Natural selection process:

1- Variation exist in any population

2- Population produces offspring

3- Selective pressure acts

4- Selected trait will reproduce

5- Population with an adaptive trait (here size)

Adaptation: Natural selection acts on phenotype (visual characteristics of an individual) and phenotype reflects one’s genotype (genetic structure)

Favoring features important for an organism's survival and reproduction.

Thus an adaptive trait can be defined as:

"The form of a trait that gives an individual a gene-transmitting advantage over other individuals with an alternative form of the trait."

Are sexually selected traits adaptive?

How about protective traits?

Adaptive traits

- Structural: Shape, ornaments, or internal arrangements
- Behavioral: Ability to escape, to learn, etc
- Physiological: Thermoregulation, development

Biological Evolution: Refers to any heritable change in attributes of a population over time

Coevolution: Interdependent evolution of two (or more) species with ecological relationship (e.g. pollinator-plant interaction)

Natural selection: Operates such that individuals which are best adapted to the environment survive and transfer genes to offspring

Charles Darwin 1809-1882
Alfred Wallace 1823-1913
Natural selection may function at different levels:

- **Individual selection**: Selection of traits that maximize individual's reproduction and survival
- **Gametic selection**: May act on a gamete population
- **Kin selection**: Favours genes that benefit reproductive success and survival of close relatives, but not necessarily the individual
- **Group selection**: Groups with less adaptive genes can become extinct and the groups best adapted will survive

Selective forces may be biotic and/or abiotic; here we will focus on biotic factors:

*Insects need to protect themselves against various predators, parasitoids and parasites present in their ecosystem*

‘Natural enemies’ may be visual, or non-visual and insects possess a range of mechanisms to protect themselves.

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**Discussion**

Invertebrate predation

**Importance of invertebrate predators:**

- They are very abundant.
- They are able to learn to avoid unpalatable prey species.
- They use various cues, including visual cues, to recognize prey.

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**Protective mechanisms of would-be prey:**

I) Mechanical defense
II) Chemical defense
III) Behavioral defense
IV) Protective colors and patterns
Protective mechanisms:
I) Mechanical defense
II) Chemical defense

Chemical defense: Unpalatability (bad taste)

Protective mechanisms:
I) Mechanical defense
II) Chemical defense
III) Behavioral defense
Evasion (e.g. Diptera and Coleoptera)
Death feigning (e.g. Coleoptera and Orthoptera)
Startle (e.g. eyespots in Lepidoptera)

Other examples

Protective colors and patterns:
Aposematism: A signal (an appearance) which warns off enemies because it denotes something unpleasant or dangerous

Some examples of defense:
1) Taste
2) Sting
3) Toxin

Edward Poulton 1856-1943

Both the warningly colored animal and receiver are expected to benefit- Why?
Protective colors and patterns:
- **Masquerade:** Resemblance to an uninteresting element of the environment.

Masquerade may be associated with behaviors that maximize its efficiency

Example: Walking stick (‘Phasmina’)

Camouflage:

a) **Background matching:** Insect colors and patterns resemble those of a random sample of the background

Camouflage:

a) **Background matching limitation**

Background matching is most effective in homogenous habitat

Limits insect movement as movement increase probability of detection

Possessor may have fewer foraging and/or mating options

This means that the insect may be seem but would not be recognized as a prey by the predator

This would allow the bearer to move in heterogeneous habitats (more frequently than a background matcher)

Cuthill et al. 2005 - Nature

Cuthill et al. 2005 - Nature
Mimicry: Resemblance in form, color, pattern etc. between mimic(s) and model(s)

- **Müllerian mimicry**
  Both mimic and model are unpalatable and they both gain protection by resembling one another.
  - Heliconius spp. butterflies (Order: Lepidoptera)
  - Bumblebee mimicry ring (Order: Hymenoptera)
  - Wasp mimicry ring (Order: Hymenoptera)

- **Batesian mimicry**
  Palatable mimics resembling unpalatable models in order to gain protection.
  - Undefended mimics
  - Defended models
  - Associated behaviors may increase the effectiveness of Batesian mimicry
    - Buzzing sound
    - Foreleg waving
    - Pretend to sting

H.W. Bates (1862)
F. Müller (1878)
Batesian mimicry in hoverflies

- **Perfect mimicry:**
  Sometimes palatable mimics resemble their noxious models very closely.

- **Imperfect mimicry:**
  More frequently however, mimics do not resemble their model closely.

Discussion

**Why are there perfect and imperfect mimics?**

- Curve of protection?
- Multi-Model hypothesis?
- There is no mimicry at all?
- Mimicry through the eye of beholder?
- Imperfect mimicry, an intermediate stage?
- Human induced habitat changes?

Various types of constrains

**Phylogenetic:** Insects inherit features that constrain their evolution

**Genetic:** Genetic mechanisms prevent evolutionary changes toward a certain direction

**Physiological:** Organisms have a limited resource for allocation to competing functions.
Host: *Drosophila nigrospiracula*  
Ectoparasite: *Macrocheles subbadius*

Some flies are able to knock mites off their body by sudden burst of flight and kicking behavior.

Selection experiment proved that this trait is heritable.

Flies vary in their ability to resist (or escape) parasitism by the mite. Why not all resistant?