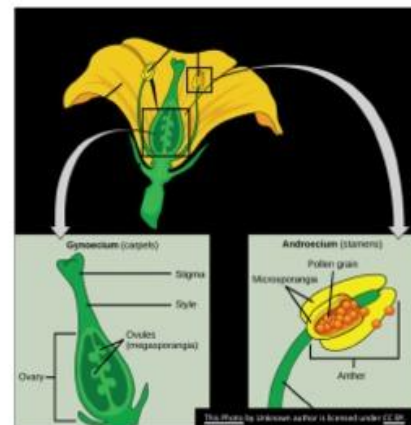# Flowering

- The first step of sexual reproduction.
- Most important in plant breeding.
- One of the most dramatic events in the ontogeny of a plant.
- Flowering leads to an exciting succession of events like anthesis, fruit set, fruit development, maturation and ripening. Flowering

PHYSIOLOGY OF FLOWERING

- Immense importance for perpetuation & origin of variability in the next generation.
- Takes place by the transformation of vegetative apex into a reproductive structure.
- The change from the vegetative state to the reproductive state.
- Shoot meristem is reduced to develop sepals, petals, stamens, stigma etc.. . in case of leaves.
- The plant must attain specific state of "Ripeness to response" before it flowers.
- Once the stage is reached, then it can induce to flower.
- Transitional phase in the life cycle of a plant.

1) Photoperiodism: Introduction & Definition

- **Definition:** The **physiological response of plants to the relative lengths of day and night** (photoperiods), most importantly expressed as **induction of flowering**.
- **Discovery:** Garner & Allard (1920) while studying tobacco and soybean.

- **Key idea:** For flowering, plants often measure the **length of the uninterrupted dark period** (critical night length) rather than day length.

Core terms

- **Photoperiod:** Duration of light and dark in 24 h.
- **Critical Day Length (CDL):** Threshold photoperiod separating inductive vs non-inductive conditions.
- **Inductive cycle:** One 24-h cycle that promotes flowering.
- **Juvenile phase:** Early stage when the plant is **non-responsive** to photoperiod.

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2) Site of Perception & Signal Pathway (what to remember)

- **Perception organ: Leaves** (not the shoot apex).
- **Photoreceptor:** Mainly **phytochrome** (Pr $\rightleftarrows$ Pfr) with help from blue-light receptors (cryptochromes).
- **Night-break effect: A short red-light pulse in the middle of the long night**:
  - **Inhibits** flowering in **Short-Day Plants (SDPs)**
  - **Promotes** flowering in **Long-Day Plants (LDPs)**
  - Effect is **reversed by far-red** light → classic **phytochrome** proof.
- **Signal transmission:** An inductive signal formed in leaves moves via **phloem** to the **shoot apical meristem (SAM)** and switches it from **vegetative → reproductive**.

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3) Classification Based on Photoperiod
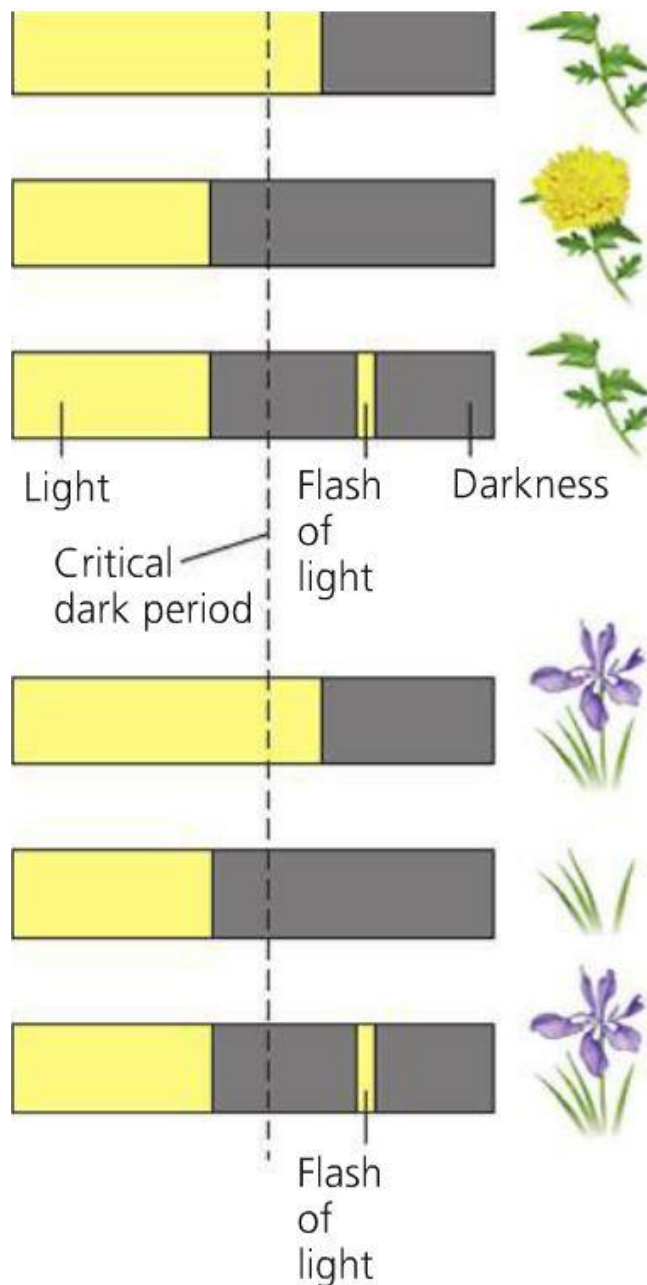
(a) Short-day (long-night) plant. Flowers when night exceeds a critical dark period. A flash of light interrupting the dark period prevents flowering.

Light Flash of light Darkness

Critical dark period

(b) Long-day (short-night) plant. Flowers only if the night is shorter than a critical dark period. A brief flash of light artificially interrupts a long dark period, thereby inducing flowering.

Flash of light

A) Short-Day Plants (SDPs) = Long-Night plants

- **Requirement: Night ≥ Critical Night Length** (day shorter than CDL).
- **Night-break** stops flowering.
- **Types:**
    - **Obligate/Qualitative SDP:** Strict short days (e.g., **Chrysanthemum**, **Xanthium**).
    - **Facultative/Quantitative SDP:** Short days accelerate (e.g., **Rice**, **Soybean**).

- **Typical examples: Chrysanthemum morifolium**, **Xanthium strumarium**, **Glycine max**, **Oryza sativa**, *Nicotiana* cv. Maryland Mammoth.

B) Long-Day Plants (LDPs) = Short-Night plants

- **Requirement: Night ≤ Critical Night Length** (day longer than CDL) or **night broken by light**.
- **Types:**
    - **Obligate LDP:** Strict long days (e.g., **Hyoscyamus niger**).
    - **Facultative LDP:** Long days hasten (e.g., **Wheat** (spring), **Barley**, **Spinach**, **Lettuce**).
- **Vernalization link:** Many LDPs need **cold (vernalization)** before responding to LD (e.g., **Sugar beet**, **Henbane**).

C) Day-Neutral Plants (DNPs)

- **Requirement: Do not depend on day length** for flowering; age/size/nutrition dominate.
- **Examples: Tomato**, **Cucumber**, **Cotton**, **Sunflower**, many garden **Roses**.

One-look table

Feature	SDPs	LDPs	DNPs
Key cue	**Long, uninterrupted night**	**Short night/night break**	Not photoperiodic
Night-break (red light)	**Inhibits** flowering	**Promotes** flowering	No effect
Examples	Chrysanthemum, Rice, Soybean, Xanthium	Wheat, Barley, Spinach, Lettuce, Henbane	Tomato, Cotton, Cucumber, Sunflower

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**4) Molecular/Physiological Basis (short, SY level)**

- **Phytochrome + Circadian clock** measure night length.
- In Arabidopsis (a model **LDP**): **CO (CONSTANS)** protein accumulates in light → activates **FT (FLOWERING LOCUS T)** in leaves.
- **FT protein** moves via phloem to the **SAM**, forms a complex (with 14-3-3 & **FD**) → turns on floral meristem genes (**AP1**, etc.).
- In rice (a **SDP**): the FT-like **Hd3a** acts as florigen; regulatory network flips so SD conditions promote Hd3a.

5) Florigen – the Flowering Hormone

- **Definition (Chailakhyan, 1936):** A **mobile floral stimulus** produced in **induced leaves** and transported to the **SAM** to trigger flowering.
- **Nature:** Now known largely as **FT-family proteins** (e.g., **FT** in Arabidopsis, **Hd3a/RFT1** in rice) acting as **systemic signals**.
- **Proofs:**
  - **Grafting:** Induced leaf on a non-induced plant causes the stock to flower.
  - **Mobility:** FT/Hd3a proteins detected moving in phloem.
- **Antiflorigen/Balance:** TFL1/CEN-like proteins antagonize FT to **delay** flowering; overall outcome = **FT : TFL1 balance**.
- **Hormone crosstalk: Gibberellins (GA)** can substitute for LD in some LDPs (e.g., rosette plants), acting upstream of floral genes.
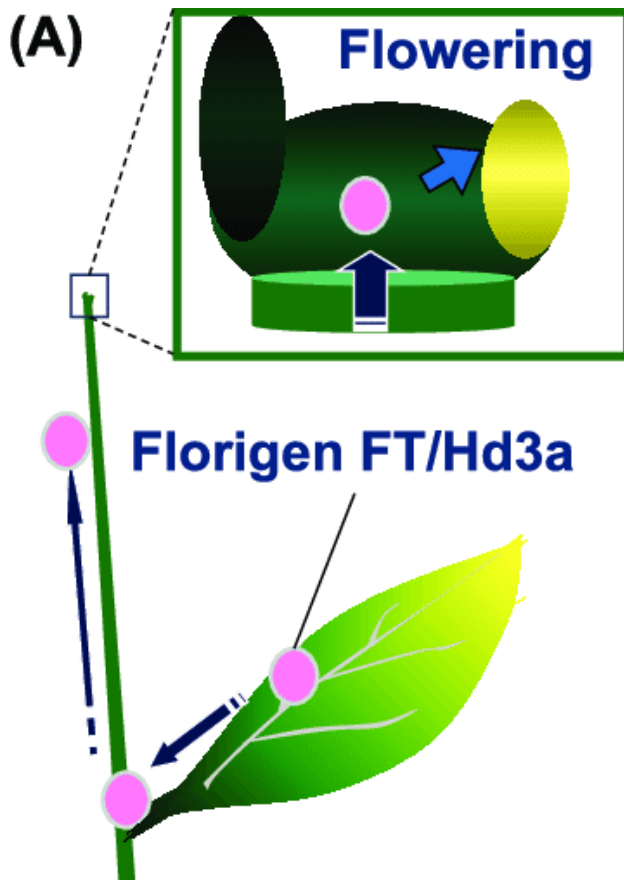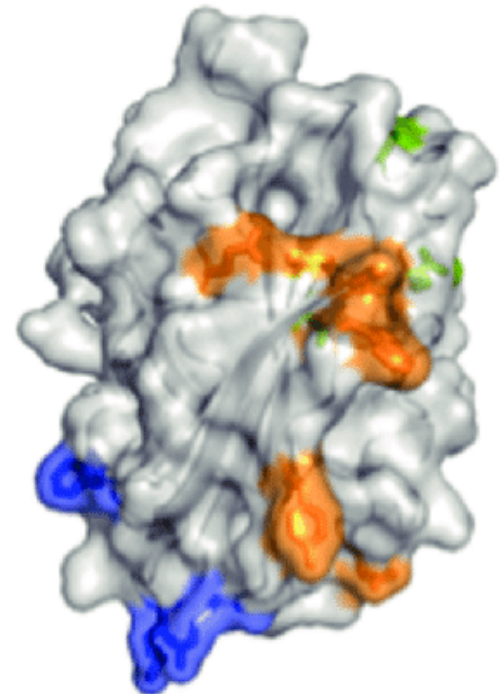
6) Practical Applications (horticulture & crops)

- **Chrysanthemum (SDP):** Black-cloth **short-day** treatment → festive flowering.
- **Lettuce/Spinach (LDP):** Long days cause **bolting**—manage sowing dates to avoid premature flowering.
- **Greenhouses: Night-interruption lighting** (weak incandescent/LED) to create LD; or **blackout curtains** to create SD.
- **Breeding:** Selecting alleles of **FT/CO/Hd3a** adjusts **flowering time** to latitude and season.

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7) Typical Exam/Viva Points

1. **Who discovered photoperiodism?** Garner & Allard (1920).
2. **What is measured—day or night? Uninterrupted night length** (critical night).
3. **Where is photoperiod perceived? Leaves**.
4. **What reverses a red night-break? Far-red** light (phytochrome).
5. **Give two SDPs/LDPs/DNPs.** (Pick from examples above.)
6. **Define florigen and name its modern identity.** Mobile floral signal; **FT/Hd3a** proteins.
7. **How does GA affect flowering?** Can **promote** flowering in some **LDPs** under non-inductive days.

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8) Quick Memory Hooks

- **SDP = Long Night; LDP = Short Night.**
- **Leaves sense → FT made → FT to apex → flowers.**
- **Red night-break: Stops** SDPs, **starts** LDPs; **FR** undoes red.