

INSTRUCTOR: Dr. Robert D. Slocum

LECTURE: MWF 9:30-10:20 AM, HS 131

OFFICE HOURS: By appointment, HS G46

PHONE: x 6303

TEXT: Taiz L., Zeiger E. (2006) *Plant Physiology*, 4th ed., Sinauer Associates, Sunderland, Massachusetts (ISBN 0-87893-856-7)

Students may purchase new or used textbooks at the College Bookstore. Another option for textbook purchases at reduced prices is websites like Half.com (www.half.ebay.com/) or Amazon.com (www.amazon.com/; "Textbooks" link). New and used texts may also be rented from companies like Chegg.com (www.chegg.com/) CampusBookRentals.com (www.campusbookrentals.com/). A good website for comparison pricing of texts is Bookfinder.com (www.bookfinder.com/).

ATTENDANCE: Class attendance is optional, but highly encouraged.

CELL PHONE POLICY: If it rings in class, you will be asked to leave.

COURSE GRADING:

PowerPoint lectures and other files will be posted on the Bio 333 BlackBoard (<http://blackboard.goucher.edu>) site after each class. All materials will be placed in the **Course Information** folder.

Exams

Exam 1	M, February 22	100 pts
Exam 2	M, March 29	100 pts
Exam 3	W, April 21	100 pts
Paper	F, April 30	100 pts
Final Exam	TBA	<u>100 pts</u>

Total: 500 pts

COURSE GRADING (cont.)Exams

Examinations will cover materials presented in lecture and from assigned readings. Exams will be of the "closed book" type, and will be held during the scheduled lecture hour, tentatively on the dates indicated above.

NOTE: Students may, under extraordinary circumstances, arrange to take an exam early. Makeup exams will not be given. In the case of an unexcused, missed exam, the lowest exam grade will be counted twice in calculating the final course grade, but this will be allowed only one time. Additional unexcused, missed exams will receive a grade of zero.

Paper

An 8 to 10 page paper (including bibliography) exploring any aspect of plant physiology will be due in class no later than **Friday, April 30**. Using a current review article (or assistance from the instructor) to get started, the paper should summarize our present knowledge of a particular subject. At least half of the cited references must have been published within the last five years in order to ensure that the student is assimilating up-to-date information. Photocopied first pages of cited references must accompany the paper.

Use of Internet resources is encouraged in researching the paper topic but these may not be cited in the bibliography. Only peer-reviewed articles may be cited.

Papers must be typed. Hand-written papers will not be accepted.

NOTE: Unless an extension is granted by the instructor, the paper will be penalized a letter grade for each day that it is turned in after the deadline!

ACADEMIC HONOR CODE:

All students are bound by the standards of the Academic Honor Code, found at <http://www.goucher.edu/documents/General/AcademicHonorCode.pdf>

FIELD TRIP:

Traditionally, students in this course spend an enjoyable day at Longwood Gardens, in Kennett Square, PA (one of the premiere botanical gardens in the U.S.) in order to more fully appreciate the diverse world of plants. This trip will be scheduled at a time that will permit the most Bio 333 students and other Biology students and faculty to attend (tentatively set for **Saturday, April 24**). Participation is voluntary and costs of the trip are covered. Depending upon the number of participants, students may be asked to drive. Designated drivers will receive mileage reimbursements for the use of their personal automobiles.

ASSIGNED READINGS (Taiz and Zeigler 2006)

NOTE: A variety of supplemental resources (specialized topics, essays by leading researchers in their respective fields of study, suggested readings, study questions) are organized by chapter at: www.plantphys.net

Structure and Function of Plant Cells, Tissues, Organs

- Review of plant cell structure and function; apolastic and symplastic compartments; functional and developmental plasticity of plastids (**Ch 1:5-31**; read general topics only)
- Three main tissue systems (dermal, ground, vascular)
- Plant vegetative organs (roots, stems, leaves) and (sexual) reproductive organ (flower); flowering plant life cycle and major groups (Monocots, Dicots)

Water Transport, Water and Salt Stress, Osmoregulation

- Diffusion, osmosis, role of aquaporins in cell-cell movement of water (hydraulic conductivity); **Ch 3:38-43**
- Water and plant cells (requirement of “turgor pressure” for cell expansion, growth)
- Water potential (φ) gradients provide driving force for water movements; φ_s and φ_p components of φ ; defining φ_s and φ_p in open systems (osmometer model) vs. living systems; equilibrium conditions; calculation of φ_s ; gravimetric method for measuring tissue φ ; **Ch 3:38-43**
- Root morphology and uptake of water from soil; bulk water transport by **xylem**; theories for “ascent of sap” in plants, cohesion-tension model; “cavitation” mechanism to survive extreme desiccation; role of stomates in regulation of transpiration; “paradox of the pores” (see **Fig. 4.13**); **Ch 4:53-69**
- Transpiration/photosynthesis compromise and physiological control of stomatal opening
- Guard cell mechanics and molecular mechanisms regulating stomatal opening and closing (abscisic acid-mediated closing under water stress, **Fig. 23.14**)
- Water stress – morphological, physiological and biochemical adaptations; compatible solutes and osmoregulation; genetic engineering of desiccation tolerance in plants (**Ch 26: 672-682**)
- Salt stress (**Ch 26:692-694**) and engineering of salt tolerance (**Apse et al. 1999**)

Mineral Nutrition (Chapter 5)

- Solute transport – passive vs. active, transport mechanisms (symport, antiport), characteristics of transport mediated by membrane transporters (specific, saturable), role of membrane potential; effects of ion size and charge density on transport efficiency (**Chapter 6**, background reading for basics)
- Nutrient uptake by roots - influence of root architecture and soil microbes (mycorrhizae); role of root endodermis in regulating nutrient uptake
- Defining “essential” mineral nutrients (C, H, O and 13 others); macronutrients (K, Ca, Mg / N, S, P) vs. micronutrients (Fe, Mo, Ni, Cu, Zn, Mn, Bo, etc.)
- Common mineral nutrient deficiencies (-N, -P, -Ca, -Fe) and symptoms (**web Topic 5.1**; www.back-to-basics.net/nds/index.htm#)
 - Nutrient mobility differences (N vs. Fe) in relation to where deficiency symptoms occur
 - Phosphate deficiency
 - Improved uptake, storage and utilization of P via genetic engineering of plants
 - Iron deficiency
 - Molecular mechanisms of Fe uptake and importance of “chelation”
- Effects of soil type and pH on nutrient availability; types of fertilizers and applications
- Nutrient runoff and eutrophication of aquatic ecosystems; excess N/P fertilizer use, phytate (P storage form) in seeds used for animal feeds
- Heavy metal toxicities and tolerance mechanisms (metallothioneins, phytochelatins, etc.; engineering of metal tolerance)
 - Phytoremediation of heavy metals, radionuclides and organic pollutants in soils and aquatic ecosystems (**web Essays 5.1 and 26.2**); characteristics of “hyperaccumulator” species and practical considerations

Photosynthesis, Carbohydrate Transport

- Significance of photosynthesis – light to chemical energy transformation, carbon “fixation”
- Historical overview of photosynthesis research; “Light Reactions” and “Dark Reactions”

Light Reactions (**Chapter 7**):

- Photosynthesis “action spectrum” and PAR
- Photosynthetic pigments (chlorophyll *a* + (chlorophyll *b* and carotenoid “accessory pigments”), structural features, characteristic absorption spectra; other accessory pigments (phycobilins) and features
- Chlorophyll absorption of visible light wavelengths - pros and cons, and why bacteriorhodopsin would be a better choice

Photosynthesis/Light Reactions (cont.)

- “Reaction center” concept - “antenna complexes” of chl *a*, accessory pigments and proteins in thylakoid membrane; absorb light energy and convert it to high-energy electrons used to produce chemical energy in coupled redox reactions (Light Reactions)
- Fluorescence energy transfer, photochemical efficiency, Landsat imaging applications (primary productivity in terrestrial and aquatic ecosystems)
 - Two types of reaction centers: photosystem I (PSI) and photosystem II (PS II)
 - “Cooperativity” of PSI and PSII activities in non-cyclic photophosphorylation; role of cyclic photophosphorylation
 - Production of O₂, NADPH and ATP
 - Jagendorf (1967) expt demonstrating ATP synthesis coupled to H⁺ gradients across thylakoid membrane
 - Herbicides targeting electron-transport steps in Light Reactions (web **Topic 7.10**)

Dark Reactions (Ch 8:159-181):

- Discovery of the Calvin-Benson Cycle for CO₂ fixation (web **Topic 8.1**)
 - Light and [CO₂] effects on cycle activities
- Dual carboxylase/oxygenase functions of “Rubisco”; photorespiration and loss of “fixed” carbon in C-3 plants
- Regulation of Rubisco and coordination with Light Reactions
 - Light-regulated synthesis of Rubisco small (regulatory) subunit
 - pH, [Mg²⁺] changes in stroma
- C-4 photosynthesis (Hatch-Slack pathway) and CAM photosynthesis (web **Topic 8.7**)
 - CO₂-concentrating mechanisms to minimize Rubisco “oxygenase” activity and photorespiration
 - Discovery of new type of C-4 photosynthesis in diatoms (**Reinfelder et al. 2000**)
 - PEP carboxylase and Rubisco CO₂-fixing steps separated spatially (C-4) or temporally (CAM)
- Assimilation of fixed carbon – sucrose and starch synthesis (**Ch 8: 182-192**)

Photosynthesis-environmental aspects

- Carbon cycle
- Plant responses to changes in [CO₂] – different effects on C-3 vs. C-4/CAM plants; predicted effects of increasing atmospheric [CO₂]; **Ch 9:211-216**
- Effects of light on photosynthesis (**Ch 9:203-209**)
 - “Sun” vs. “shade” plant adaptations
 - Light avoidance mechanisms (leaf and chloroplast movements; “sunscreens” pigments (xanthophyll cycle, **Ch 7: 151-152**))

Photosynthesis - environmental aspects (cont.)

- Effects of temperature on photosynthesis (**Ch 9: 209-211**)
 - Engineering of heat-tolerance by manipulation of plastid lipid composition (**Murakami et al. 2000**)
- Predicted effects of increasing [CO₂] and global warming (“greenhouse effect”) on plant growth and crop productivity

Phloem (**Ch 10: 221-247**)

- Anatomy, discovery of role in sugar transport (translocation)
- “Source” and “sink” tissue concept for allocation of sugars; regulation of photosynthate partitioning in plants (**Fig. 10.21**; sucrose vs. starch synthesis in source leaves)
- Phloem loading (sucrose carrier, active transport) in source tissues, sugar transport, unloading in source tissues (Münch “pressure-flow” model); rates of translocation
- Analysis of phloem sap (aphid stylet technique)
- Maple sugaring – an exception

Nitrogen Metabolism

- Importance of N for plant growth (most limiting nutrient; types N compounds: proteins, nucleic acids, secondary products and precursors); N-cycle overview (**Fig. 12.1**)
- N₂ “fixation”; nitrogenase; formation of N₂-fixing root nodules in legumes
- (**Ch 12:296-304**)
- Assimilation of nitrite (NO₂) and nitrate (NO₃) into ammonia (NH₃) (**Ch 12:291-296**)
- NH₃ assimilation into all other N compounds via amino acids and transamination reactions
 - Conserved biochemical pathways involving GDH, GS, GOGAT
 - Relationship between carbon and nitrogen metabolism
 - Loss of “fixed” N via photorespiration
- N transport (amides, ureides, etc.) and N-cycling (catabolism of N compounds; tissue “senescence”)
- “Green manure” vs. chemical fertilizers (Haber-Bosch process) – crop yields, human population growth, environmental issues (**Smil 1997**)

Plant Growth and Development

- Overview of growth and development and involvement of plant hormones
- Definition of plant “hormone” (vs. “growth regulator”); major classes of plant hormones (auxins, gibberellins, cytokinins, ethylene, abscisic acid; others)

Plant Hormones

Auxins (Chapter 19)

- Discovery (Went phototropism expts); chemical identification of IAA
- Structural features of naturally-occurring and synthetic auxins
- Regulation of cell/tissue levels of auxins (synthesis, degradation, conjugation)
- Polar transport of auxins in shoots vs. roots
 - Chemiosmotic model; asymmetric distribution of uptake (permease AUX1) and efflux carriers (PIN, ABC transporters)
 - Auxin transport inhibitors and applications
- Physiological and biochemical effects of auxins
 - Tropisms, maintenance of lateral bud dormancy (“apical dominance”), root growth (true roots and “adventitious” roots)
- Use of auxins as “herbicides”; Agent Orange, dioxins, implication in various cancers
- Cellular mechanisms of auxin perception and action (**Ch 19:501-504**)
 - Auxin receptors (**Chow and McCourt (2006) review**)
 - Auxin-binding protein (ABP1) regulates H⁺-ATPase and cell wall acidification
 - TIR1 component of ubiquitinating complex of 26S proteasome regulates Aux/IAA degradation and ARF function
 - Auxin signal-transduction pathways and auxin-regulated gene expression
 - Genes with auxin response-elements (AuxRE) in promoters
 - ARF transcription factors activate/repress genes with AuxRE
 - Aux/IAA repress ARF function

Gibberellins (selected topics, Chapter 20)

- Discovery (rice fungal pathogen, “bakana.e” disease)
- Physiological roles of GAs
 - Stem internode growth; “dwarf” mutants deficient in GA synthesis or transport
 - Promotion of seed germination; mobilization of carbohydrates, activation of α -amylase expression in barley seeds (**Fig. 20.22**)

Cytokinins (Chapter 21)

- Discovery, structural features, regulation of cellular levels; transport
- Physiological and biochemical effects of CKs
 - Promote cell division and lateral bud growth
 - Regulate shoot and root development, in coordination with auxins (CK:auxin ratios)
 - Relative CK levels establish “source” and “sink” tissue relationships

Plant Hormones

Cytokinins (cont.)

- Anti-senescence properties (**Gan and Amasino (1995)**, *IPT:SAG12* “autoregulated” senescence)
- CK receptor and signaling pathways (**Ch 21: 563-567**)

Ethylene (**Chapter 22**)

- Discovery, synthesis and regulation of ethylene production
 - Methionine/SAM precursors; ACC is controlling step in synthesis
- Physiological effects
 - Epinasty and leaf abscission
 - Involvement in short-term thigmonastic (tendrill coiling) and thigmomorphogenetic (wind-induced “stunting” of growth) responses
 - Promotion of flowering in bromeliads (pineapple)
 - Fruit ripening and rotting (senescence)
 - Ethylene adsorbents/oxidizers or synthesis inhibitors -commercial applications
 - Fruit, vegetable storage
 - Regulation of fruit ripening
 - Initiation of plant defense mechanisms against pathogens and herbivores (see below)
- Ethylene receptor, signaling pathways (**Fig. 22.16**)

Abscisic Acid (**Chapter 23**)

- Synthesis from carotenoids
- Physiological effects
 - Maintenance of seed and bud dormancy
 - Regulation of stomatal opening via ABA-mediated osmoregulation in guard cells

Salicylic Acid

- SA-induced thermogenesis and pollination of *Arum* lilies (web **Essay 11.14**)
- Heat-production via SA-inducible “alternative oxidase” in mitochondrial respiration (**Ch 11:272-273**)

Plant Defense Mechanisms (Chapter 13)

Two main types of defenses

Constitutive defenses – cutins, waxes, suberin

- hydrophobic materials that coat plant surfaces exposed to air
 - prevents water loss
 - blocks pathogen entry
- high levels of toxic or feeding deterrent compounds

Inducible defenses – wide variety of responses

- production of toxins, hydrolytic enzymes, structural barriers, feeding deterrents in response to pathogen infection or herbivore grazing
- formation of “sunscreens” in response to UV stress

Types of secondary metabolites functioning as defense compounds (**Fig. 13.4**)

Terpenes (isoprenoids)

- pyrethrins (insecticides)
- “essential oils” (insect repellents)
 - mono- and sesquiterpenes; flavors, volatiles in lemon, peppermint, etc.
- plant steroids
 - e.g., phytoecdysone – disrupts insect molting

Phenolics

- Derived from aromatic amino acids via shikimic/malonic acid pathways (**Fig. 13.10**)
- Phenylalanine ammonia lyase (PAL) catalyzes first step in synthesis of phenolics from phenylalanine; PAL expression upregulated in many defense responses by “wound-induced” ethylene and by jasmonic acid (JA)
 - Examples of Phe/PAL-derived phenolics and functions:
 - Flavonoids - UV “sunscreens”
 - Lignin, callose - structural polymers, physical barrier to infection
 - Coumarins - antifungal cpds; block new cell wall synthesis
 - Tannins – herbivore feeding deterrents; chemically modify gut proteins and prevent digestion, food absorption
 - Benzoic acid-derived phenolics – e.g., salicylic acid, which induces HR and SAR defense responses (see below)

Plant Defense Mechanisms - Secondary Metabolites (cont.)Nitrogenous compoundsAlkaloids

- 15,000+ compounds (**Table 13.2**); include nicotine, cocaine, caffeine (CNS stimulants, depressants)

Cyanogenic glucosides, glucosinolates – release respiratory poison HCN upon herbivore feeding (**Fig. 13.20**)

Ethylene- and jasmonic acid (JA)-regulated plant defense mechanisms

Herbivore feeding deterrence (Ch 13:334-338)

- Gypsy moth feeding induces “wound” ethylene synthesis and ethylene-induced tannin production in damaged poplar leaves; plant-to-plant communication (via volatile ethylene hormone) induces tannin production in surrounding trees, deterring further feeding (**Baldwin and Schultz 1983**)
- Other chewing insects induce synthesis of JA (**Fig. 13.24**) and JA-induction of plant defenses:
 - Synthesis of lectins, α -amylase-inhibitors, protease-inhibitors (block nutrient absorption in gut)
 - Production of volatile organic compounds (VOC), which activate plant-defense mechanisms in damaged plant and surrounding plants
 - Saliva constituent of beet armyworm feeding on corn induces “volicitin”; volicitin elicits VOC synthesis; VOC attract parasitic wasp, which paralyzes worm and lays eggs in it – limits further damage to plant
 - **Web Essay 13.8** on plant VOC and defense responses

Defense against pathogens (Ch 13:338-341)

- Plant resistance to pathogen infection – two stages

Hypersensitive response (HR)

- Cells adjacent to infection site rapidly undergo apoptosis and produce

Phytoalexins – secondary products with broad antimicrobial activities

Hydrolytic enzymes - e.g., chitinase, degrades fungal cell walls;

“pathogenesis-related (PR) proteins

Lignin, callose – physical barrier to spread of infection

Plant Defense Mechanisms – Defense against pathogens (cont.)

“Reactive oxygen species” (ROS) – chemically reactive; denature proteins, lipids, etc.

- Superoxide anion ($O_2^{\cdot-}$), hydrogen peroxide (H_2O_2), hydroxy radical (OH^{\cdot}); **Fig. 13.26**

Salicylic acid (SA) – induces SAR (below)

Systemic acquired resistance (SAR)

- Following HR (increase in PR proteins, H_2O_2 and SA), entire plant initiates defenses against both specific pathogen that induced HR, and other pathogens (broad-based, like plant “immune system”)
- SAR develops over period of days
- SA translocation via phloem, of volatile forms of SA, like Me-SA, may induce SAR in infected and uninfected plants nearby

Plant Movements

Differential growth responses; two types: nastic and tropistic

Nastic movements in leaves (non-directional stimulus)

- Nyctinastic movements
 - “Sleep movements” under circadian control
 - Non-physical external stimuli (e.g., light)
 - *Oxalis* (shade plant) response to light “flecks” under forest canopy
- Thigmonastic movements
 - responses to physical stimuli (Venus flytrap, “sensitive plant”)

Tropistic (bending) movements in stems and roots (directional stimulus)

- Phototropic responses
 - Involvement of blue light photoreceptors (see below)
- Gravitropic responses
 - Positive (roots) and negative (shoots) bending responses
 - Role of root cap amyloplasts in graviperception

Hangartner time-lapse movies

Photomorphogenesis

- Effects of light on plant growth and development (light-grown vs. “etiolated” phenotypes)
- Involvement of blue and red light in various processes
- Identification of blue light photoreceptors (**Ch 23:449-462**)
 - Carotenoids vs. flavins; action spectra for phototropism, guard cell opening, inhibition of hypocotyl elongation
 - Use of mutants to identify “cryptochromes” (CRY1, CRY2) and “phototropins” (PHO1, PHO2)
- Photoperiodic control of flowering and discovery of phytochromes (**Ch 25:648-652**)
 - Garner and Allard expts identify “short-day” plants (SDP), “long-day” plants (LDP) and “day-neutral” plants (DNP), with respect to critical photoperiod for each species; later “night interruption” expts (Borthwick et al.) establish importance of critical night length and phytochrome as primary photoreceptor (**Fig. 25.23**)
 - Pr (inactive form) converted to Pfr (active form) by red light; Pfr to Pr conversion by far-red light; photoreversible
 - Leaf is site of photoperiodic reception (floral induction)
 - Hamner and Bonner grafting experiments between SDP, LDP demonstrate phloem translocation of flowering stimulus (“florigen”) from leaf to apical (vegetative) meristem (see below)

Circadian Rhythms in Plants (Ch 17: 433-435; Ch 25:646-648)

Circadian-regulated responses (day-night movements in plant leaves; photosynthesis/respiration activities, etc.)

Features of circadian clocks

- In absence of environmental inputs, “free-running” clock has periodicity characteristic of a given organism’s clock components
- Endogenous rhythms are “entrained” (synchronized) to 24 hour (“circa” (about), “dian” (day)) period by light or other environmental signals
- Temperature compensation – same periodicity at different temperatures

Characterization of circadian “clock” components in plants

- Identification of circadian-regulated gene expression (e.g., chlorophyll a/b-binding protein, *CAB* gene)
- Strategy to identify putative clock mutants (*CAB* promoter:firefly luciferase gene “reporter” constructs, spatial and temporal bioluminescence patterns in WT plants (circadian expression) vs. clock mutants; **Millar et al. 1995**)

Circadian Rhythms – Characterization of “clock” components (cont.)

- *toc* (“timing of CAB expression”) mutants with disrupted rhythms -> identification of TOC1 as a clock component (**Strayer et al. 2001**)
- further mutant analyses identify two transcription factors as additional clock components: *CIRCADIAN CLOCK ASSOCIATED 1 (CCA1)* and *LATE ELONGATED HYPOCOTYLS (LHY)*

Molecular oscillation mechanism

- Similar to clock mechanisms in cyanobacteria, fungi, insects, mammals – clock genes/proteins involved in transcriptional/translational “negative-feedback” loop (**Fig. 17.16** model with TOC1, CCA1 and LHY components)
 - e.g., LHY in Arabidopsis is a homolog of PER protein in Drosophila
- Temperature compensation – temperature affects individual biochemical steps in clock oscillations but responses of different clock components cancel each other out (e.g., decreased rates synthesis paralleled by decreased rates degradation of components at lower temperature)

Physiological and Molecular Genetic Control of Flowering

Role of circadian rhythms in regulation of flowering (**Ch 25:652-655**)

- Effectiveness of “night break” to promote or inhibit flowering depends upon when it is given, not the absolute length of the dark period; *not* all-or-nothing response
 - Bünning (1936) expts (“coincidence model”; **Figs. 25.20, 25.21**) suggest a circadian input into photoperiodic control of flowering
- Clock/photoperiod regulation of flowering in Arabidopsis (**Fig. 25.22**)
 - LD (inductive) photoperiod results in accumulation of transcription factor CONSTANS (CO) protein and flowering
 - CO gene expression controlled by clock; phytochrome/cryptochrome photoreceptors regulate CO protein levels
 - PHYB targets CO protein for degradation at dawn (when CO mRNA levels low, little CO protein synthesis)
 - CRY/PHYA stabilize or CO protein at dusk, when CO mRNA levels/CO protein synthesis high -> accumulation of CO protein during night
 - LD conditions, CO mRNA increases during light period so more CO protein made and stabilized; CO levels remain high during night

Control of Flowering (cont.)

Genetics of floral induction in *Arabidopsis*

- CO protein promotes expression of *FLOWERING LOCUS T (FT)*; FT is the flowering stimulus (see below)
 - FT protein; (see **Essay 25.2**) translocated in phloem to apical meristem (**Fig. 25.33; Ch 25:665-666**)
 - FT complexes with transcription factor FD to activate *SUPPRESSOR OF CONSTANS 1 (SOC1)*
 - SOC1 activates expression of *LEAFY (LFY)* and *APETALA 1 (AP1)* genes
 - LFY and AP1 induce expression of floral homeotic genes and flower development (see below);
 - *SOC1* is a “master switch” gene, receiving various types of physiological and environmental inputs directly, or indirectly via *FLOWERING LOCUS C (FLC)*, a repressor of *SOC1*; focus on photoperiodic and vernalization inputs

Genetics of floral development in *Arabidopsis* (**Ch 25:636-641**)

- Floral meristems initiate separate whorls (concentric rings) of 4 different types of organs: sepals, petals, stamens, carpels (**Fig. 25.3**)
- 3 classes of genes regulate floral development

Meristem identity genes – TF that induce floral organ identity genes (e.g. *SOC1, AP1, LFY*)

- *lfy* mutants do not flower (floral organ identity genes not expressed)
- overexpression of *Lfy* causes early, prolific flowering

Floral organ identity genes – “homeotic genes”; encode transcription factors which control genetic programs leading to formation of floral organs

Cadastral genes – set “boundaries” for expression of floral organ identity genes in meristem

- “ABC” model for acquisition of floral identity (**Figs. 25.6; Meyerowitz et al. 1991**)
 - Organ identity in each whorl determined by unique combinations of 3 classes of floral organ identity genes:

Type A – control organ identity in 1st and 2nd whorls; loss of genes, e.g., *APETALA 2 (AP2)*: carpels, not sepals, in 1st whorl; stamens, not petals, in second whorl

Type B – control organ identity in 2nd and 3rd whorls; loss of genes, e.g., *APETALA 3 (AP3)* or *PISTILLATA (PI)*: sepals, not petals, in 2nd whorl; carpels, not stamens, in 3rd whorl

Control of Flowering - “ABC” model (cont.)

Type C – controls organ identity in 3rd and 4th whorls; loss of genes, e.g., *AGAMOUS 1 (AG1)*: petals, not stamens, in 3rd whorl; 4th whorl (normally carpel) is new flower – flowers form within flowers (sepal, petal, petal; sepal, petal, petal)

- Since Type A and Type C genes repress each other, they also have cadastral functions
- **Fig 25.8** interprets homeotic mutant phenotypes, based upon the ABC model

Other Readings

Students may occasionally be assigned additional readings. These may be recent review articles, reports in scientific journals, or web resources.