اکسین (Auxins)

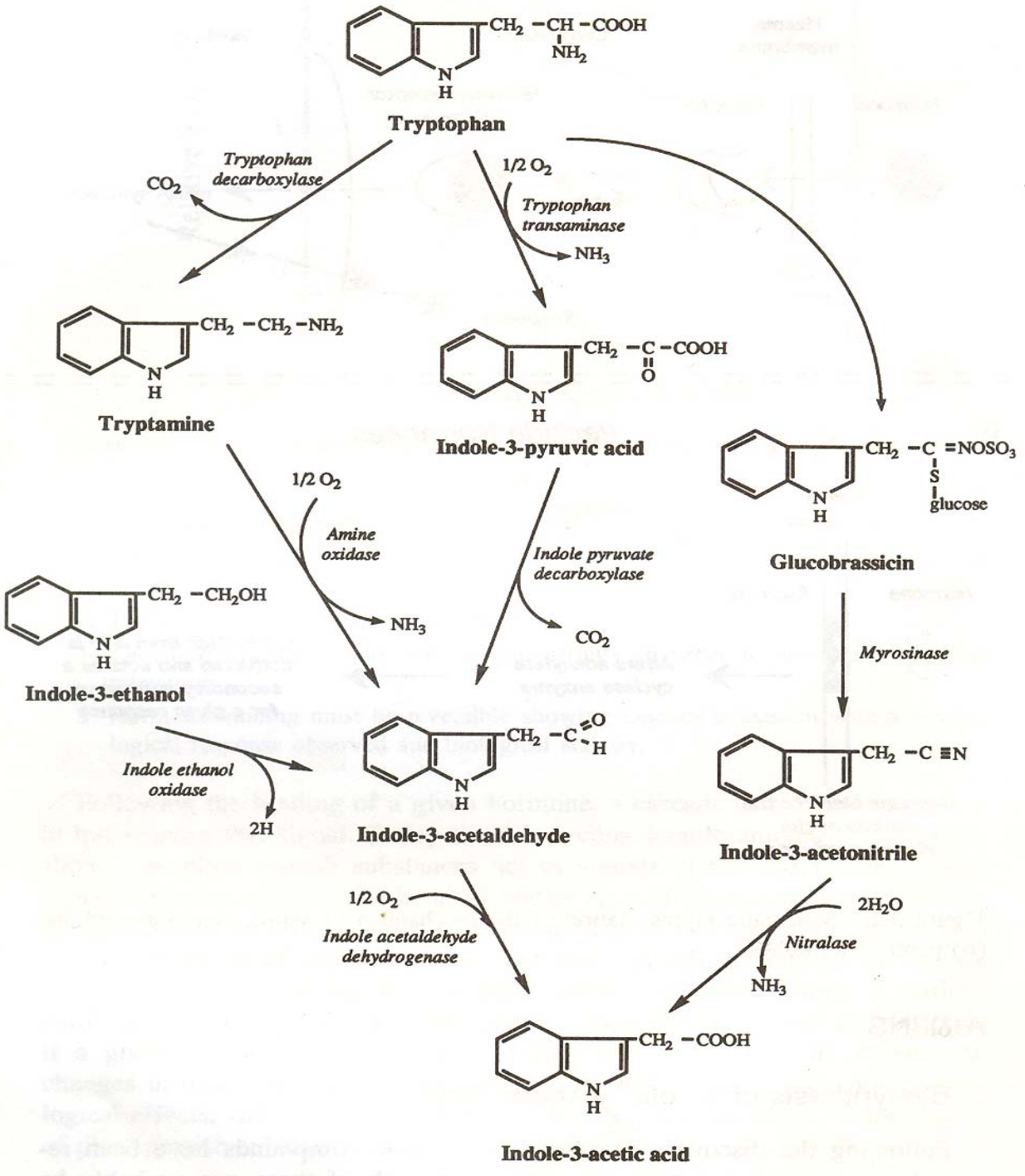
a- Biosynthesis of IAA

Thimann (1935)

- ✓ در کپک تریپتوفان می تواند تبدیل به IAA شود.

Wildman et al (1947)

- ✓ در برگ اسفناج یک سیستم آنزیمی موجود است که تریپتوفان را به IAA تبدیل می کند.


Tryptophan
Tryptophan decarboxylase
CO2
1/2 O2
Tryptophan transaminase
NH3
Tryptamine
Indole-3-pyruvic acid
Glucobrassicin
glucose
1/2 O2
Amine oxidase
NH3
Indole pyruvate decarboxylase
CO2
Myrosinase
Indole-3-ethanol
Indole ethanol oxidase
2H
Indole-3-acetaldehyde
Indole-3-acetonitrile
1/2 O2
Indole acetaldehyde dehydrogenase
2H2O
Nitralase
NH3
Indole-3-acetic acid

b-Free Versus Bound Auxins

اکسین های آزاد و باند شده

اکسین های آزاد:

۱- به آسانی به خارج بافت منتشر می شوند.

۲- به آسانی توسط حلال های مختلف می توان عصاره گیری نمود.

۳- به سرعت در تنظیم پدیده های فیزیولوژیکی بکار می رود.

Indole-3-acetaldehyde

Indole-3-acetonitrile

Indole-3-ethanol

Indole-3-pyruvic acid

تبدیل اکسین های باند شده

1- Hydrolysis تجزیه شیمیائی یک پیوند یا باند بوسیله اسید یا باز

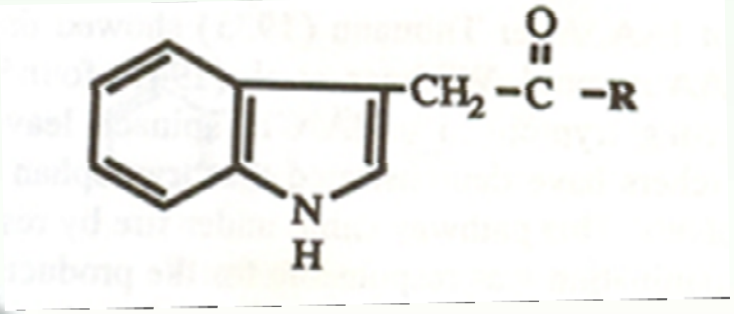
2- Enzymolysis (enzymatic breakdown)

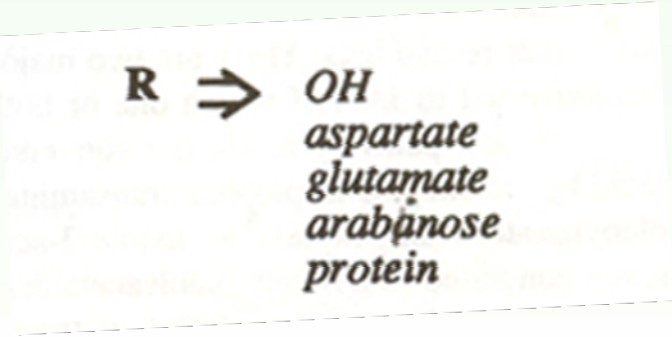
3- Autolysis (self-digestion)

اکسین های باند شده:

۱- فرم های ذخیره IAA-glucosides (گلوکوزیدهای IAA, تجزیه آنزیمی)

۲- فرم های مسمومیت زدا Detoxification (ترکیبات اسید آمینه و پروتئین، هیدرولیز اسیدی یا بازی)





C- Destruction of IAA IAAتخریب

1- Enzymatic oxidation (IAA oxidase)

2- Photo oxidation

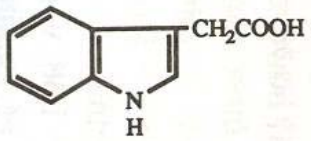
D- Synthetic Auxins

اکسین های سنتز شده ترکیباتی هستند که در تاثیرگذاری مشابه با IAA و حتی قویتر اما از نظر ساختمانی متفاوتند:

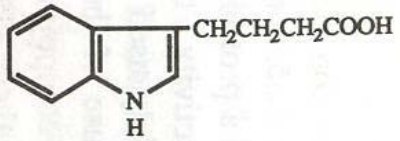
۶ گروهند که دو گروه خاصیت علف کشی دارد.

ترکیبات آزاد- نمک ها- نمک های آمینه

Indoles



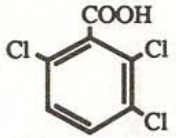
Indole-3-acetic acid
(IAA)



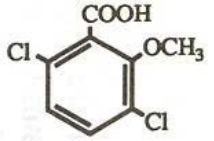
Indole-3-butyric acid
(IBA)

مشتقات ایندول

Benzoic acids



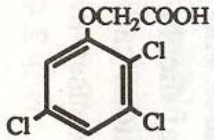
2,3,6-trichlorobenzoic acid



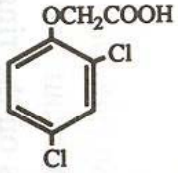
2-methoxy-3,6-dichloro-
benzoic acid
(dicamba)

اسیدهای بنزوئیک

Chlorophenoxy acids



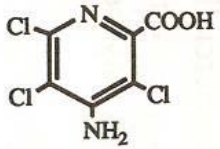
2,4,5-Trichlorophenoxy
acetic acid
(2,4,5-T)



2,4-dichlorophenoxy
acetic acid
(2,4-D)

۱ کلروفنوکسی استیک اسید

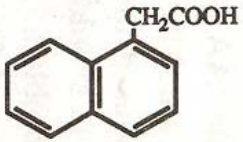
Picolinic acids



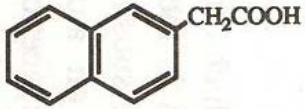
4-amino-3,5,6-trichloro-
picolinic acid
(Tordon or pichloram)

۱ پیکولینیک اسید

Naphthalene acids



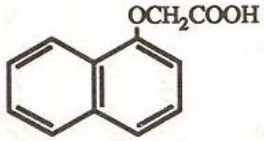
α-Naphthalene acetic acid
(α-NAA)



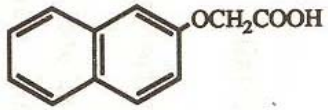
β-Naphthalene acetic acid
(β-NAA)

اسیدهای نفتالن

Napthoxy acids



α-Napthoxyacetic acid



β-Napthoxyacetic acid

نفتوکسی استیک اسید

Auxin Transport

F. Went (1934): basipetal

Jacobs (1961): $\frac{\text{acropetal}}{\text{basipetal}} = \frac{1}{3}$

سرعت حرکت در ساقه basipetal ۶-۲۶mm/h

سرعت حرکت در ریشه basipetal ۱-۲mm/h

حرکت اکسین در گیاه active فعال است.

✓ **Danielli (1954)**

خصوصیات حرکت فعال در گیاه را توصیف نموده است:

۱- سرعت حرکت ترکیب باید بیشتر ازسرعت diffusion باشد.

۲- ترکیب باید به وسیله نیروهای متابولیکی به جلو برده شود.

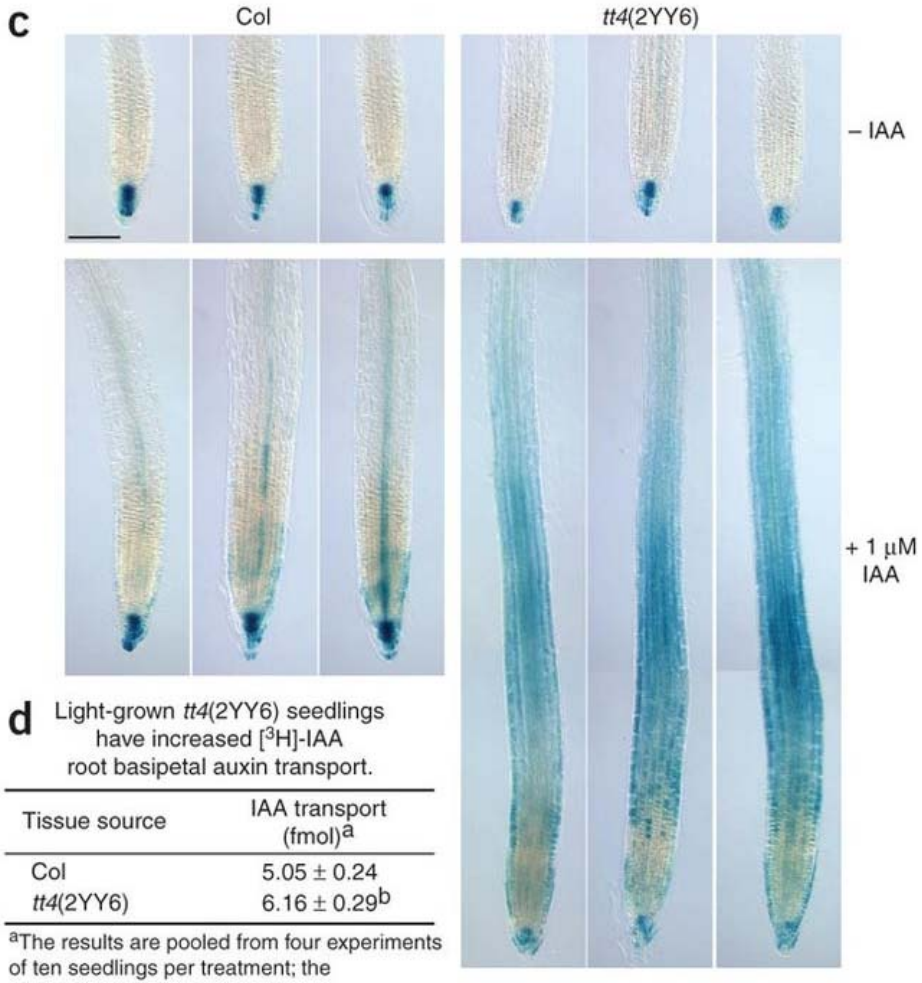
۳- ترکیب برخلاف شیب غلظت حرکت کند.

۴- سیستم انتقال بایستی برای یک ترکیب خاص اختصاصی باشد.

۵- ترکیبی که منتقل میشود باید یک اثر اشباع نشان دهد

- این انتقال به دو روش قابل اندازه گیری است:
- 1- سنجش حیاتی روی قطعه آگار پائینی
- اندازه گیری آن بوسیله کروماتوگرافی

2- نشان دار کردن



d Light-grown *tt4*(2YY6) seedlings have increased [^{3}H]-IAA root basipetal auxin transport.

Tissue source	IAA transport (fmol)[a]
Col	5.05 ± 0.24
tt4(2YY6)	6.16 ± 0.29[b]

[a]The results are pooled from four experiments of ten seedlings per treatment; the average and SE are reported.
[b]Significantly different as judged by Student's *t* test, $P = 0.005$.

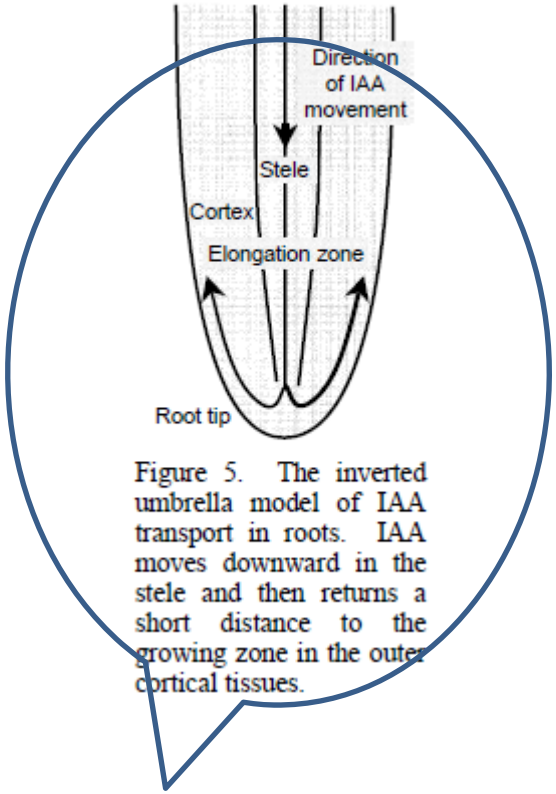
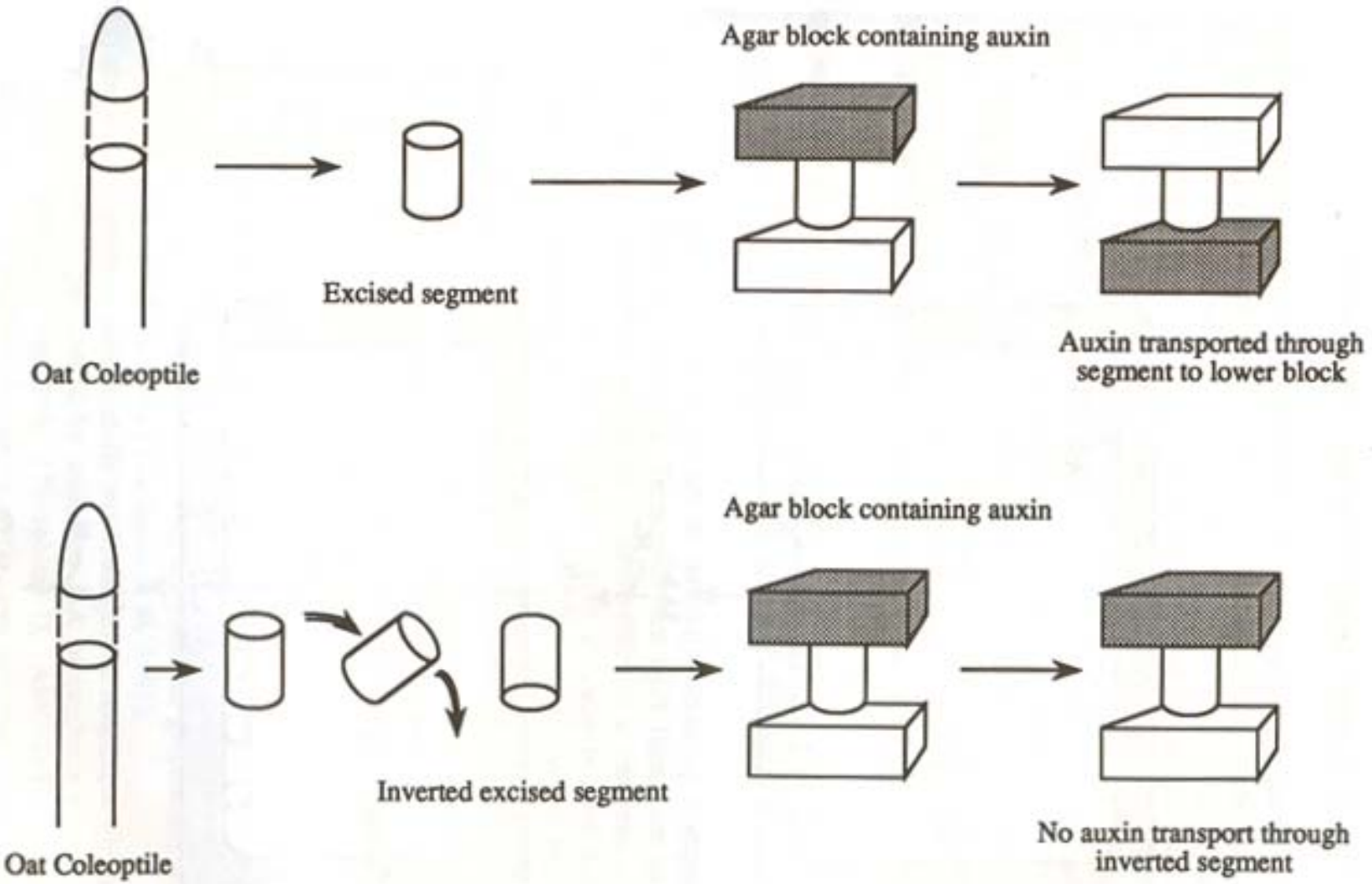


Figure 5. The inverted umbrella model of IAA transport in roots. IAA moves downward in the stele and then returns a short distance to the growing zone in the outer cortical tissues.

آزمایش انتقال IAA



فرضیه Chemiosmotic
انتقال قطبی IAA

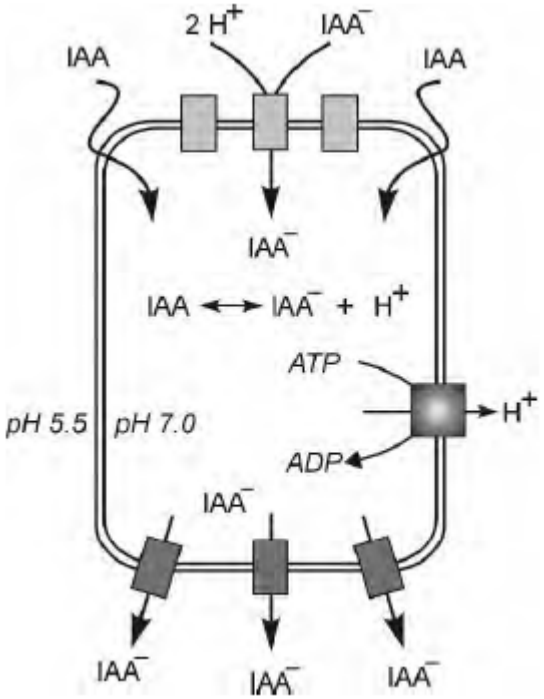
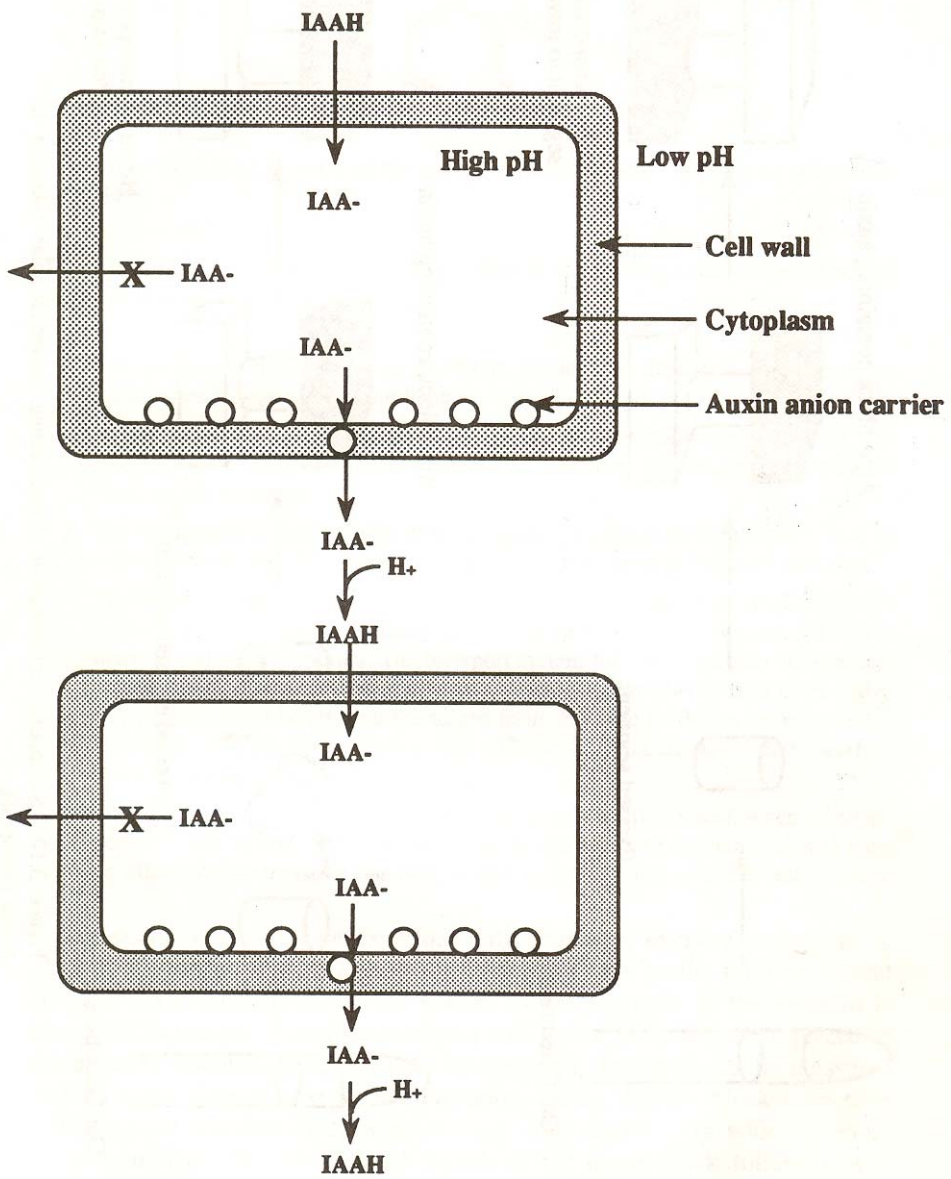
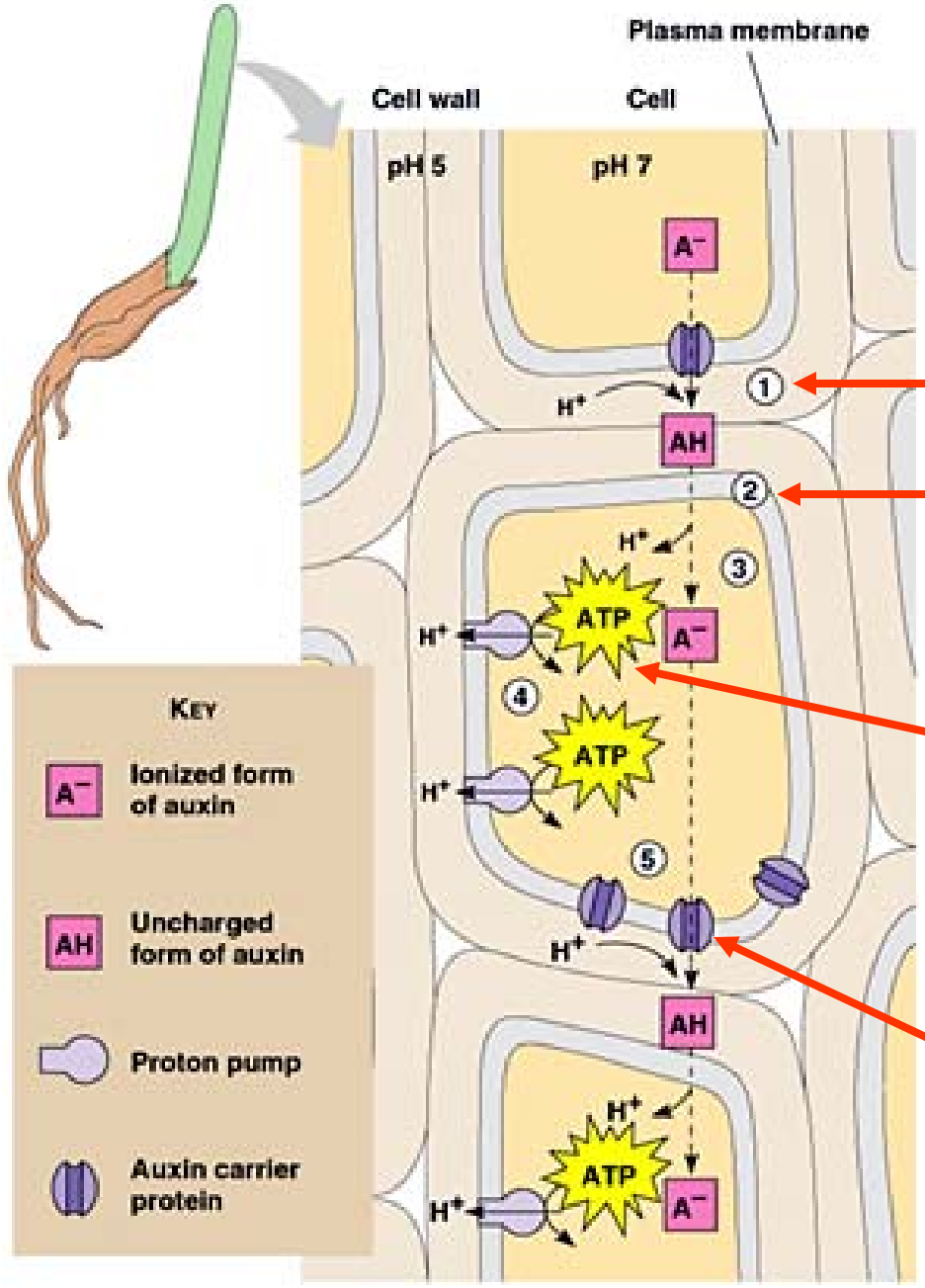


Figure 3. Components of transmembrane auxin transport according to the chemiosmotic polar diffusion model (33). A membrane pH gradient (maintained by plasma membrane H^+-ATPases) drives diffusive accumulation of undissociated auxin molecules. At the higher pH of the cytoplasm, some of the auxin molecules which enter the cell dissociate. The plasma membrane is relatively impermeable to auxin anions (IAA^-), which are "trapped" in the cytoplasm and can only exit or enter the cell through the action of specific influx (upper; light shading) and efflux (lower; heavy shading) carrier systems. Asymmetry in the distribution of the two carrier systems, more especially the efflux carrier, results in a net polar transport of auxin through the cell.



- A component of auxin transport, which is highly polar, appears to be catalyzed by auxin efflux carriers, membrane proteins thought to pump auxin molecules from the interior of cells into the surrounding extracellular space, or apoplast, from where they can enter neighboring cells. In this model, an **asymmetric distribution of auxin carrier** proteins within the plasma membrane, defines the direction of auxin transport.

Polar transport of auxin



Transport at ~1 cm/hr implies active transport

Picks up a hydrogen ion at the acid wall environment

Passes across membrane as a neutral molecule

Gives off the H^+ into the cell which induces the proton pump

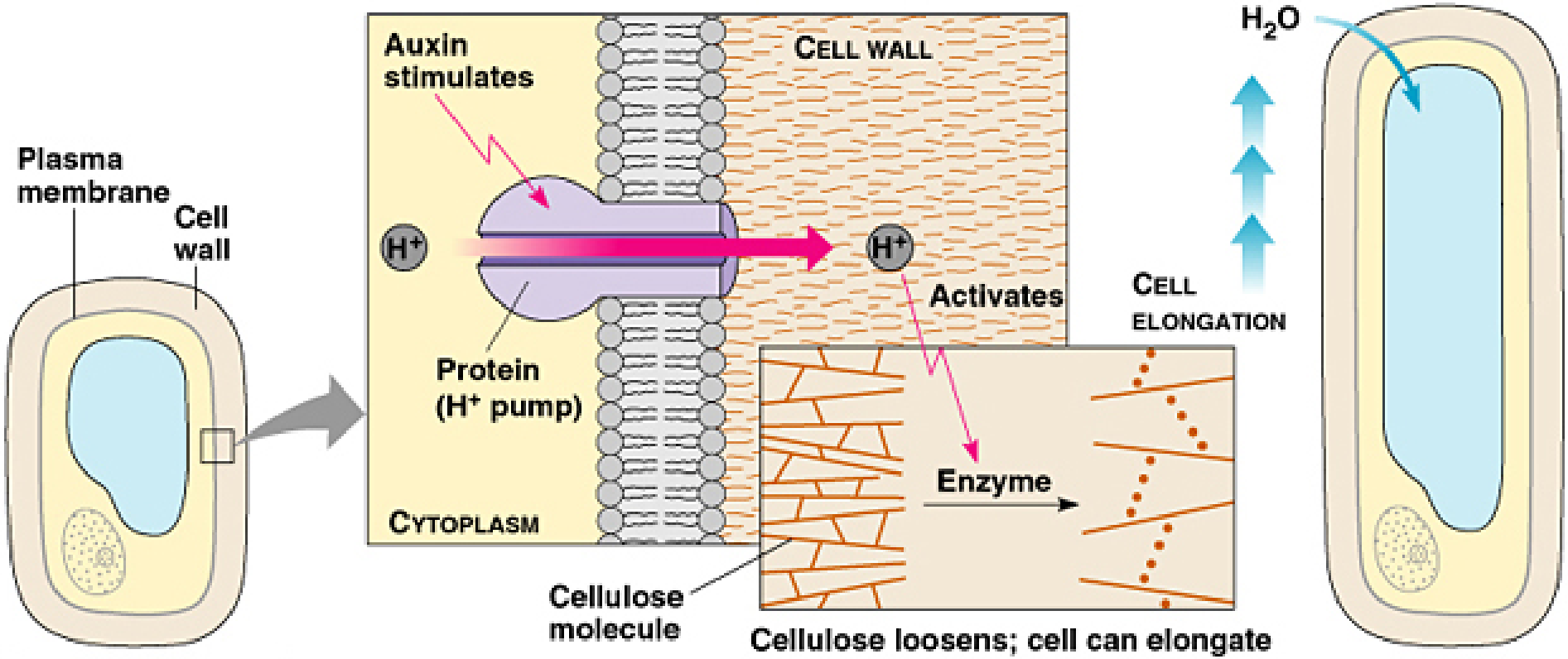
Auxin can only exit the cell at its basal end where there are specific carrier proteins

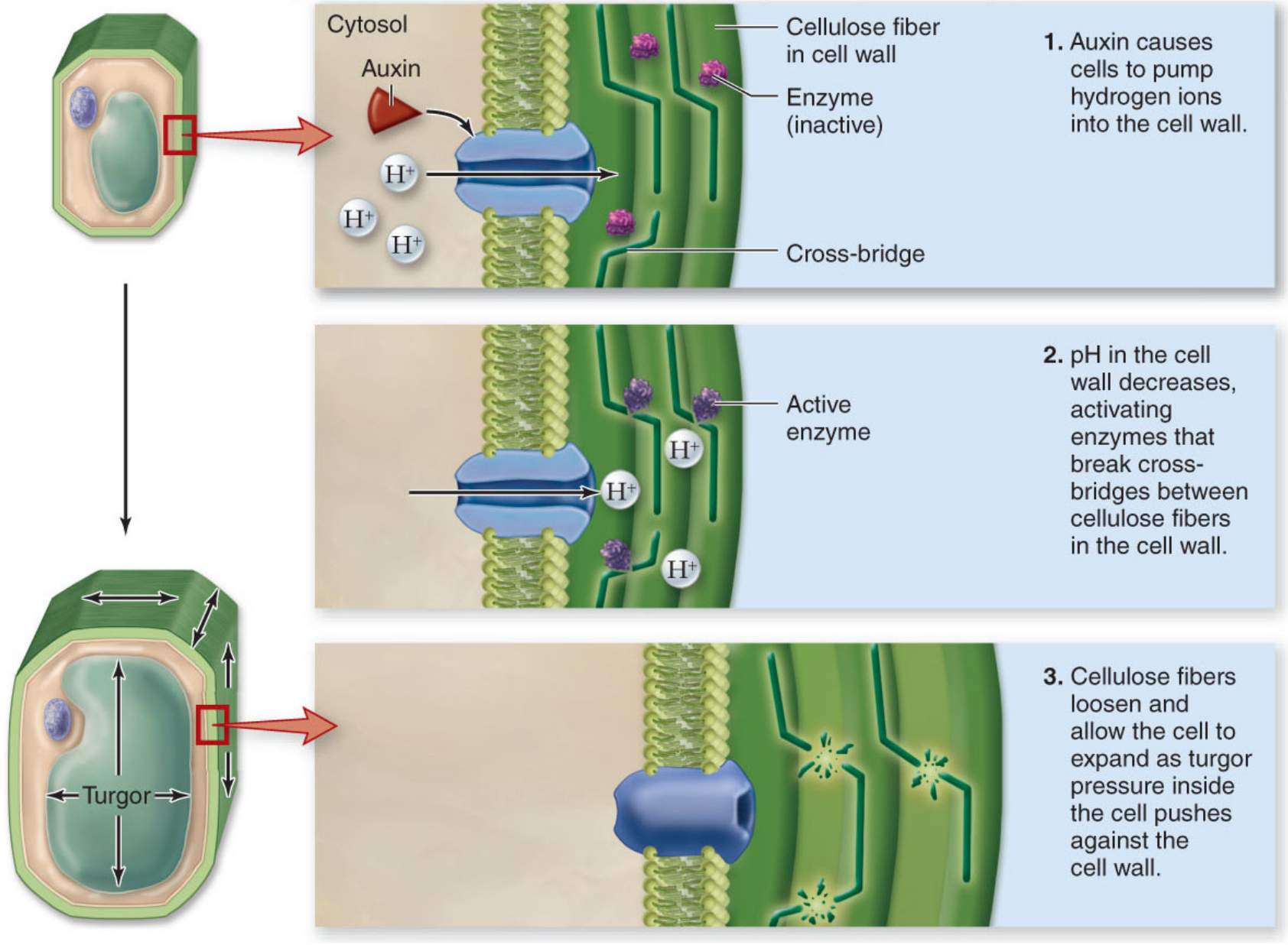
E- Physiological Effects of IAA

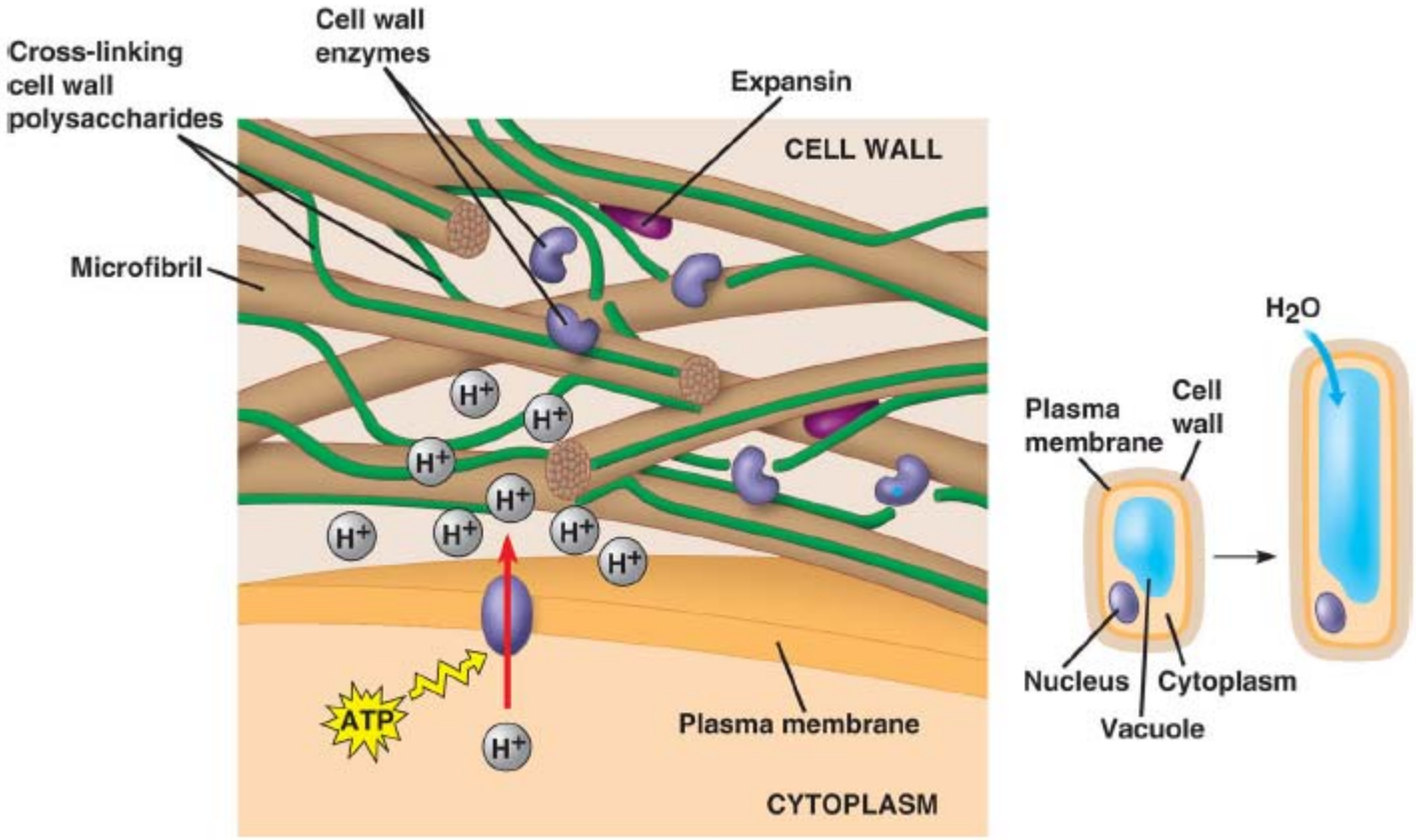
1- Cellular Elongation طویل شدن سلولی

مراحل طویل شدن سلولی

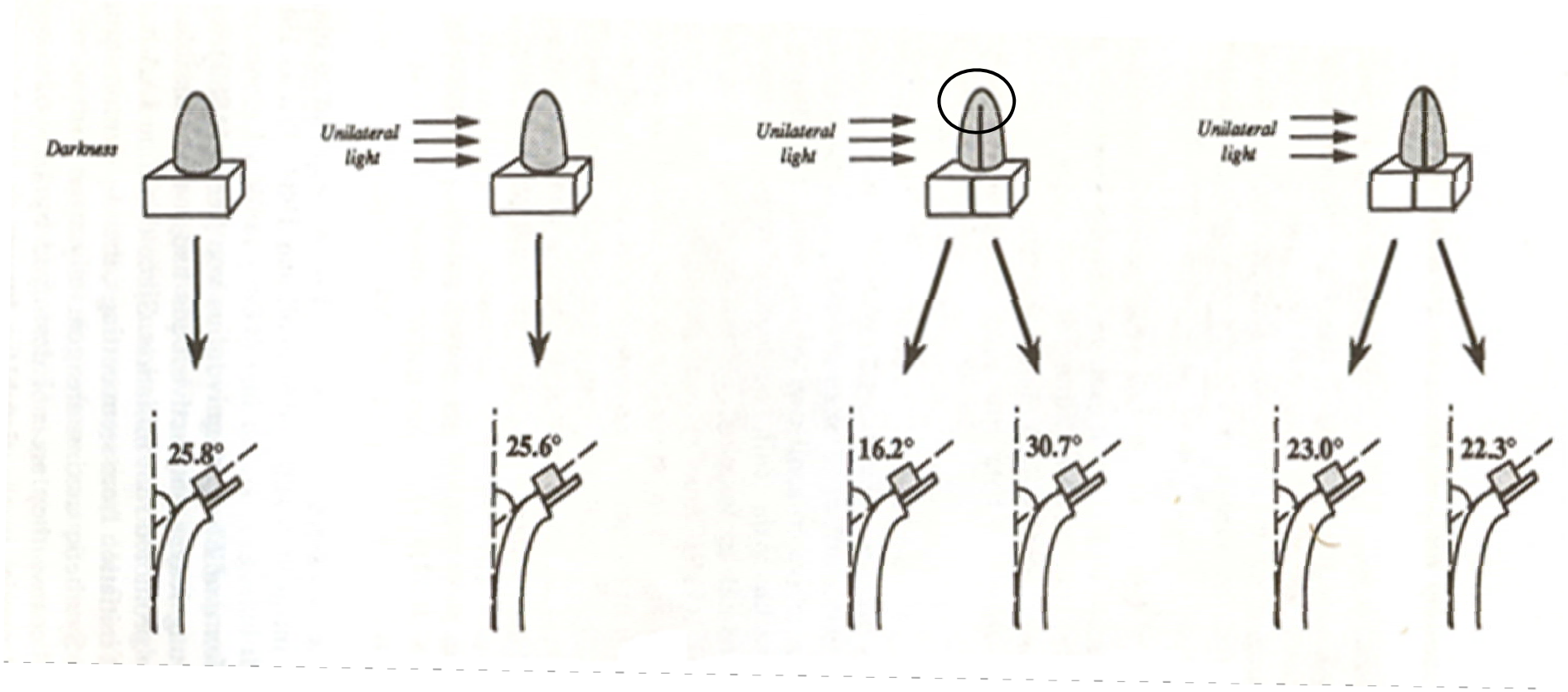
The acid growth hypothesis



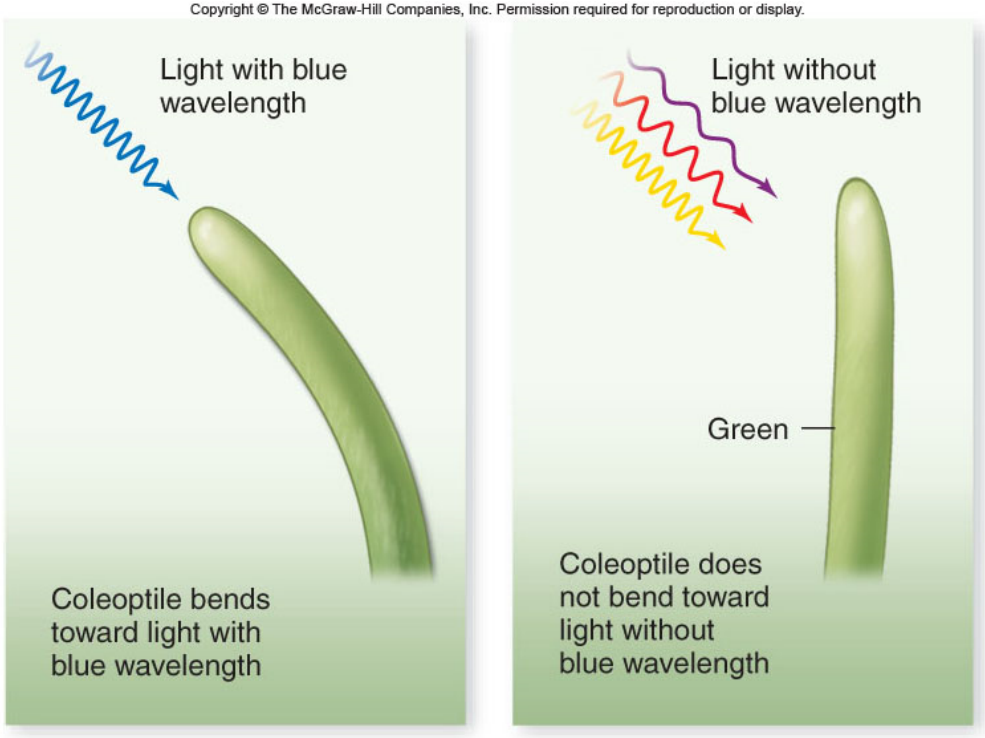



Cell wall enzymes
Cross-linking cell wall polysaccharides
Expansin
CELL WALL
Microfibril
H+
ATP
Plasma membrane
CYTOPLASM
H2O
Plasma membrane
Cell wall
Nucleus
Cytoplasm
Vacuole

2- Phototropism نورگرائی



Phototropic responses including the bending of growing stems to sources of light with blue wavelengths (460-nm range)



Phototropisms photoreceptor

A blue-light receptor **phototropin 1 (PHOT1)** has been characterized

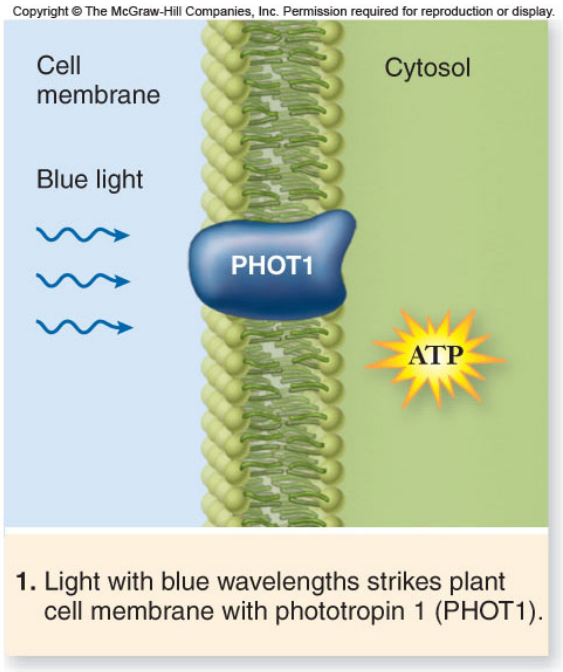
-Has two regions

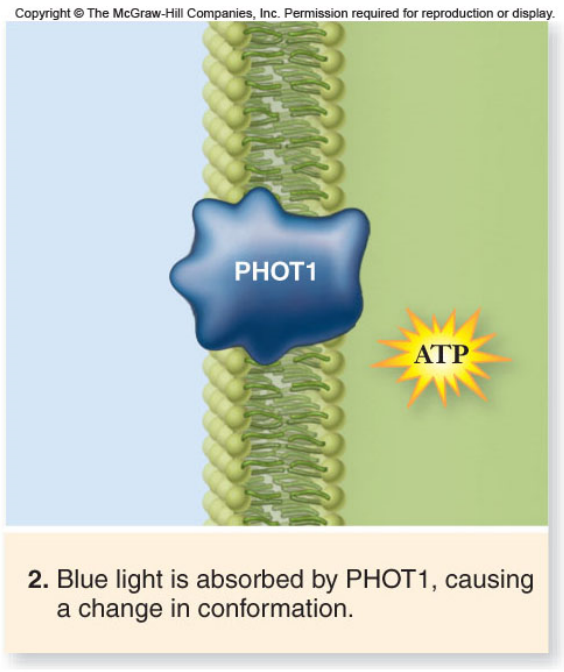
-Blue-light activates the light-sensing region of PHOT1

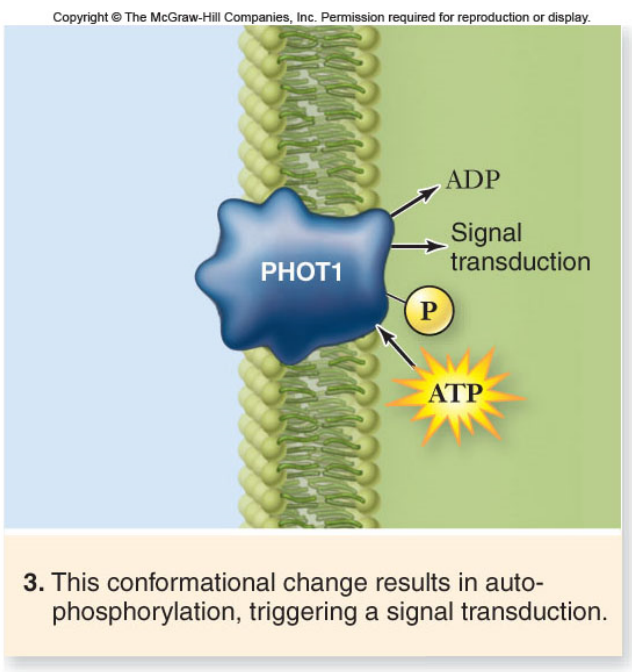
-Stimulates the kinase region of PHOT1 to autophosphorylate

-Triggers a signal transduction

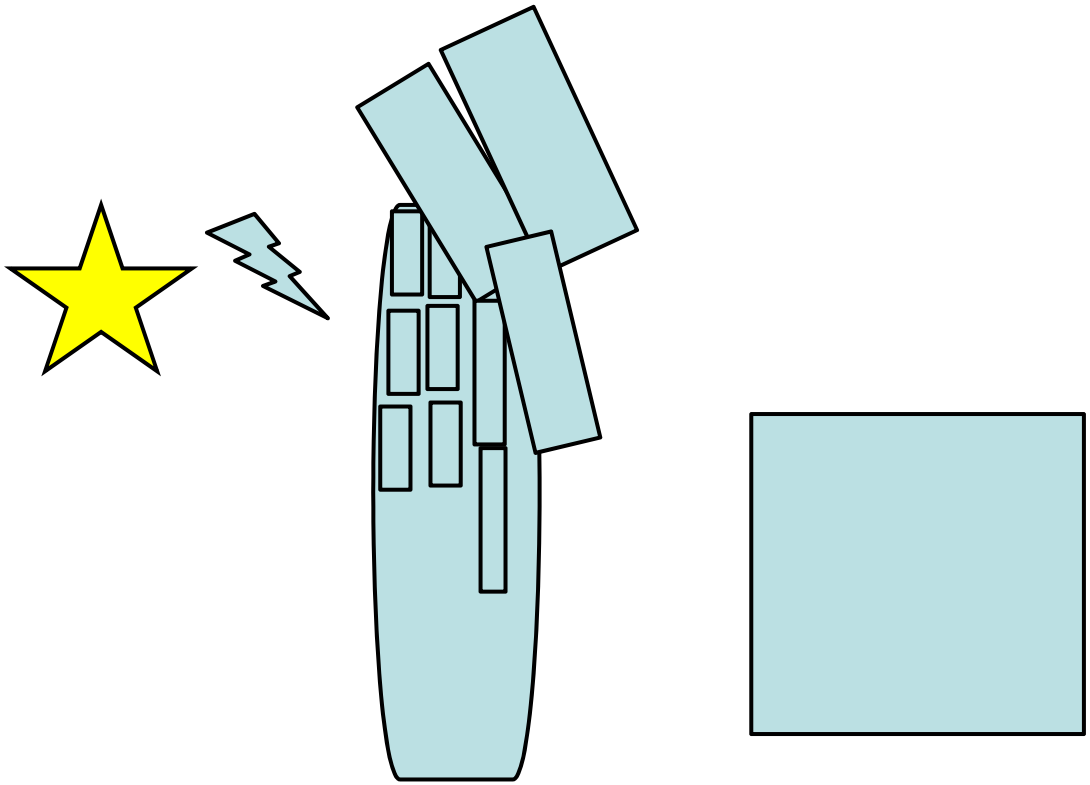
Phototropisms

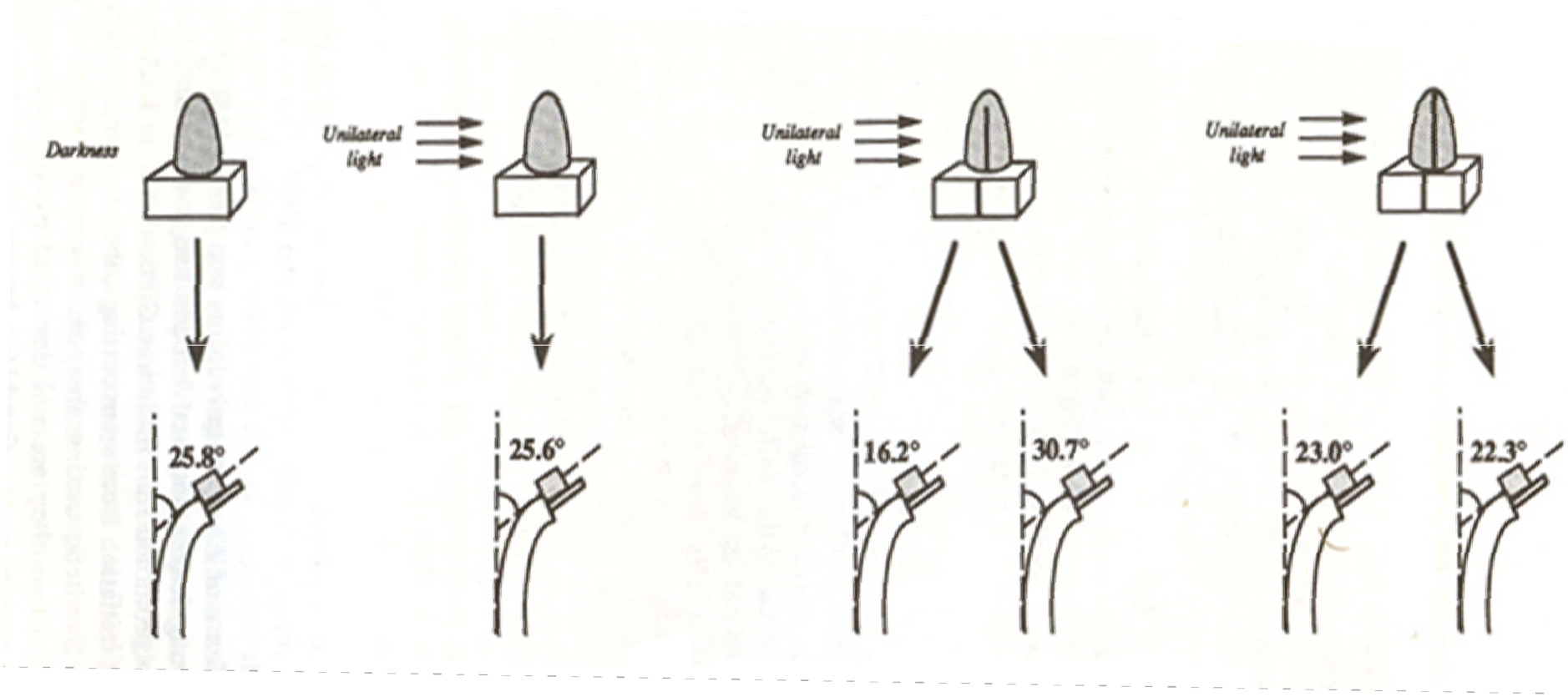






A **protein kinase** is a **kinase** enzyme that modifies other molecules, mostly **proteins**, by chemically adding phosphate groups to them (phosphorylation)



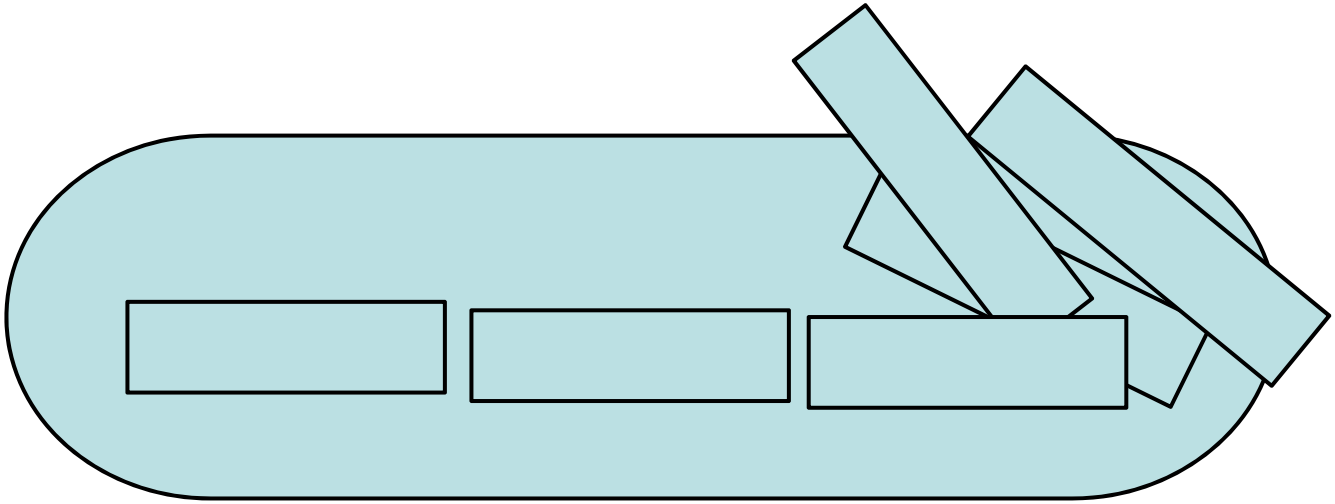

Darkness
25.8°
Unilateral light
25.6°
Unilateral light
16.2°
30.7°
Unilateral light
23.0°
22.3°

Responses to Gravity

Gravitropism is the response of a plant to the gravitational field of the Earth

-Shoots exhibit negative gravitotropism; roots have a positive gravitropic response

© Ray Evert



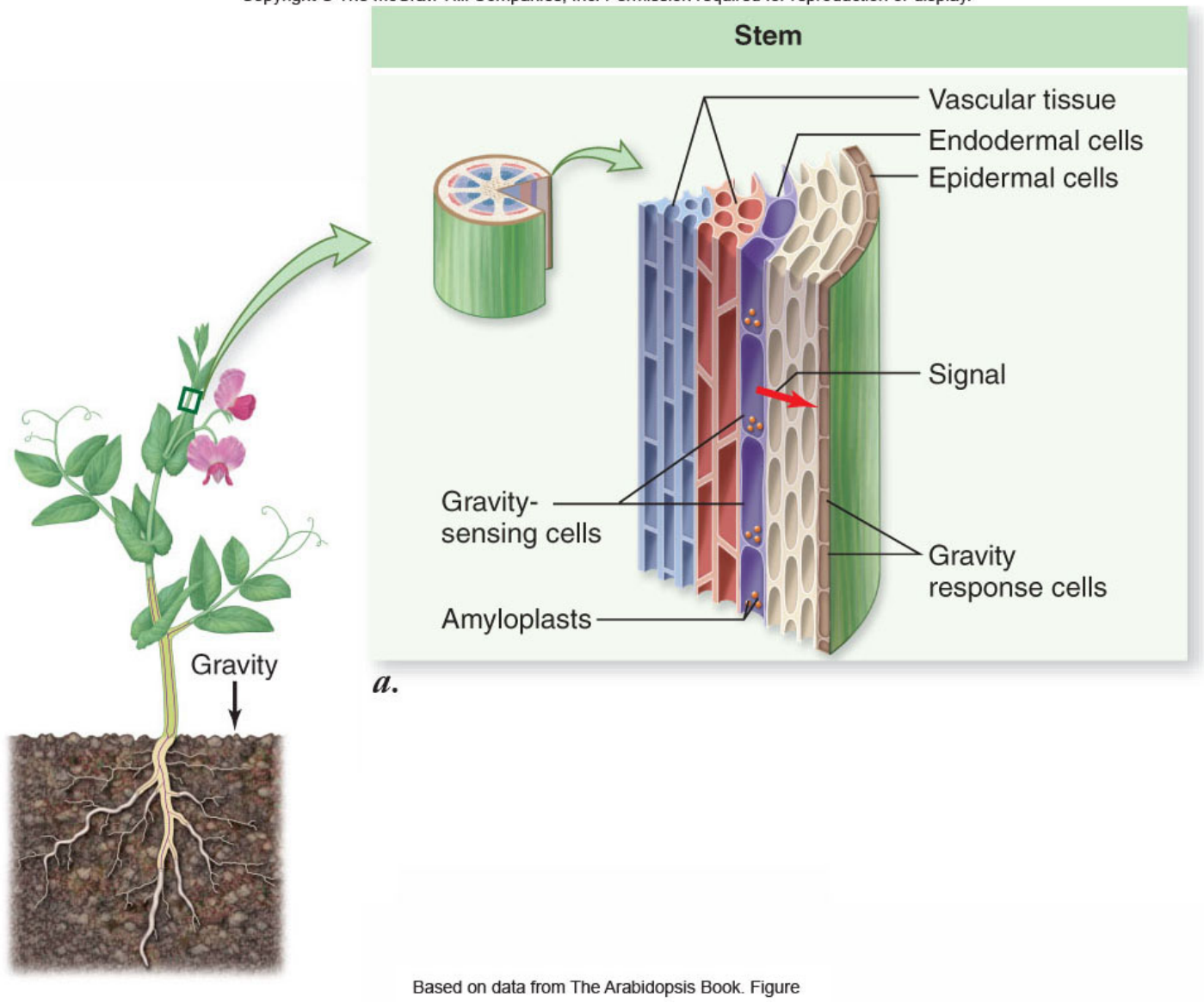
Responses to Gravity

In shoots, gravity is sensed along the length of the stem in endodermal cells surrounding the vascular tissue

-Signaling is in the outer epidermal cells

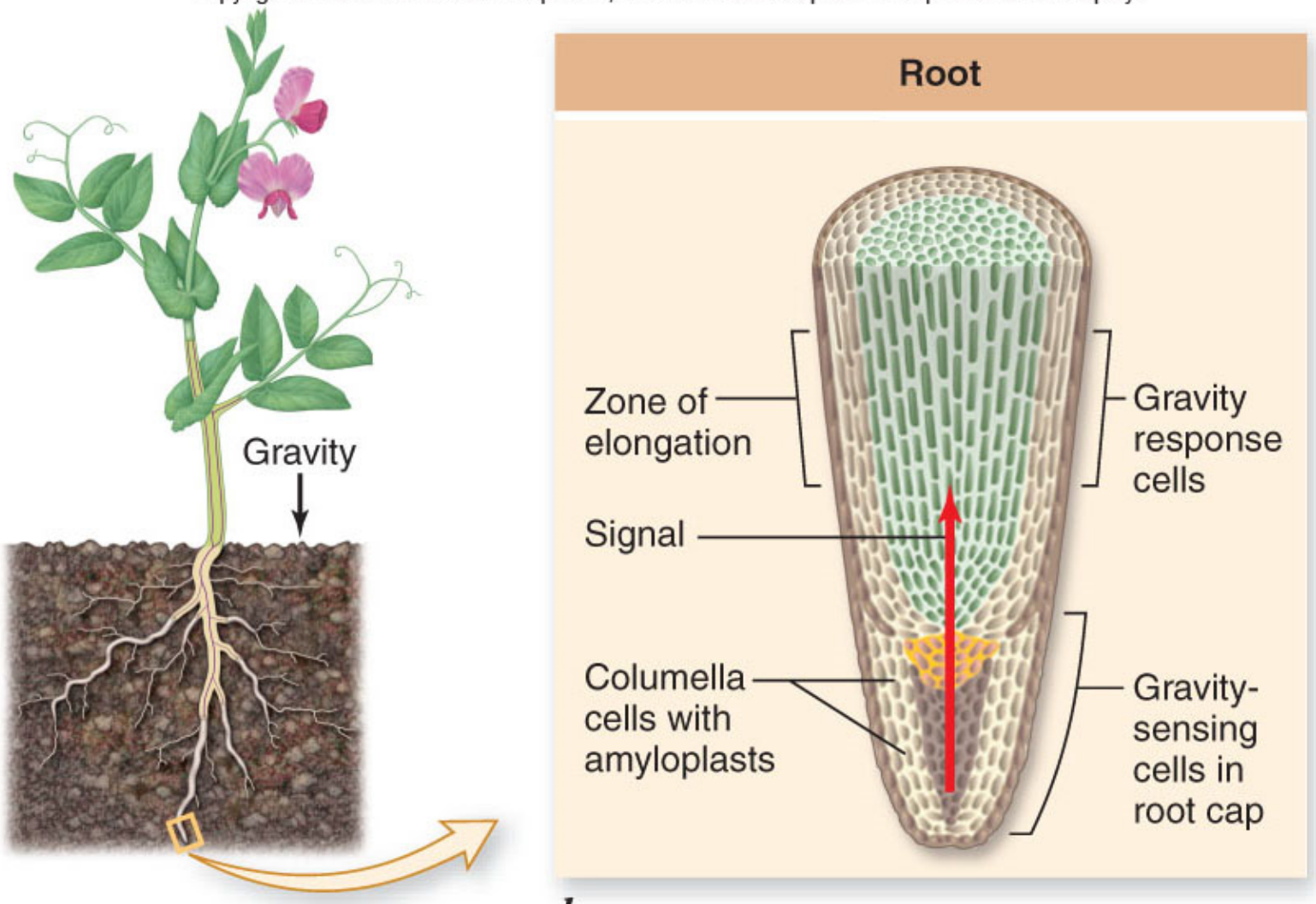
In roots, the cap is the site of gravity perception

-Signaling triggers differential cell elongation and division in the elongation zone



Based on data from The Arabidopsis Book. Figure

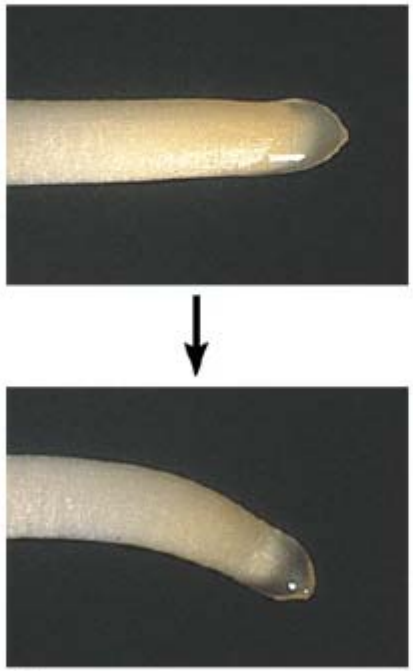
استاتولیتها دانه های بسیار ریز نشاسته هستند که به وسیله غشایی احاطه شده و غالبا در سلولهای بافتهای در حال رشد یافت میشوند



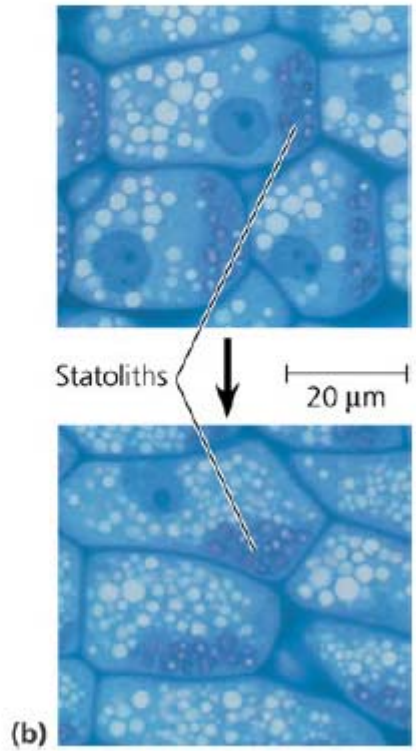
b.

Based on data from The Arabidopsis Book. Figure

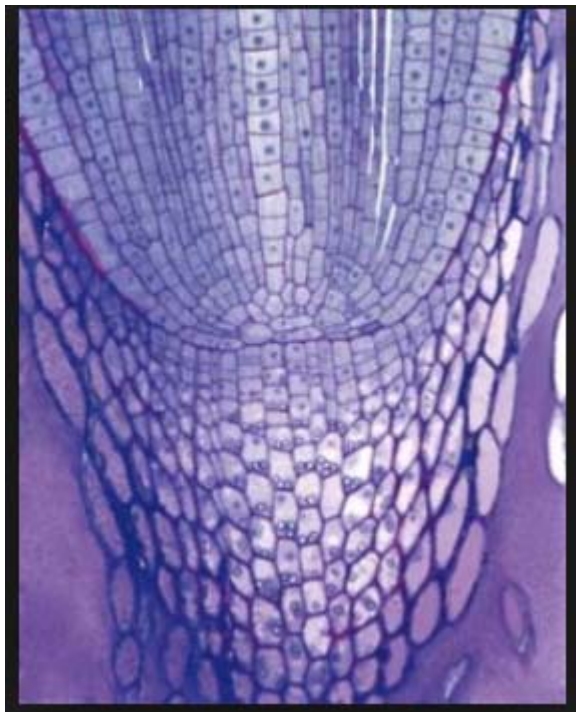
Gravitropism



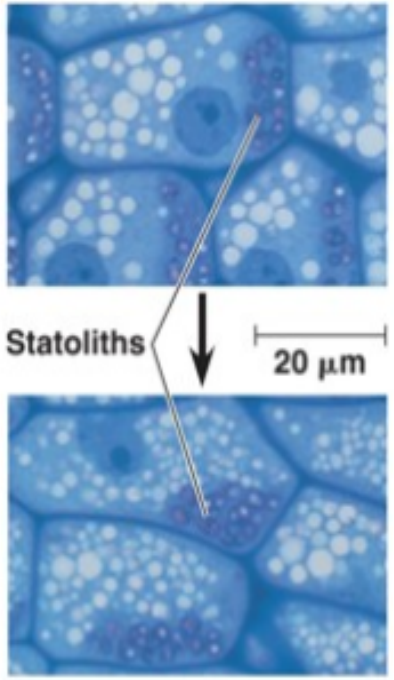
(a)



(b)



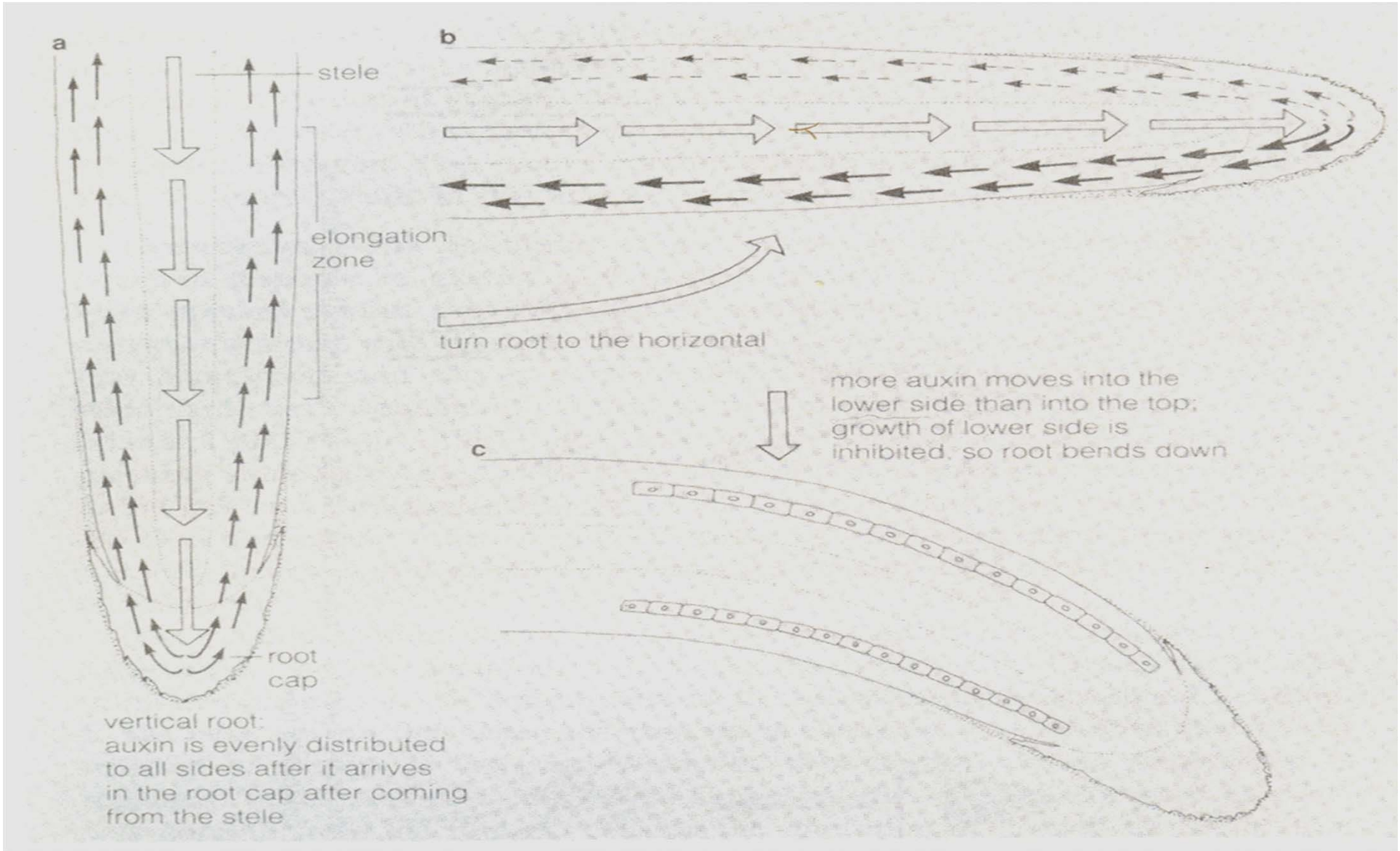
- Plants may detect gravity by settling of **statoliths**, specialized plastids containing dense starch grains located in lower portions of cells (in roots, certain root cap cells)
  - Aggregates at lower points trigger redistribution calcium, which causes lateral transport of auxin root
  - Calcium/auxin accumulate on lower side of root's zone of elongation
  - At high concentrations, auxin inhibits cell elongation, slowing growth on root's lower side
  - More rapid elongation on upper side causes root to curve as it grows



(b) Statoliths settling

  - Still occurs in plants w/no statoliths (dense organelles, in addition to starch granules, may contribute to gravity detection)

3- Geotropism



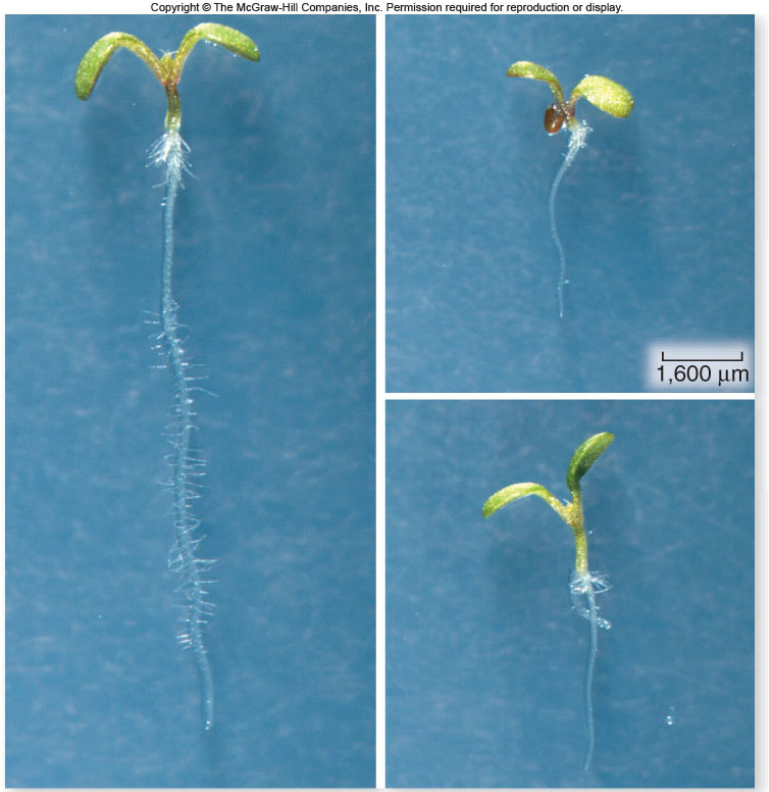
Stem Response to Gravity

Auxin accumulates on lower side of the stem

-Results in asymmetrical cell elongation and curvature of the stem upward

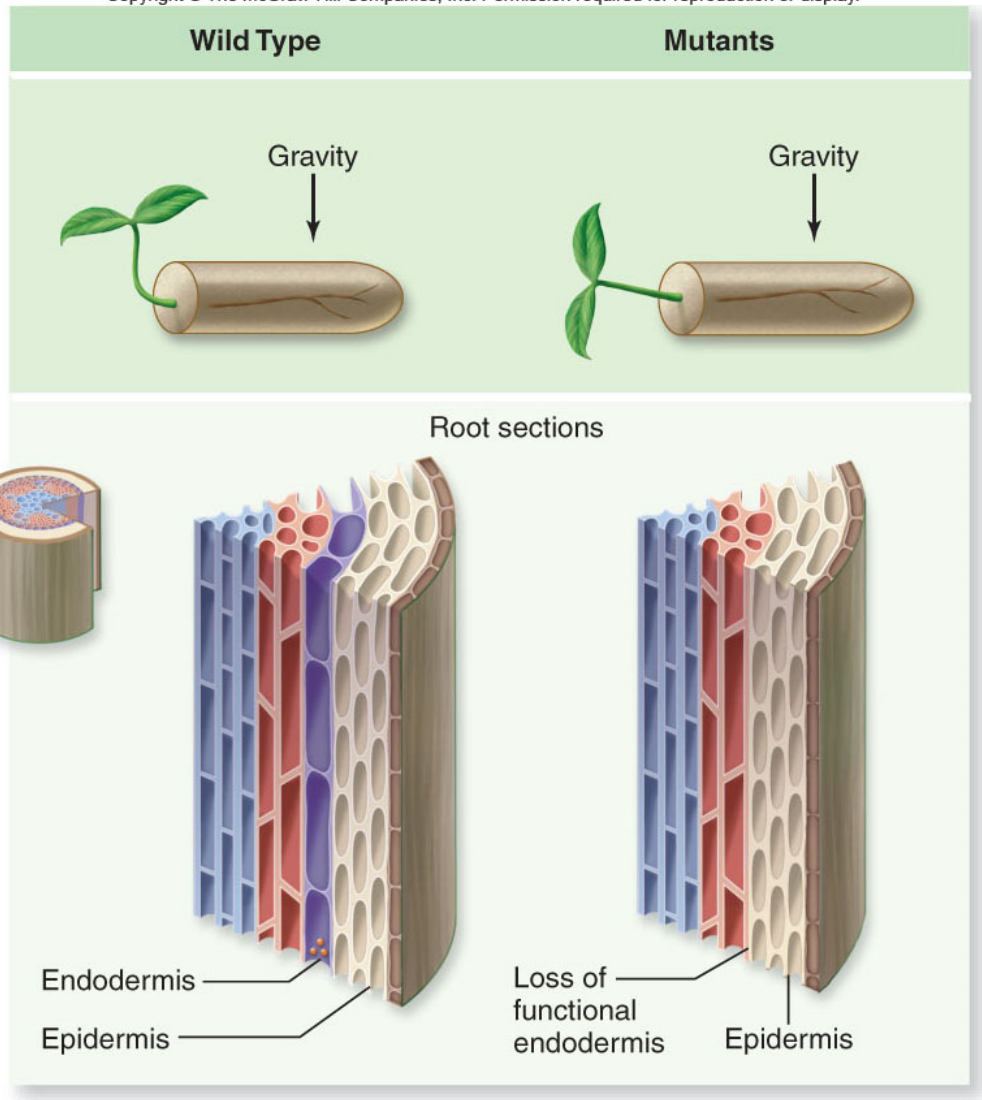
Two *Arabidopsis* mutants, *scarecrow* (*scr*) and *short root* (*shr*) do not show a normal gravitropic response

-Due to lack of a functional endodermis and its gravity-sensing amyloplasts



a.

Based on data from The Arabidopsis Book



b.

(all): Jee Jung & Philip Benfey

Root Response to Gravity

Lower cells in horizontally oriented root cap are less elongated than those on upper side

-Upper side cells grow more rapidly causing the root to ultimately grow downward

Auxin may not be the long-distance signal between the root cap and elongation zone

-However, it has an essential role in root gravitotropism