Lecture – Floral development – a case study of plant developmental genetics

Overhead - rose

- Concepts and terminology in (flower) development

<table>
<thead>
<tr>
<th>General</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>adaxial/abaxial</td>
<td>gametophyte</td>
</tr>
<tr>
<td>cell autonomy</td>
<td>sporophyte</td>
</tr>
<tr>
<td>cell, tissue, organ</td>
<td>meristem</td>
</tr>
<tr>
<td>determinant, indeterminant</td>
<td></td>
</tr>
<tr>
<td>differentiation</td>
<td></td>
</tr>
<tr>
<td>homeotic</td>
<td>whorls = sepal, petal, stamen,</td>
</tr>
<tr>
<td></td>
<td>carpel</td>
</tr>
<tr>
<td>radial symmetry</td>
<td>calyx = sepals</td>
</tr>
<tr>
<td>spatial</td>
<td>perianth = sepals + petals</td>
</tr>
<tr>
<td>temporal</td>
<td>corolla = petals</td>
</tr>
<tr>
<td>totipotency</td>
<td>stamen = anther + filament</td>
</tr>
<tr>
<td>zygomorphy</td>
<td>carpel = stigma, style, ovary</td>
</tr>
</tbody>
</table>

- Overheads to explain structure terminology

  - life cycle of plants
  - meristems
  - induction of floral meristem
  - structure of idealised flower
  - rose overhead again

- Overheads to explain the ABC model of flower developmental genetics

  - model plants
  - cartoon of flowers
  - second cartoon – simplified structures showing similarities
  - homeotic mutants (3 overheads)
  - Table summarising mutants
  - Colour ABC model

* Asymmetry

  - Australian pollinators
  - NH pollinators
  - Table showing key to pollinators wrt structure and colour
  - Snapdragon mutants
  - Luo et al figure of cyc expression
  - Evolution of floral morphology – altered cyc expression

* Lab 01H - added references.
A flower by any other name is still a rose

Rose Photo SJ Barker  Fan flower Source LANDSCOPE,
Autumn 1994
Figure 1. Life Cycle of a Flowering Plant.

From Goldberg (1988) and reproduced with permission of AAAS.
A. SHOOT APICAL MERISTEM (SAM)
INDETERMINANT SPIRAL PHYLLOTAXY

B. FLORAL MERISTEM (FM)
DETERMINANT WHORL PHYLLOTAXY
Induction & evocation

Organ specification at floral apex

Differentiation of tissues within organs
Structure of an idealized flower (Figure 34.3)
Arabidopsis thaliana
wild type (Meyerowitz)

Antirrhinum majus wild type
(Coen)
Figure 2  Flowers of Antirrhinum (upper) and Arabidopsis (lower). Flowers are shown in side view (left) or face view (right). The Antirrhinum flower shown in side view is opened slightly to illustrate the hinge between upper and lower petals. The face view of Arabidopsis is at a 45° orientation relative to the floral diagram in Figure 2. Antirrhinum drawings were adapted from Weberling (106); Arabidopsis drawings were by Keith Roberts.
floricula: Failure to develop whorls and floral organs (Coen)
Arabidopsis homeotic mutants *apetala* and *agamous* (Meyerowitz)

*apetala*    *agamous*
Arabidopsis homeotic mutants *apetala* and *agamous* (Meyerowitz)

*apetala*  

*agamous*
Homeotic mutants of snap dragon lacking respectively B (deficiens) and C (plena) functions (Coen)
<table>
<thead>
<tr>
<th>genotype</th>
<th>phenotype</th>
<th>whorl 1</th>
<th>whorl 2</th>
<th>whorl 3</th>
<th>whorl 4</th>
<th>region affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>wild-type</td>
<td>sepal</td>
<td>petal</td>
<td>stamen</td>
<td>carpel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ovu, ap2</td>
<td>carpel</td>
<td>stamen</td>
<td>stamen</td>
<td>carpel</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>def. glo, sep, pi, ap3</td>
<td>sepal</td>
<td>sepal</td>
<td>carpel</td>
<td>carpel(^b)</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>pleni, ag</td>
<td>sepal</td>
<td>petal</td>
<td>petal</td>
<td>variable(^b)</td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Whorl 4 does not always develop in some of these mutants.

\(^b\)In *Antirrhinum*, whorl 4 can be petaloid, sepaloid, carpeloid, or a mixture of these; in *Arabidopsis* this whorl contains sepals.

In both species extra petaloid or sepaloid whorls are produced within whorl 4.
Genetics of floral organ identity: The ABC model

Source: Zik and Irish (2003)
Pollinators at work
Photos from LANDSCOPE, Summer 1993-94; Autumn 1994
By thrusting its face into the tubular corolla of an organ-pipe cactus (Lemaireocereus) flower, this bat of the genus Leptonycteris is able to lap up nectar with its long, bristly tongue. Pollen grains clinging to the bat's face and neck are transferred to the next flower it visits. Bat-pollinated flowers have dinky colors and a musty scent (similar to that produced by bats to attract one another), and they open at night.

"Honey guides" on the flowers of the foxglove (Digitalis purpurea) serve as distinctive signals to insect visitors.

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Spectrum of visible light is slightlyrent for the bee than for the human bee's eyes are sensitive to ultraviolet light. Therefore, a flower such as that of the marsh marigold (Caltha palustris), which appears solid yellow to the human eye (a), is seen under ultraviolet light to have distinctive markings visible to the bee (b).
<table>
<thead>
<tr>
<th>Structural blossom class</th>
<th>Pollinator</th>
<th>Color preference (human perceptive light)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dish bowl</td>
<td>Beetles</td>
<td>Brown</td>
</tr>
<tr>
<td>Bell beaker</td>
<td>Wasps</td>
<td>Drab</td>
</tr>
<tr>
<td>Brush</td>
<td>Flies</td>
<td>White</td>
</tr>
<tr>
<td>Gullet</td>
<td>Bats</td>
<td>Yellow</td>
</tr>
<tr>
<td>Flag</td>
<td>Bees</td>
<td>Blue</td>
</tr>
<tr>
<td>Tube</td>
<td>Moths</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Butterflies</td>
<td>Green</td>
</tr>
</tbody>
</table>
Snapdragon mutants: CYC and DICH are floral asymmetry genes

Normal    dich    cyc    cyc.dich


Cyc expression in early floral primordia of snapdragon

Figure 6

a
b
c
d
e
f
g
h
i
j

wild type (zygomorphic)  
cyc (semipeloric)
Altered floral morphology involves
differential expression of symmetry genes

Source: Hileman et al. (2003)
PNAS 100: 12814-12819
Additional References

A general paper looking at the differences between plants and animals


A recent review that summarises the current knowledge about the molecular genetics regulating floral development


A updated review of the ABC model


Evolution of MADS box genes


De Bodt S et al. (2003) And then there were many: MADS goes genomic. TRENDS Plant Sci. 8(10): 475-483


Evolution of floral morphology


Variations in flower development: cauliflowers and cucumbers


Analysis of (non) cell autonomy in specification of whorl identities