Canadian Ornamental Horticultural Alliance # 11

Temperatures within Horticultural Plants:
Stems & Flowers
Growth, micrometeorology, morphology & physiology

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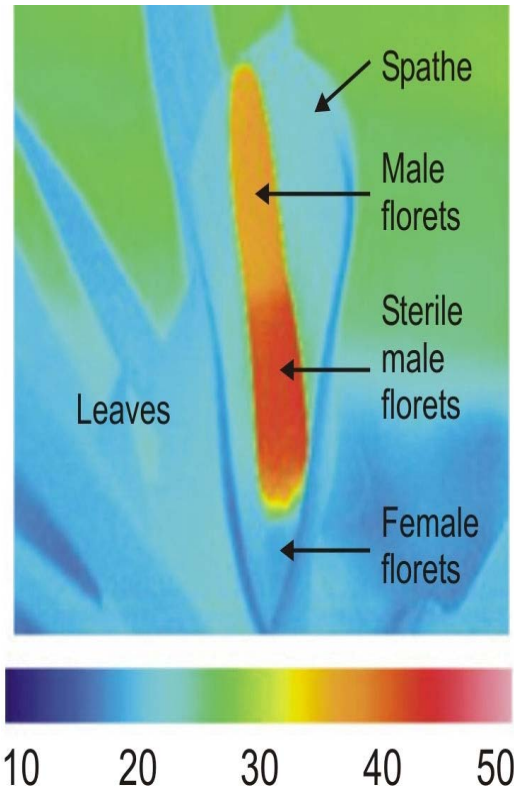
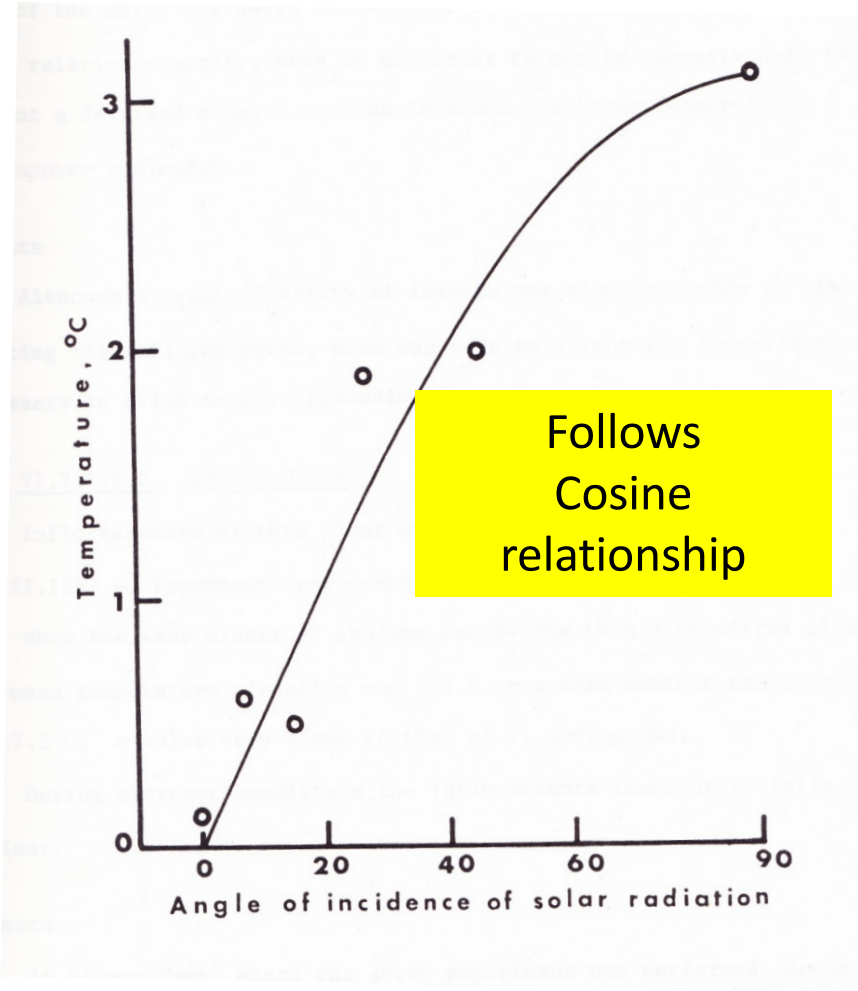
Well Known since 18th C: Temperatures within Bossoms Flowers & Stems of Araceae

Not just tropical!
E.g. Metabolic Heat
in Skunk Cabbage
& other Araceae



Temperatures in Disc Blossom with Solar Incidence



Follows Cosine relationship

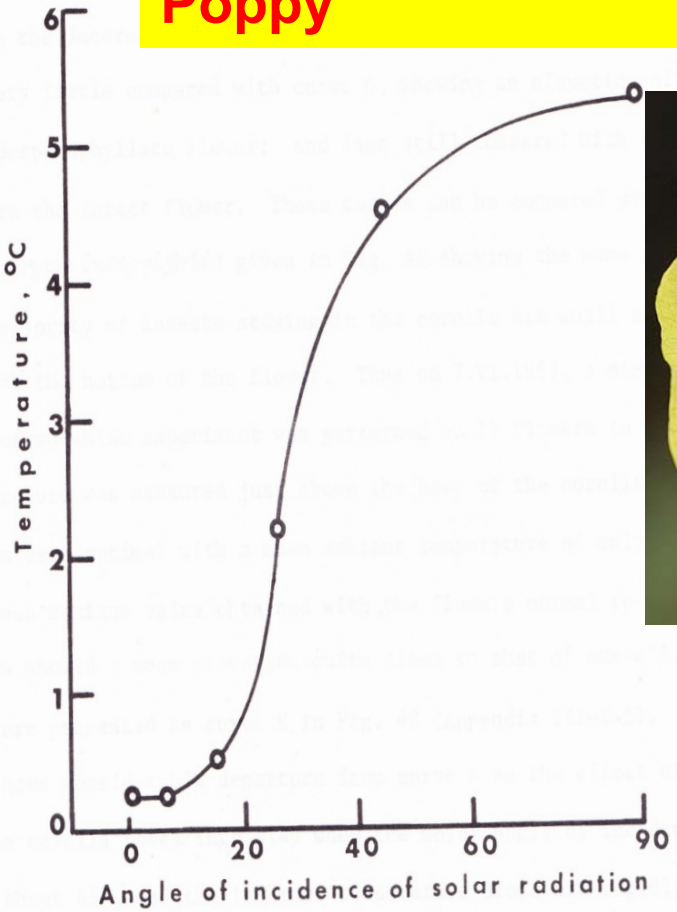
Some species:

Blooms track the sun! Asteraceae, etc.

Diaheliotropism

Temperatures in Open Bowl Blossom with Solar Incidence

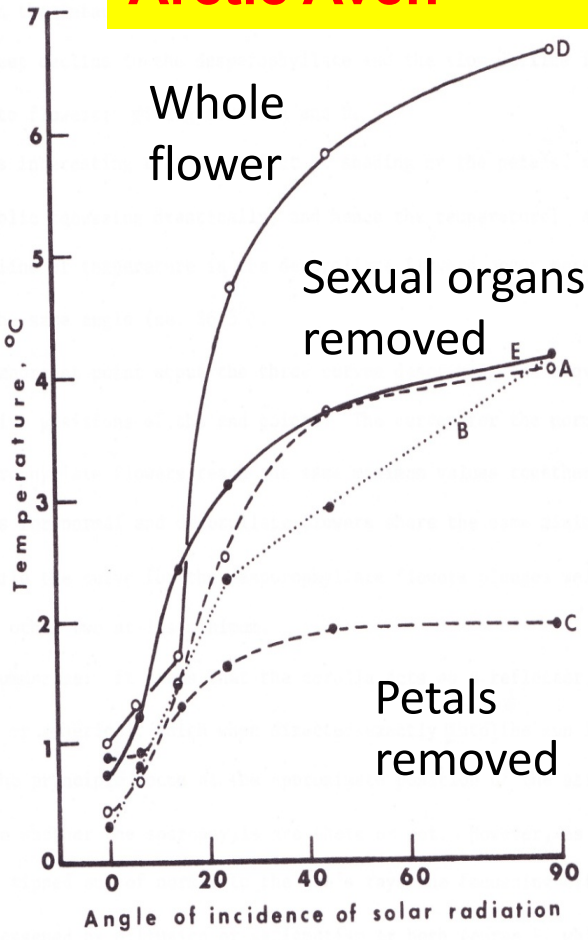
Diaheliotropic Arctic Poppy

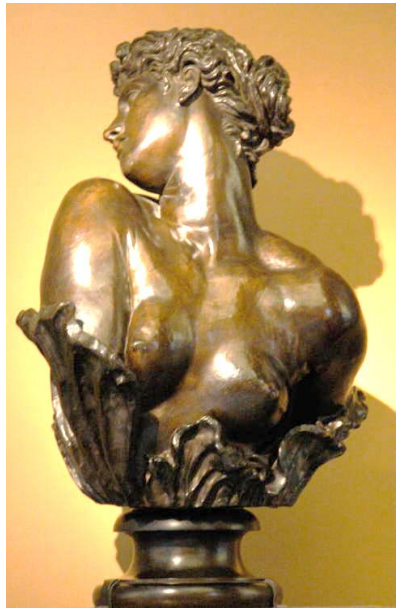


Convex Reflector: Parabolic or Spheric

Temperatures in Open Bowl Blossom with Solar Incidence

Diaheliotropic Arctic Aven





Clyte:
from Ovid's
"Metamorphosis"

Other flowers:
Ranunculus spp.,
Anenome

Pubescence traps Heat
Willow (*Salix*) Catkins

General:
2 – 4 C warmer than ambient air at 5 -10 C

Sexual differences:
Pistillate warmer than Staminate by 1 – 3 C

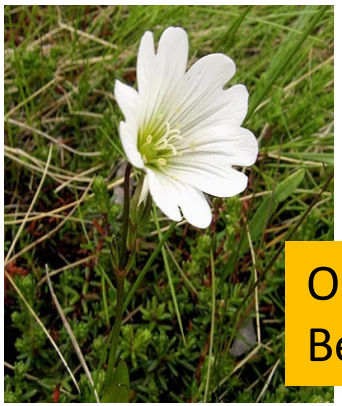
Orientation:
Insolated side warmer than shaded side by 1 – 2 C

Cloudy:
Temperatures as ambient air

Mechanisms of Heating in Open Flowers

⇩ Irradiance: Solar energy

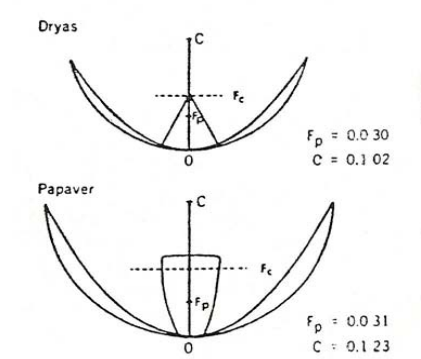
Shapes & Forms



Open Bells

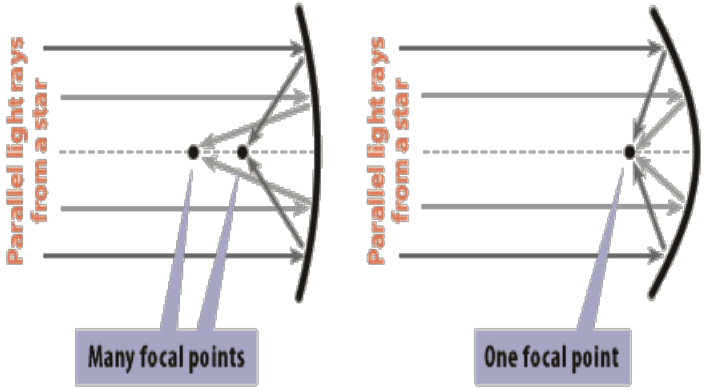
Discs

Pubescence



Spherically shaped mirror has spherical aberration

Mirror with parabolic shape has no spherical aberration



NOTE: The parabolic shape above has been exaggerated.

Bowls: Parabolic or Spheric radiation collectors

Different wavebands including IR

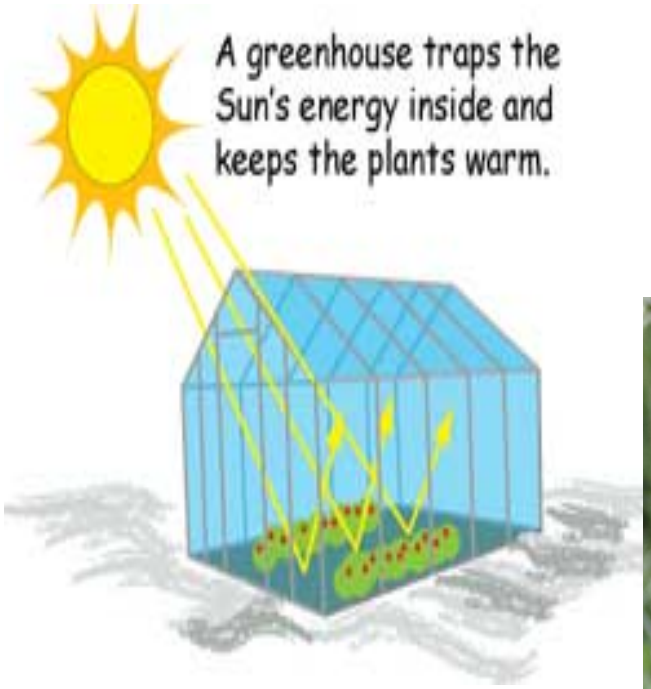
Pigments in solution (D-G, I-K)
in plastids (A ~~+ C~~, H)
Differential placement of pigments
(cell layers, plastid placement)
Surface texture (glossy, matte, iridescence)
Other mechanisms

Hanging flowers trap Convected Warm Air

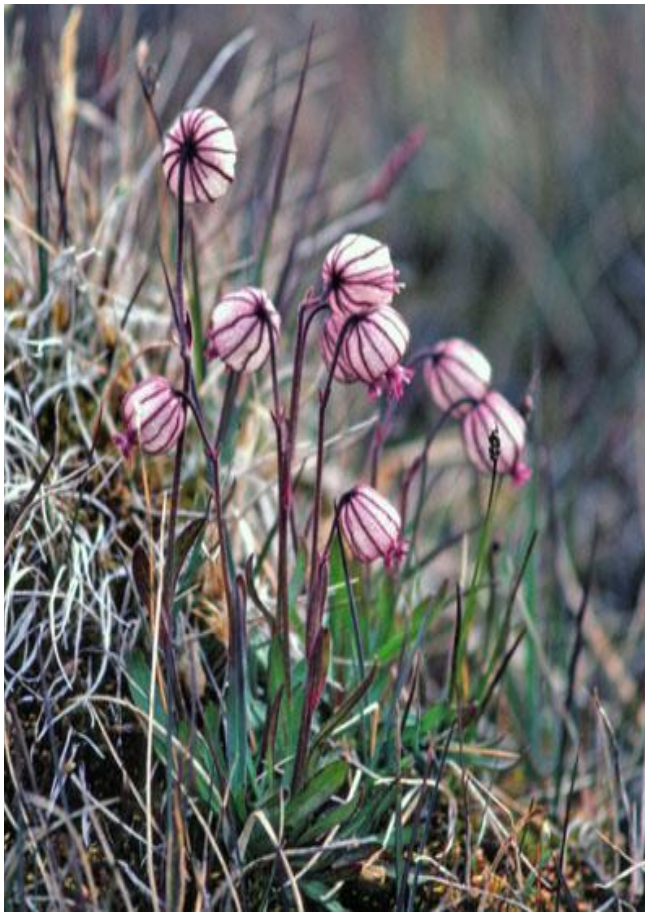
Ericaceae:
1 – 2 C warmer than surrounding air

Others, e.g. *Mertensia, Campanula,* etc. may function similarly but not investigated

Heating in Enclosed Flowers & Stems: Microgreenhouses



Microgreenhouse Calyx



Melandrium apetalum

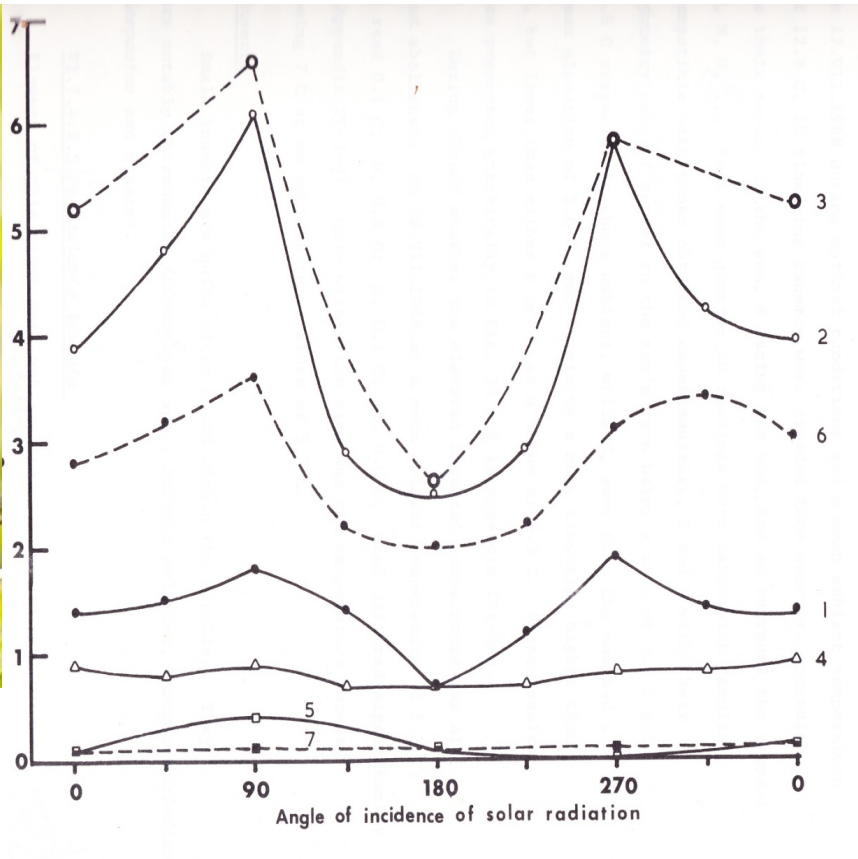
Calyx forms translucent enclosure

Pistil within absorbs solar heat

Enclosure warms to 4 – 5 C above ambient air in sunshine

No effect under cloud or shade

Heating in Enclosed Flowers & Solar Incidence: E.g. Arctic *Pedicularis* spp.



Snapdragon Flowers

Yes, Temperature excesses in flowers
(up to 7 C)
Compare floral colours

Results (2018) not as expected:
more questions:

Should pale coloured flowers be warmer from greater micro-greenhouse effect?

Or

Should darker flowers be warmer from more solar absorption?

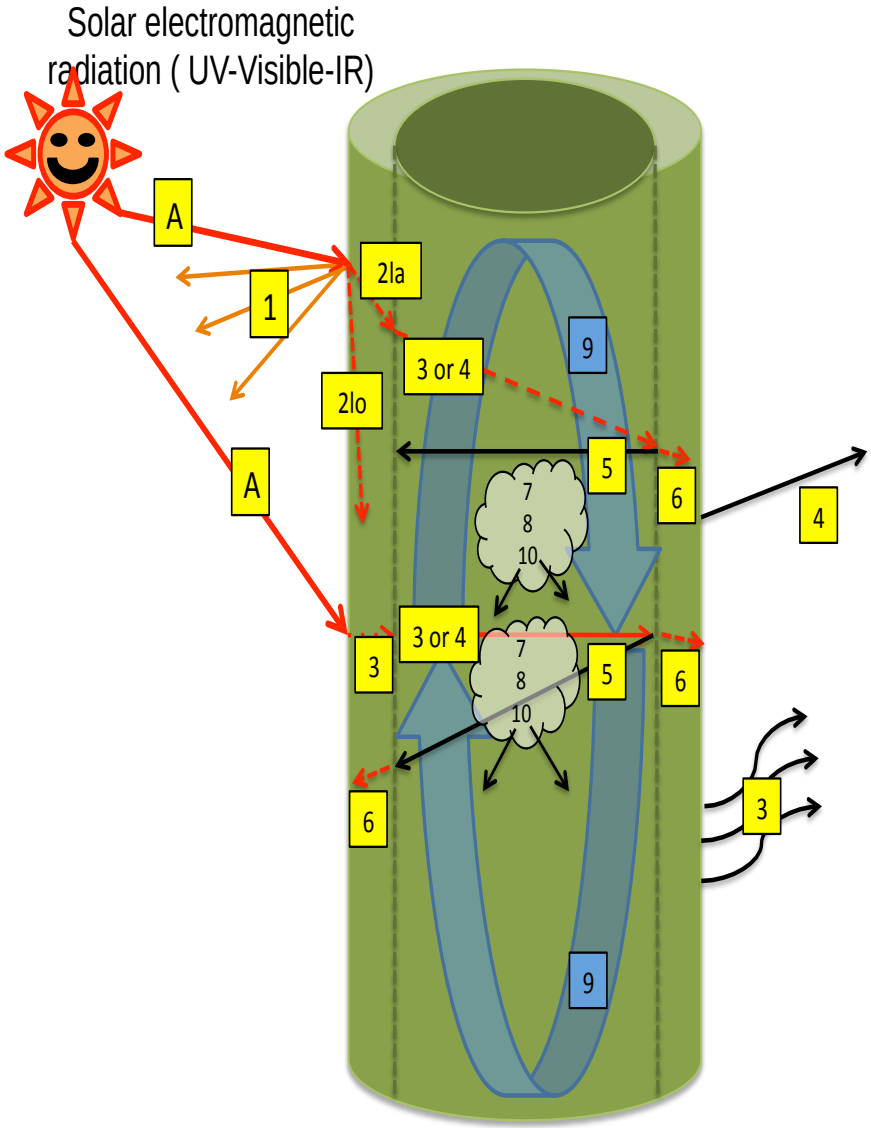
H
Heating in Hollow Stems: New Studies

Balsam weed stems: +3 – 4 C

2017 Survey (ON, QC, MB, UK):
50% of herbaceous plant have hollow stems

Arctic Mastodon Flower stems: + 3- 5 C
Growth: > 2 cm/day

Complex Mechanisms of Heating in Stems



Solar radiation (UV-Visible-IR) (A):

Some Reflected (1),
Some Absorbed (2),
Some Transmitted (3) (translucence).

Absorbed radiation Conducted (2la; 2lo).

Some lost (radiation (3)/conduction (4)) in/out of (lumen) stem.
Transmitted (3)/conducted (4) heat adds energy to the lumen.
Within, radiant energy (3), can be a) reflected (5), b) absorbed (6),

and also

Absorbed by atmosphere in lumen (7), then exchange by Conduction (8) , Convection (9) and Reradiation (10).

= Greenhouse Effect

Heat in stems liberated by radiation (Emissivity; 3) & conduction (4) to environment. Some conducted away by phloem & xylem; 2lo). Some is used in photosynthesis, and metabolism (not shown).

Paperwhite Narcissus Stems

Hollow stems ca. 5 C warmer than surrounding air (2019 Results)

Hollow

Translucent

Inside surface shiny (not wet)

Microgreenhouse effects coupled with Thermos bottle effect?

Mechanisms of Heating in Enclosed Flowers & Stems

- **Methods:**
- **Temperature measurements** (thermocouples, thermistors)
- **Shape & Form Measurements**
  - Physical dimensions
  - Reflectance spectrophotometry (including IR)
  - Absorbance spectrophotometry (pigments as filters)
  - Histology (morphology cellular & subcellular)
- **Light & Electron (SEM & TEM) microscopy** (cell & cellular morphology)
- **IR thermography (Heat)**
- **Thermal Conductance etc.**

Synthesis, State of Science, & Novel Interdisciplinary Opportunities in Biophysics

Characteristic	Flowers	Stems
A. Pigments	**++++**	**++++**
B. Pigment placement	**+**	**+**
C. Pigment absorption/reflection	**+++**	**++**
D. Floral/stem morphology (gross)	**+++**	**+**
E. Floral/stem morphology (microscopic)	**++**	**+**
F. Floral/stem colorimetry (re: A – E)	**+++**	**+**
G. Floral behaviour (diaheliotropism, epinastism)	**++**	**?**
H. Internal temperatures & Heat flux	**+**	**0**
I. Mechanisms for internal temperatures	**+**	**0**

Relations to Pollination & Plant Reproduction

General Botany

- Floral maturation
  - Anther maturity
  - Pistil maturity
  - Pollen tube growth
- Floral display
  - Visibilty & Conspicuousness
- Floral rewards to pollinators
  - Warmth
  - Nectar viscosity & warmth
  - Pollen display
- Seed & Fruit display
  - Stem elongation
  - Dispersal by wind
  - Animal dispersal

Horticultural Specifics

- Seed production
- Propagation
- Floral display
  - Stem bending
  - Floral life (shelf life)
- Stem elongation
  - Temperature fluctuations
- Water relations
  - Transpiration
  - Irrigation needs
- Diseases
  - Humidity & Temperature

Thank you!