Flowering

I. Flowering prosses:

An overview:

The process of flowering requires the vegetative meristem (buds) to change into a reproductive meristem. This process, which is termed ***evocation***, involves the following sequence of events:

Juvenile vegetative phase → adult vegetative phase → adult reproductive phase → flowering

A. Juvenile to adult phase:

Juvenile plants cannot flower; they are capable of only vegetative growth. Thus, like in humans and other animals, the ability to reproduce marks the transition from the juvenile phase to adulthood. Juvenile plants often differ in appearance from the adult. For example, leaves may change shape (*i.e.* simple leaves; juvenile - lobed leaves) or degree of compounding (*i.e.*, beans: adult compound leaf; juvenile simple leaf). Juvenile tissues are produced first, near the base of the plant. The adult phase is usually stable and can be propagated from plant to plant.

B. Ripe to Flower:

The adult plant, can be flowered and is said to be ***"ripe-to-respond (or flower)***" or "***competent"***. In other words, it has the ability to flower when the conditions are appropriate. This may be a mechanism to insure that there is a sufficient vegetative mass (*i.e.*, leaves, roots) to support the reproductive output (that is, flowering).

C. Juvenile to Adult Transformation.

The maturation of the juvenile into the adult may be mediated by a variety of factors including:

1. Size.
2. Age.
3. Leaf number.
4. Growth conditions. (Conditions that favor growth promote the transition to adult phase; poor conditions, such as water stress, lack of light, low temp, prolong the juvenile phase).
5. Other factors.

Ultimately, one or more of these factors likely induce changes in: **(1)** hormones (such as GA; for example, recall that GA application stimulates the adult phase in conifers but in ivy promotes juvenility), **(2)** nutrient levels (*i.e.*, lack of a carbohydrate supply to the meristematic region), or **(3)** other chemicals, that in turn trigger the developmental switch to adulthood.

Thus we can modify our original scheme:

Juvenile vegetative phase → transition factors (*i.e.*, size, age) → induce hormonal or other changes → adult vegetative phase (competent) → adult reproductive phase → flowering.

D. Adult Vegetative-to-Reproductive Transition:

The transition from the vegetative to reproductive buds is usually triggered by an environmental signal, typically photoperiod or temperature. This signal synchronizes flowering to environmental events. Thus, this is a type of "timing mechanism" that plants use to coordinate actions with the season. If flowers are produced at the wrong time of the year the pollinator may not be available, or it may be too dry (or wet), or there may not be enough time before winter to allow time for successful seed set. Once the inductive signal has been received then the plant meristem is said to be "determined". In other words, it is now committed to flower. Thus, we can modify the diagram again:

Juvenile vegetative phase → transition factors (i.e., size, age) → induce hormonal or other changes → adult vegetative phase (competent) → environmental signal (i.e., photoperiod, temperature) → adult reproductive phase (determined) → flowering expressed.

In some plants, an environmental signal is not necessary to trigger the transition to the determined state. These plants move directly in the reproductive phase after becoming competent.

The two major signals for inducing flowering are light (photoperiod) and temperature (cold treatment).

II. Light, or more specifically, photoperiod and flowering:

A. brief history:

Tournois (1914) was one of the first to report the influence of photoperiod on hops and hemp. Garner's and Allard's classic studies showed that a tobacco mutant, Maryland Mammoth, which failed to flower under field conditions, did so in the greenhouse in the winter in response to photoperiod.

B. The flowering response to day length varies with the species:

1. Short day plants (SDP) - require one or more days with less than a certain amount of daylight. Or, the critical day length to induce flowering must be less than some maximum. These species usually flower in the spring or fall.
2. Long day Plants (LDP) - require one or more days with more than a minimum day length to flower. The critical day length must be longer than a minimum.
3. Day neutral plants (DNP) - ambivalent to day length
4. Plants exhibit a variety of intermediate responses and combinations. For example, there are long-short day plants. After an inductive long-day photoperiod, these plants require short days to flower. This is a good strategy to insure flowering in the late summer.
5. One inductive photoperiod may suffice to induce flowering (*i.e.,* cocklebur, Japanese morning glory); or, flowering many require several days, with a cumulative effect.
6. Light may have a quantitative effect on flowering - in other words, SD may stimulate the percentage of plants that flower.

C. The night period is more important than the day:

Using cocklebur plant, a (SDP), (Bonner & Hamner) showed that it flowers if it received one critical photoperiod with less than 8 hours of light (or, > 16 h darkness). The proportion of light/dark is not important in flowering.
A light break during the night interrupts the flowering response, but a dark period during the day has little effect on flowering. The timing of the night break is important. **Conclusion:** long day plants can be called "short night plants" and short day plants can be called "long night plants".

D. Receptor.

1. Location.

The receptor is located in the leaves. **Evidence:** **(a)** defoliated plants are insensitive to photoperiod; **(b)** plants with a single leaf in the inductive photoperiod will bloom; **(c)** the receptor doesn't seem to reside in meristem since treating the meristem with inductive photoperiod doesn't initiate flowering.

2. Nature of the receptor.

Since light is involved, it suggests that a pigment plays a role in photoperiodism. Phytochrome is a likely candidate because: **(a)** the light break shows red/far red sensitivity; **(b)** the action spectrum for the light break in cocklebur is consistent with phytochrome. In fact, there is evidence for the participation of two forms of phytochrome.

E. Transducing mechanism

1. A diffusible substance plays a role. This is clear since the leaves are the receptors, but the meristem is converted to reproductive stage. Something must be translocated from the reception site (leaves) to the action site (meristem). Grafting experiments provide further evidence.
2. Rate of transport consistent with phloem movement.
3. The diffusible substance is probably similar in most plants. If a SDP is grafted to a LDP and they are placed in a short-day photoperiod (that can induce flowering in the SDP), they will both flower, even though the LDP is not in its inductive photoperiod.
4. Florigen - name given to the proposed flowering "hormone". There is little direct chemical evidence for its existence. Most evidence is from physiological experiments as described above. An extract of induced cocklebur has weak floral-inducing ability.
5. GA may be involved. In brief, exogenous application of GA can substitute for photoperiod, especially in LDP's
6. Ethylene, IAA or cytokinins are associated with flowering in some species. One problem with many of these studies is that the concentration of hormone used was much larger than the amounts that are naturally-occurring and could stimulate abnormal processes. Other substances may be involved in flowering, too.
7. Anthesin is a hypothetical hormone proposed by Chailakhyan that may stimulate flowering in SDP when associated with GA. This existence of this substance is dubious.