Unit 6 · Plant Growth and Movement

STUDY NOTES

WHAT NEB'S GRADE 12 EXAM ASKS

- **CDC's grid (2078):** Plant Physiology (Units 2–6 together): 11 of 75 marks; 3 MCQs (knowledge, application, higher ability) and 1 long question (8 marks: knowledge 1, understanding 3, application 2, higher ability 2)
- **The paper:** Botany 37 + Zoology 38; each part: MCQs × 1 (5 Botany, 6 Zoology) · 4 short × 4 · 2 long × 8; one OR in each short and long group; 3 hours; 1 mark per expected point
- **MCQ (1 mark)**
  - hormones again (IAA, Went, 2,4-D, bakanae, zeatin, bolting)
  - hypogeal; moisture; *Rhizophora* viviparous
  - dormancy; physical dormancy of legumes
  - photoperiodism; LDP 14–16 h; radish
  - senescence; vernalization at 0–5 °C, hydrated seeds
  - autonomic; *Desmodium*; tropism; seismonasty
- **Short and long (in parts)**
  - phytohormones; apical dominance; bolting, parthenocarpy
  - seed germination process
  - dormancy: factors, advantages
  - photoperiod classes, two examples each; SDP vs LDP
  - senescence; abscission: significance
  - vernalization and significance
  - autonomic growth movements; paratonic movements; tropisms
  - nastic movements of *Drosera* and *Mimosa*

Key terms

Seed: mature ovule after fertilization; coat (**testa** outside, **tegmen** inside), **micropyle**, **hilum**, embryo (cotyledons, radicle, plumule), endosperm or not.

Germination: irreversible reactivation of the embryo; ends in the radicle and plumule coming out.

Hypocotyl: axis below the cotyledons, ends in the radicle; **epicotyl**: above, ends in the plumule.

Scarification: weakening a hard seed coat.

Vivipary: seed germinates on the parent plant.

Seed dormancy: a **viable** seed fails to germinate in favorable conditions.

Stratification: moist cold given to seeds in moist sand.

Photoperiodism (Garner and Allard, 1920): response, mainly flowering, to the relative length of day and night.

Critical day length: day length that separates flowering from not, for each plant.

Phytochrome: leaf pigment; red light activates it, far-red reverses it.

Senescence: deteriorating, **catabolic** phase ending an organ's or organism's life.

Abscission: shedding of leaves, flowers, fruits at the **abscission layer**.

Vernalization (yarovization): flowering promoted by cold on a **hydrated** seed or growing plant.

Autonomic movement: from within, no outside stimulus; **paratonic** (induced): by an outside stimulus.

Tropism: directional growth curvature; **nastic**: direction fixed by the organ; **taxis**: a whole organism swimming to or from a stimulus.

Seed germination

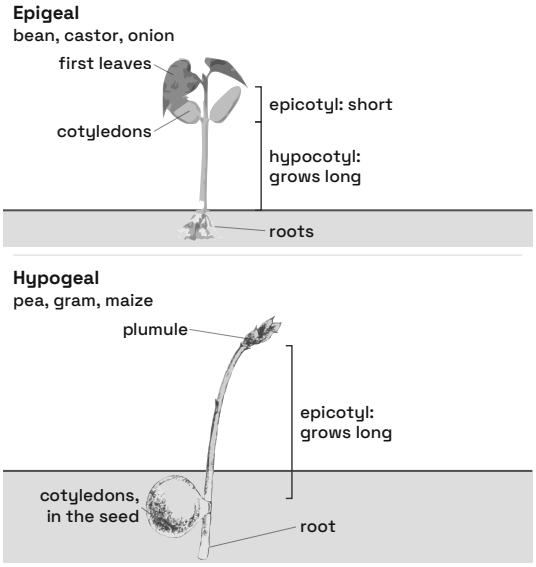
1. **imbibition**: water in through micropyle and coat; seed swells, coat bursts; hydrolytic enzymes → sugars, amino acids
2. **respiration**: fast; needs **oxygen** (sow shallow, drain fields)
3. **light**: most indifferent; lettuce, tobacco, forest-floor seeds need it

4. **temperature**: many 16–24 °C; vegetables 24–32 °C; radish, spinach down to 4 °C
5. **scarification**: fire, soaking, animal gut; sandpaper, nicking, hot water, acid
6. **reserves and hormones**: ABA inhibits; gibberellin promotes (α-amylase)
7. **embryo axis**: radicle out first, grows down; plumule up

- needs: **water** (main factor), temperature, oxygen, sometimes light
- soaked gram seeds ~2× the mass of dry ones

	Hypogeal	Epigeal
cotyledons	**below** ground	**above** ground
grows long	**epicotyl**	**hypocotyl** (often a hook)
examples	gram, pea; maize, rice, wheat (most monocots)	castor, cotton, papaya, onion (green); bean (fleshy, fall off); sunflower, gourds

- **onion**: a monocot, but epigeal



Hypogeal and epigeal germination.

Vivipary (mangroves of salty, oxygen-poor mud: *Rhizophora*, *Bruguiera*, *Kandelia*, *Ceriops*)

- no dormancy; germinates in the fruit on the tree
- hypocotyl + radicle grow long (to ~70 cm): **propagule**, heavy at the root end
- drops; lodges upright in mud or floats for months; roots fast
- nearest: Sundarbans (Ganga–Brahmaputra delta)

Seed dormancy

- apple, pear, cherry dormant; mango, citrus not; a **survival mechanism**
- **physical** (seed coat): hard, impermeable to water and gases; drupes, nuts, legumes (suberized coat); broken by scarification
- **mechanical**: coat too strong for the radicle (walnut shell, stone of olive)
- **chemical**: **inhibitors** (phenols, **coumarin**, **ABA**) in fleshy fruits (citrus, cucurbits, tomato); washed out
- **morphological**: embryo **underdeveloped** (celery)
- **physiological** (commonest): high ABA : gibberellin; broken by **stratification**

Advantages

- survival through bad seasons
- seed banks, storage
- synchronized germination → cross-pollination
- dispersal (coats scarified in animals' guts)

Photoperiodism

- **SDP** (long-night): day < critical; 8–10 h light, 14–16 h **continuous dark**; rice, coffee, soybean, tobacco (Maryland Mammoth), chrysanthemum; red flash (660–665 nm) at night → **no flowering**
- **LDP** (short-night): day > critical; 14–16 h light; wheat, radish, cabbage, sugar beet, spinach; night flash **promotes** flowering
- **DNP**: any day length; tomato, cotton, sunflower, cucumber, pea
- **leaves** sense it with **phytochrome**; red → active, far-red cancels; signal to the shoot tip
- names compare with each plant's **critical length**, not 12 h: 13-h day → *Xanthium* (SDP, < 15½ h) and henbane (LDP, > 11 h) both flower

Short-day plants	Long-day plants
photoperiod **below** critical	photoperiod **above** critical
dark break in the light period: still flower	dark break in the light period: **no** flowering
light flash in the night: **no** flowering	light flash in the night: flower (promoted)
long **continuous** dark critical	dark period not critical
rice, soybean, chrysanthemum, coffee	wheat, radish, spinach, sugar beet

Senescence and abscission

Types (Leopold, 1961)

- **overall**: annuals die after seeding (paddy, wheat, soybean)

- **top**: shoot dies, roots and rhizomes live (*Rumex*, ginger, turmeric)
- **deciduous**: all leaves at once (autumn, dry season)
- **progressive**: old leaves, base to top (coconut)

Causes

- loss of chlorophyll, RNA, enzymes; contents made slower, broken faster
- nutrients drawn to fruits and seeds; senescence factor from soybean fruits
- short days, long nights
- **ethylene, ABA speed it; cytokinins delay it**

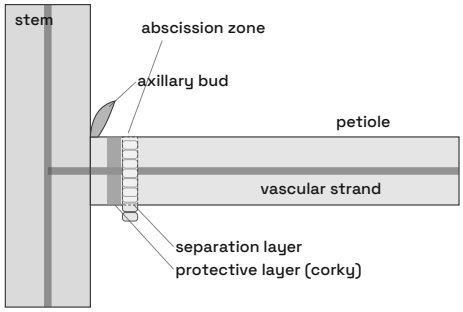
Significance

- monocarpic plants (wheat, rice, bamboo) die with seed setting
- nutrients to young leaves and to fruits (N of wheat grain from leaves)
- escape seasonal hardship: less transpiration

Abscission

- deciduous: all at once; evergreen: gradually; herbs: dead leaves stay on
- chlorophyll breaks down → carotenoids show; anthocyanin red
- **abscission zone** at the petiole base: layers of small cells (**abscission layer**)

1. **pectinase, cellulase** dissolve middle lamella and primary walls (ethylene on; auxin holds back)
2. held only by vascular strands → weight, wind → leaf falls
3. vessels plugged by **tyloses**, gums
4. **corky layer** (suberin, lignin) heals; **leaf scar**



The abscission zone.

- significance: water, nutrients to young leaves; **self-pruning**; dispersal of fruits and propagules; removes parts holding wastes

Vernalization

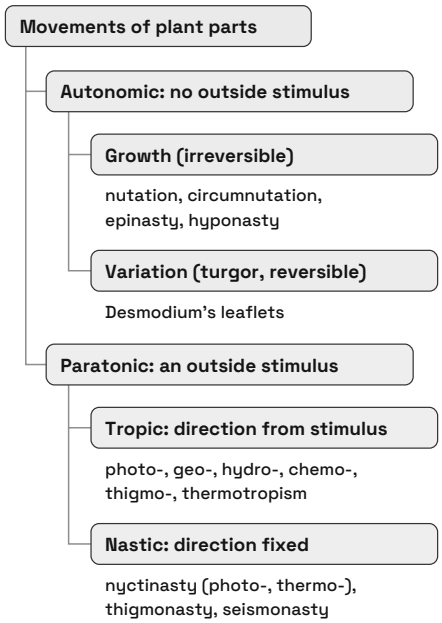
- Latin *vernalis*, of spring; Lysenko's **yarovization**; winter wheat needs winter to flower
- **shortens the vegetative period** → early flowering; without it: late, or rosettes (cabbage, carrot, radish, sugar beet, henbane)
- soaked seeds germinate a little → **0–5 °C** for days to weeks → dried → sown
- sensed by the **shoot apex**; any dividing cells in some (*Lunaria biennis*, honesty)
- passes by **grafting**; proposed hormone **vernalin**, never found (*Arabidopsis*: cold switches off *FLC*)
- best 1–6 °C; falls from 7 °C; 12–14 °C almost ineffective
- **aerobic**, needs energy, **water**; **dry seeds can't be vernalized**; age matters

Significance

- early flowering
- resistance to fungal disease and cold
- biennials flower and fruit in the first year
- induction by grafting
- crop improvement: winter crops sown in spring

Plant movements

- **vital** movements: from the **irritability** of protoplasm
- **locomotion**: *Chlamydomonas*, sperm, cytoplasmic streaming; **taxis** (phototaxis)

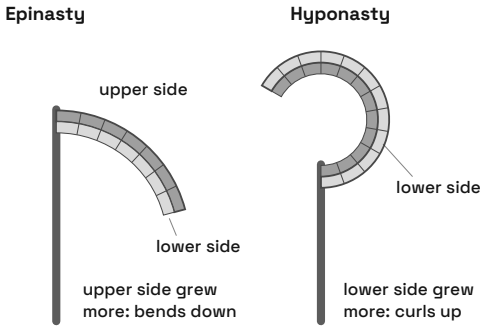


Kinds of plant movement.

Autonomic growth (unequal growth, irreversible)

- **nutation**: twiner's tip nods side to side (pea, bean)
- **circumnutation**: tip, tendril coils spirally (Darwins, 1880)

- **epinasty**: upper side grows faster → curves **down, out** (leaves open; tomato with ethylene)
- **hyponasty**: lower side faster → **up, in** (fern fiddlehead, closed bud)



Epinasty and hyponasty.

Autonomic variation (turgor, reversible): **pulvinus**; telegraph plant *Desmodium gyrans* lateral leaflets jerk up and down

Tropic (paratonic; growth, irreversible, **directional**, slow; radial organs)

- **phototropism**: stems +, roots −; auxin to the shaded side
- **geotropism**: roots +, shoots −; laterals **diageotropic**
- **hydrotropism**: roots +; roots into leaking drains
- **chemotropism**: pollen tube to the ovule; hyphae to sugars
- **thigmotropism** (haptotropism): tendrils coil round a support
- **thermotropism**: towards moderate temperature
- seeds in a jar: roots down, shoots up whatever way placed; shoot bends to the window

Nastic (direction fixed by the organ; diffuse stimulus; mostly turgor)

- faster, specialized, dorsiventral organs, special plants only
- **nyctinastic** (sleep): *Maranta*, tamarind; **photonastic** (*Oxalis*, chari amilo); **thermonastic** (tulip, *Crocus*)
- **thigmonastic**: *Drosera* tentacles bend over an insect to the leaf's center
- **seismonastic**: *Mimosa pudica* (lajjawati): pulvini lose water → leaflets fold, leaf drops in seconds; electrical signal; reopens in 10–30 min

	Tropic	Nastic
direction	set by stimulus	set by organ
stimulus	one side	diffuse
mechanism	growth	mostly turgor
reversible	no	yes (most)
speed	slow	faster
organs	radial, all plants	dorsiventral, special plants

COMMON MISTAKES

✗ In hypogeal germination the hypocotyl grows long
✓ the **epicotyl**; hypocotyl in epigeal.

✗ All monocots are hypogeal
✓ **onion** is epigeal.

✗ Dormant seeds are dead
✓ they are **viable**.

✗ SDP need a day under 12 h
✓ under their **critical** length; they measure the **night**.

✗ A night flash of red light helps SDP
✓ it **stops** SDP flowering; helps LDP.

✗ Dry seeds can be vernalized
✓ need **water** and **oxygen**.

✗ Vernalin has been isolated
✓ **never found**.

✗ Cytokinin speeds senescence
✓ **delays** it; ethylene, ABA speed it.

✗ *Mimosa* folding is thigmotropism
✓ **seismonasty** (nastic, turgor).

✗ Epinasty bends an organ up
✓ **down and out**; hyponasty up.