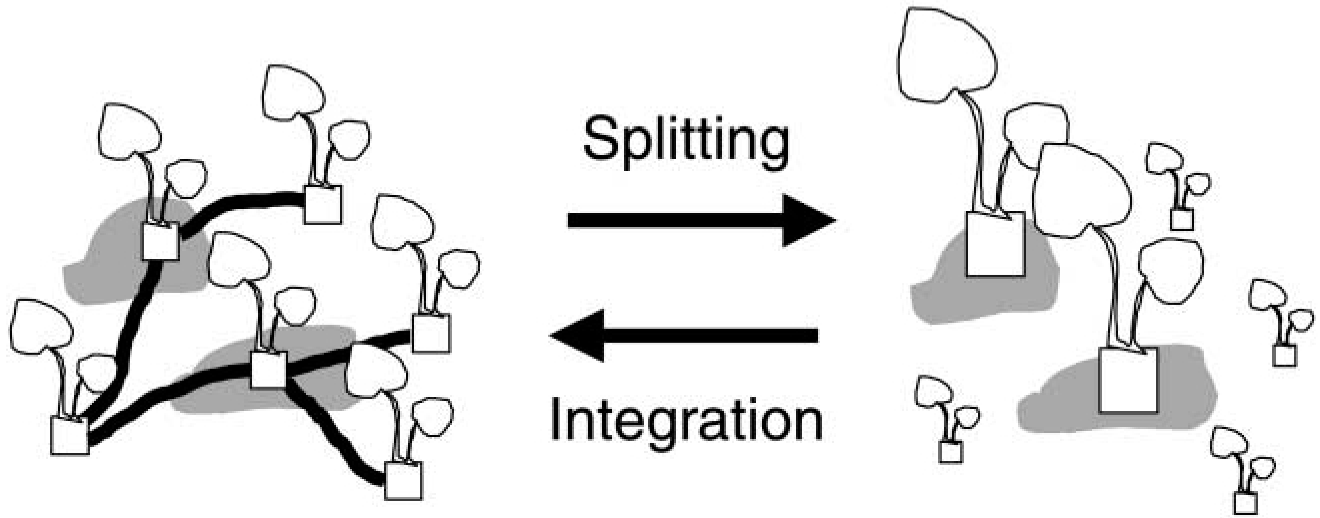
Reproductive



Clonal plants

Clonal plants

Clonal plants



Magori et al., 2003

Clonal integration is adaptive in heterogenous habitats, where sharing of resources can be beneficial to the plants (connected clones)

Phenotypic plasticity

Phenotypic plasticity
capacity of the
organism to alter
phenotype to get
acclimated
to the environment

http://www.geochembio.com/ecology/climate-change/climate-change-on-plants.html

Phenotypic plasticity

Alyssum gmelinii, Gmelina alise, dune forest edge

Foto: Ģ. Ieviņš

Phenotypic plasticity

Alyssum gmelinii, Gmelina alise, white dune

Foto: Ģ. Ieviņš

Phenotypic plasticity

Alyssum gmelinii, Gmelina alise, white dune

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Phenotypic plasticity

Alyssum gmelinii, Gmelina alise

Foto: Ģ. Ieviņš

Phenotypic plasticity

Honckenya peploides, biezlapainā sālsvirza

Foto: Ģ. Ieviņš

Phenotypic plasticity

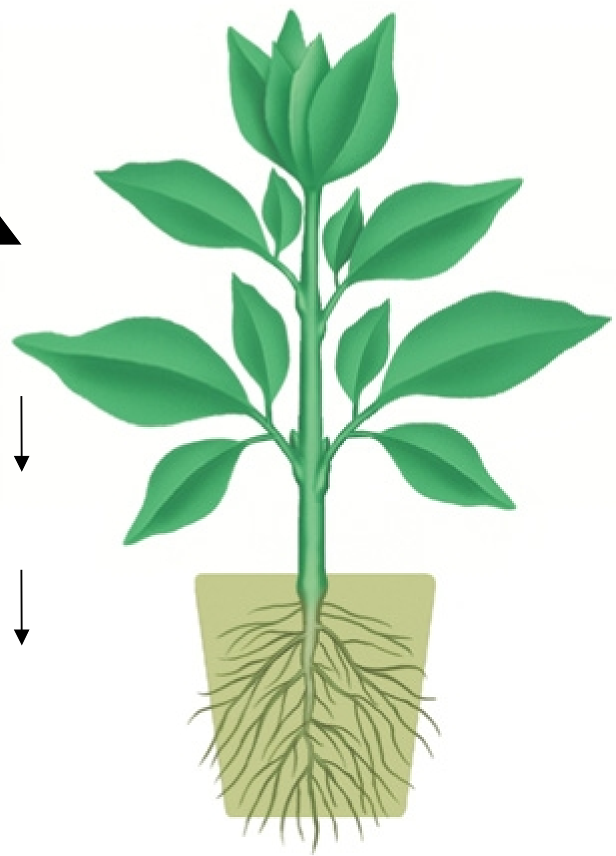
Honckenya peploides, biezlapainā sālsvirza

Foto: Ģ. Ieviņš

Plant reaction to the environment

Sub-optimal conditions (physical, chemical factors)

Herbivores, pathogens



Signal perception

↓

Signal recognition and transduction

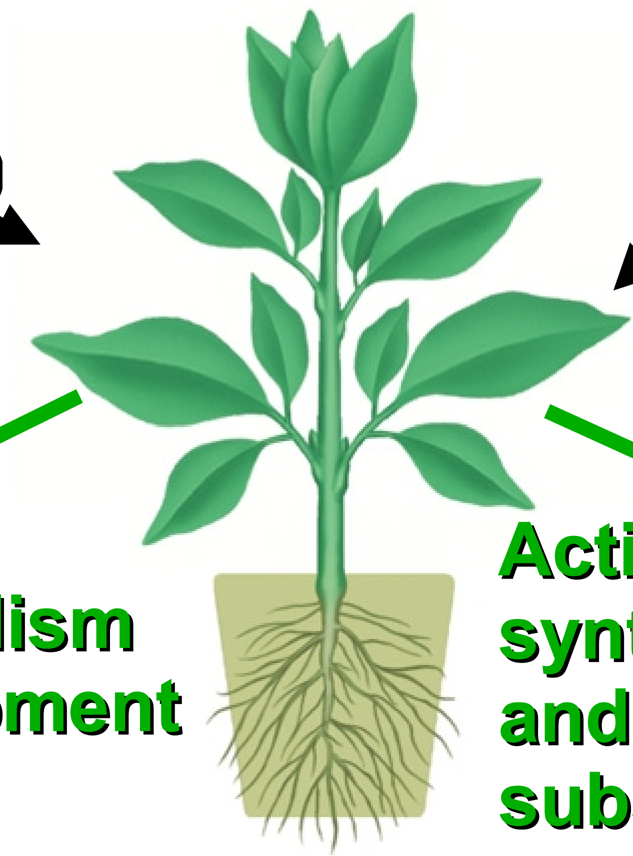
↓

Reaction

Plant reaction to the environment

<u>Abiotic stress:</u>
Sub-optimal conditions (physical, chemical factors)

<u>Biotic stress</u>
Herbivores, pathogens competition



Active reactions:
- **Changes in metabolism**
- **Changes in development**
- **protection**

Active reactions: synthesis of toxins and other protextive substances

Example: freezing tolerance

When temperature lowers below 0 ºC bulk water in the cells freezes and forms ice crystals

Uncontrolled formation of crystals as a result of rapid decrease of temperature may lead to cell damage

Plant reactions

Cell dehydration, minimizing bulk water
Dehydrins protect macromolecules from damage

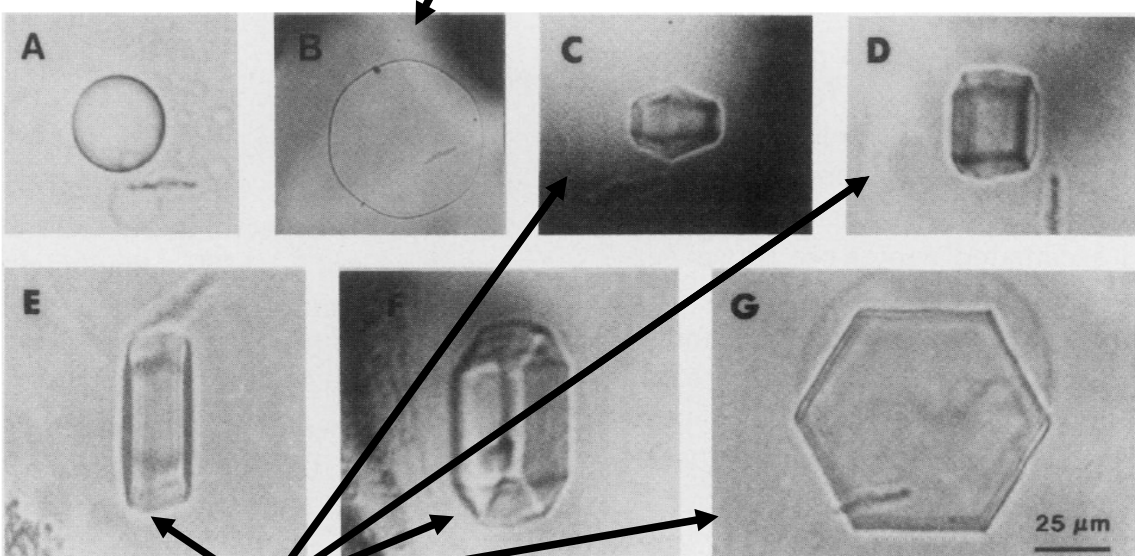
«controlled» formation of crystals
- synthesis of *antifreeze proteins* (lower temperature of ice formation and altered crystal shape)
- ice crystals form in the apoplast

Example: freezing tolerance

Effect of antifreeze protein on ice crystal formation in rye

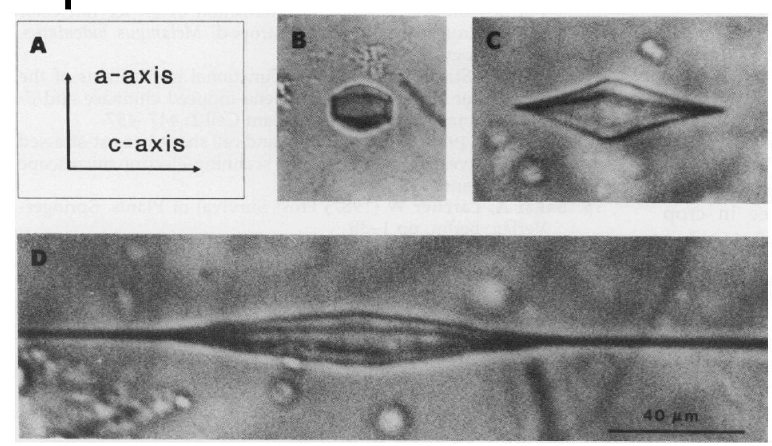
Ice crystals in distilled water

Ice crystals in non-acclimated plants



Ice crystals in acclimated plants

Stages of ice crystal formation in antifreeze protein solution



Griffith et al. 1992

Example: protection against herbivores

Plants are able to recognize specific damage caused by herbivores and
induce active protective reactions

Example: protection against herbivores

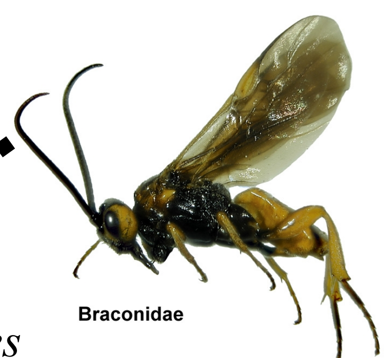
Linolenic acid

volicitin

Spodoptera exigua

Zea mays, kukurūza

volatiles



Microplitis croceipes

Turlings et al. 2000

Example: protection against herbivores

Constitutive protection

Morphological adaptation
(mechanic protection)
- reinforced cell walls
- cuticule
- spines, thorns

Physiological adaptation
(chemical protection)
- toxinc
(nicotin)
- antinutrients
(proteinase inhibitors)
- repellents

Induced protection

Direct

Indirect

volatiles
that attract
natural
enemies of
the herbivores
(parasites etc)

Plant movements

Tropisms

direction of the movement
depends on the
direction of the stimulus
that causes the movement

phototropism
geotropism
tigmotropism
hydrotropism
chemotropism

Nastic movements

direction of the movement
is independent of the
direction of the stimulus

nictinasty
seismonasty
hydronasty

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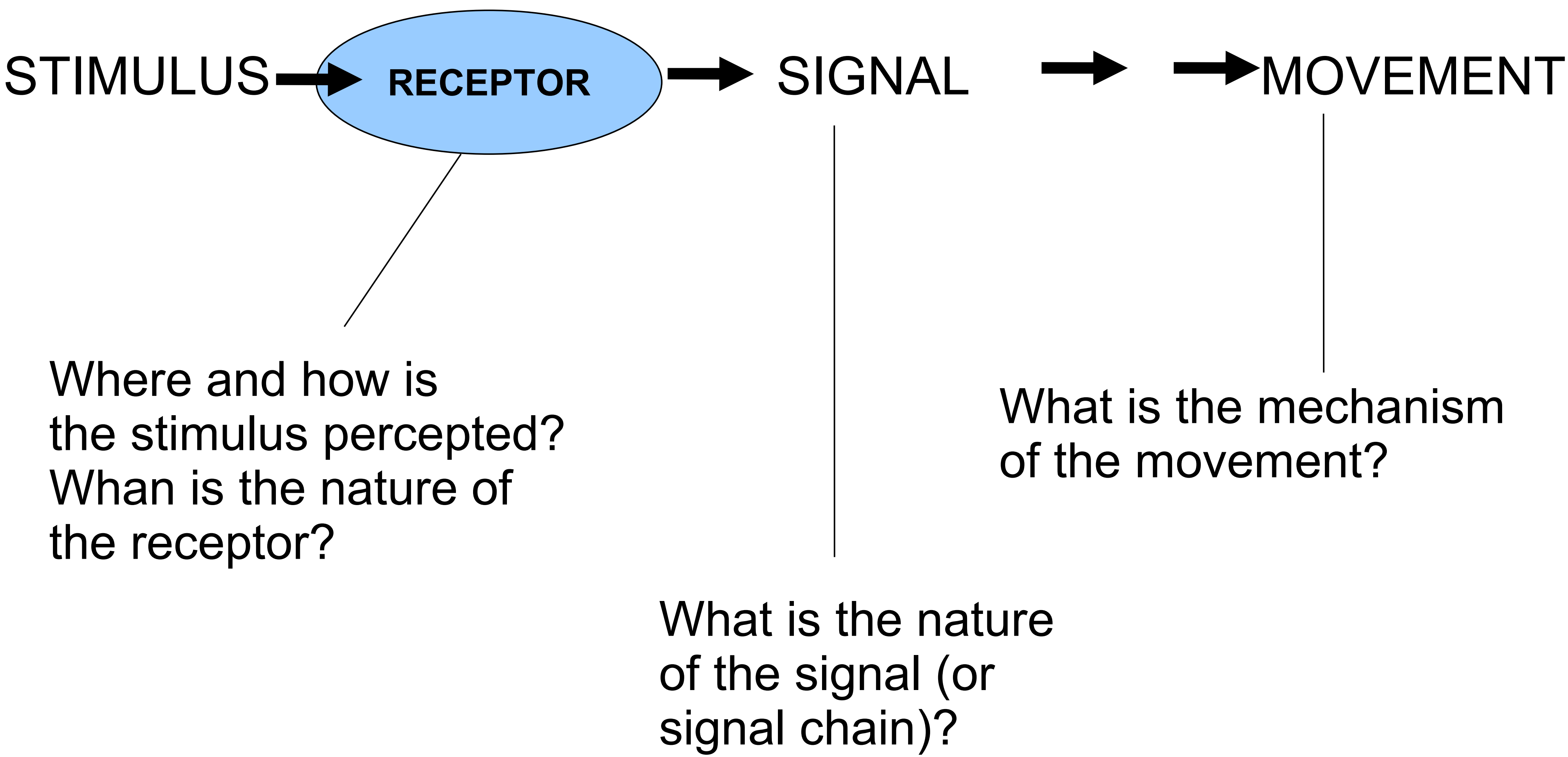
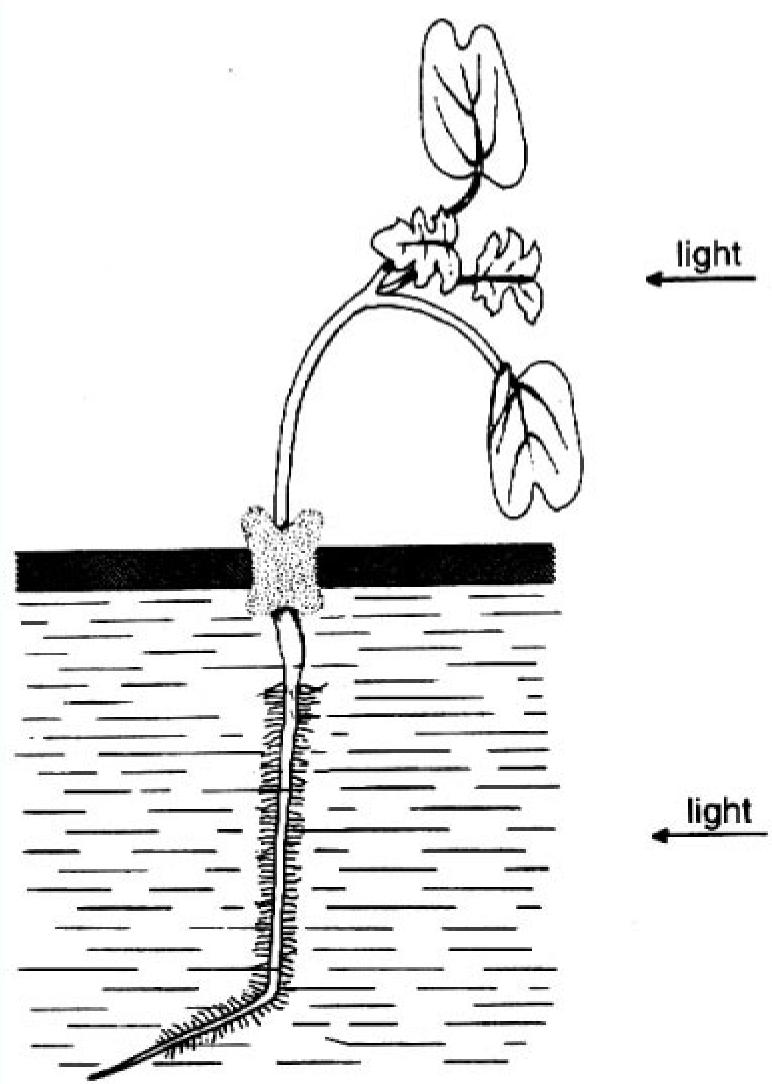
Nutation
autonomous movement caused by
growth. Elliptic movement
of the apex (tip of the plant)

Movement is a reaction to stimulus



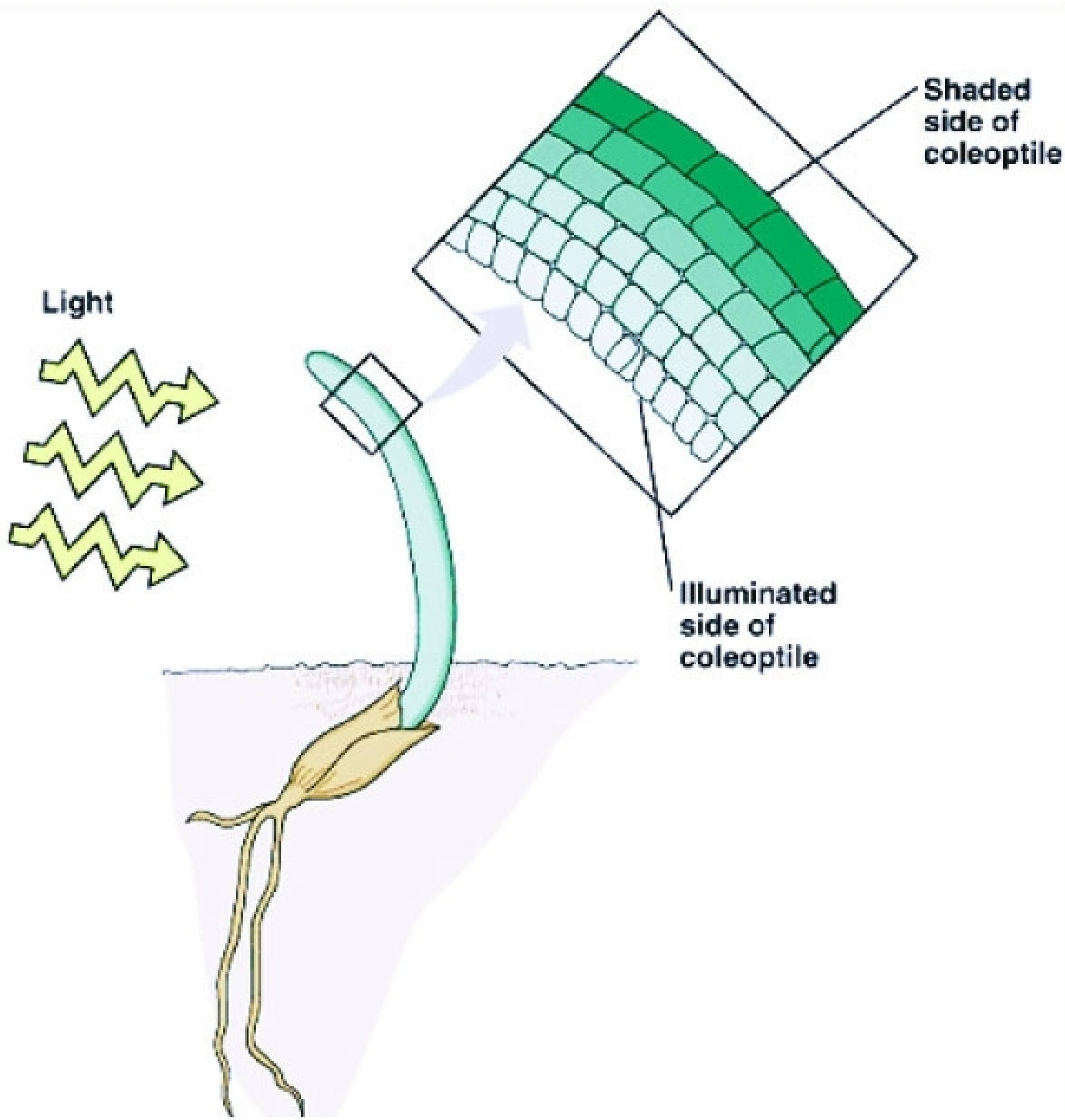
Phototropism: growth reaction to light



STEM:
positive phototropism
(growth towards light)

ROOT:
usually negative phototropism
(growth away from light)

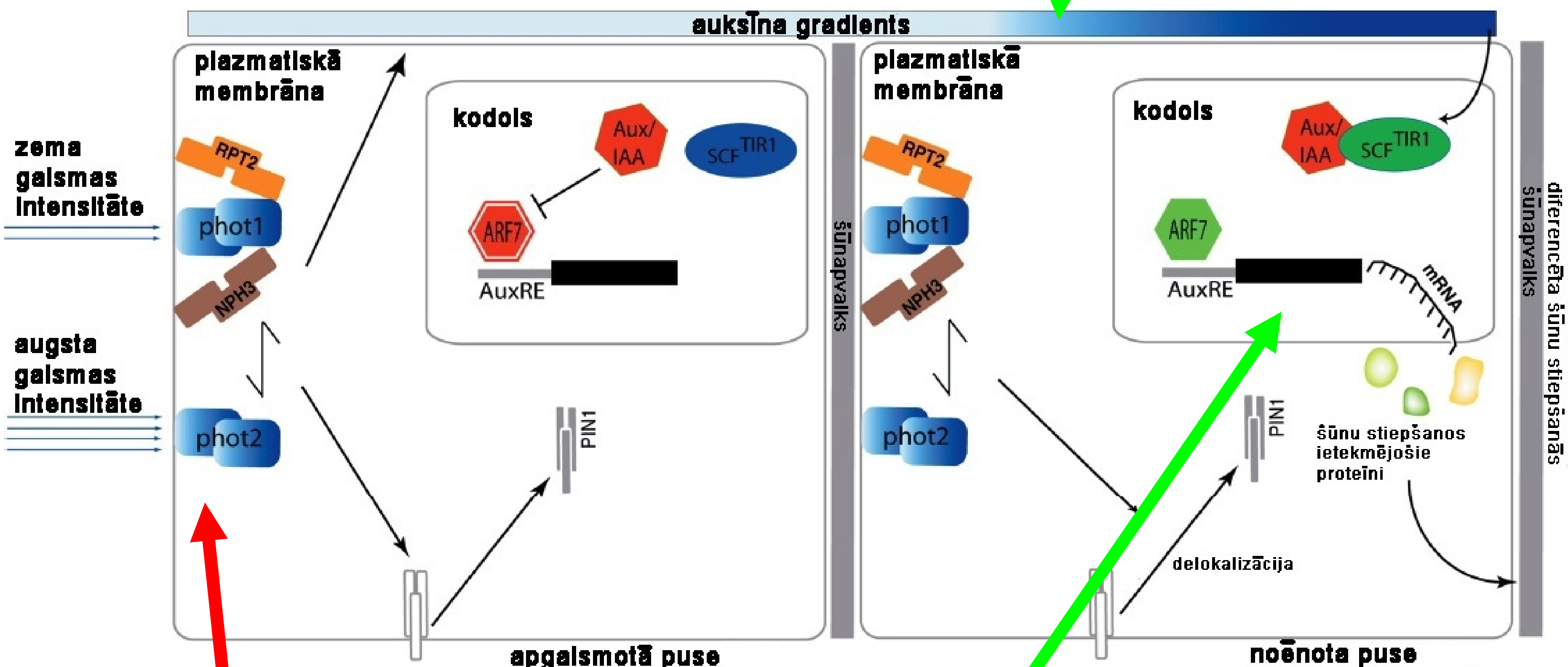
Phototropism: growth reaction to light



Phototropism: growth reaction to light

Stimulus: light

Signal transduction: formation of auxin gradient



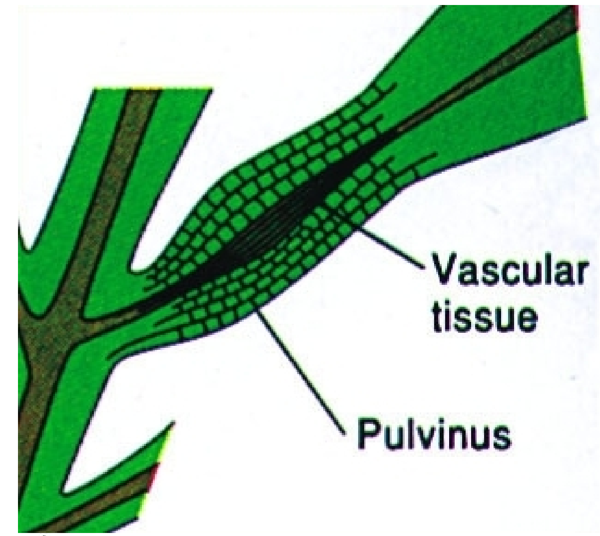
Perception of stimulus: photoreceptors

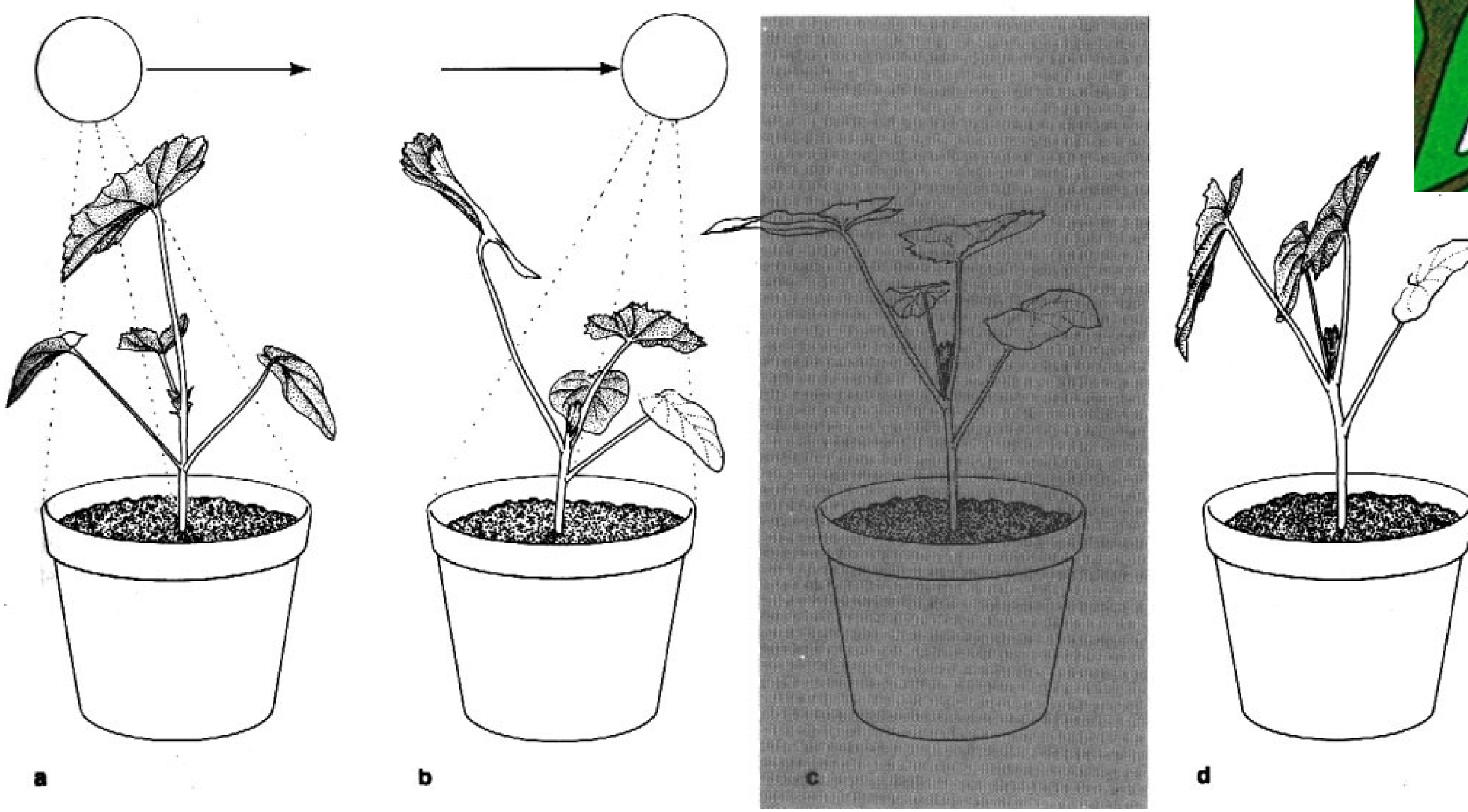
Signal transduction: exspression of specific genes

Reaction: shaded side grows faster, the plant bends

Phototropism: growth reaction to light

Change of cell turgor as a mechanism of movement

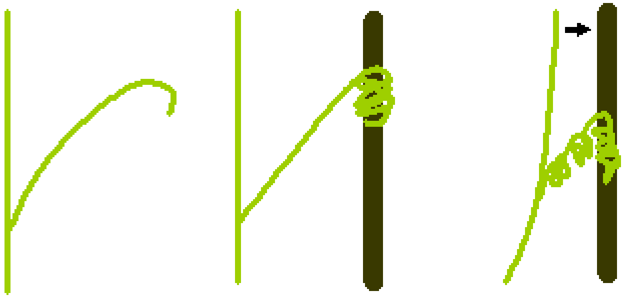




Tigmotropism: reaction to touch

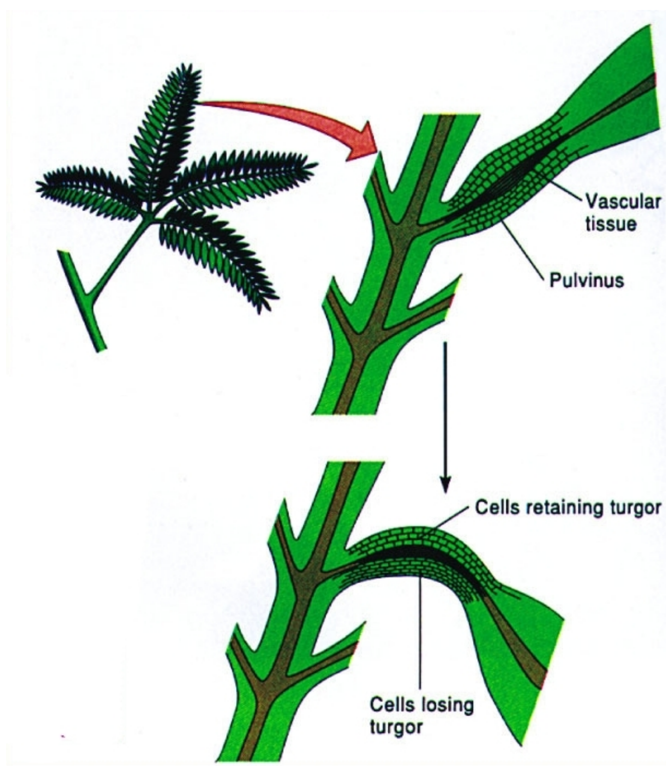
Plant has tendrils that bind around objects if the touch is percieved from the inner side

Part of the reaction mechanism is volatile growth regulator methyljasmonate



Seismonasty: reaction to touch

Mimosa pudica



- Stimulus is percieved by specialized cells sensitive to touch
- An electrical signal is generated and is translated to other cells
- Ion permeability of the cell plasma membrane is changed and results in change of turgor
- Cell size is changed and because of that — spatial orientation of the plant organ