BIOL2007
Evolution of warning colour and mimicry

DEFENSIVE COLORATION

Camouflage - also called *crypsis*, *cryptic coloration*.

Flash coloration. e.g. flying grasshoppers which have blue or red underwings or "underwing" moths. Eyed hawkmoth.

Aposematism or **warning colour.** Avertises punishment could be in the form of:

Unpalatability e.g. wasp stings, distastefulness.
Smelliness e.g. skunk.
Dangerousness e.g. coral snakes (cobra family).

Warning colours are usually ***learned***
But ***innate recognition*** of coral snake patterns.

Mimicry. A ***mimic*** evolves to look like an unpleasant ***model*** species.

Two major kinds of mimicry are:
Batesian mimicry - (Bates 1862), cheats, parasites!
Müllerian mimicry - after Müller (1879), mutualists.

EVIDENCE FOR MIMICRY AND WARNING COLOUR

Experimental evidence for the efficacy of warning colour and mimicry.

Jane van Zandt Brower & Lincoln Brower in the 1950s performed ***laboratory experiments*** with blue jays and monarch butterflies (*Danaus plexippus*):

1) Jays fed monarchs became sick & wiped beak
∴ monarchs are unpalatable.
2) Jays learn to avoid monarchs
∴ appropriate learning is possible
3) Having learnt, Jays avoid mimics of monarchs
∴ mimicry theory correct

EVIDENCE FOR MIMICRY AND WARNING COLOUR
Experimental evidence for the efficacy of warning colour and mimicry.

Field experiments few! e.g. Jeffords, Waldbauer & Sternberg - Batesian mimicry.

Painted palatable male day flying moths (*Callosamia promethea*), a natural mimic of the unpalatable papilionid *Battus philenor*, to resemble unpalatable and palatable species [OVERHEAD 6A].

Recaptured by baiting traps with females, which "call" using pheromones.

Mimics of palatable species recaptured at a rate only 40% of rate of recapture of mimics of unpalatable species
$\therefore s=0.6$.
Similar field experiments with Müllerian mimicry in *Heliconius*:
$s \approx 0.2\text{-}0.6$.
Selection for mimicry can be strong!

Evolution of unpalatability and warning colour

Unpalatability
Potentially a **costly** altruism
(a) metabolic energy to sequester or synthesize the unpalatable compounds
(b) danger in teaching predators

Benefit to the individual potentially enormous
e.g compounds are sequestered wings of Danaidae

If the **cost** > **the** individual **benefit** unpalatability would be a true **altruism**

a warningly coloured cheat would do rather well by avoiding the cost of chemical sequestration, but gaining protection due to others' unpalatability.

Kin selection a possible mode of evolution.

Fisher (1930) suggested that this is why gregarious larvae, usually laid as eggs by a single female, associated with warning colour

If **Benefits** to the individual **> costs,** unpalatability **not** altruism can evolve under individual selection alone. (possibly helped along by kin selection)

Solitary larvae, like the famous monarch butterfly *Danaus plexippus*

Adults migrate thousands of km as though as far away from their relatives as possible!

Living gregariously.

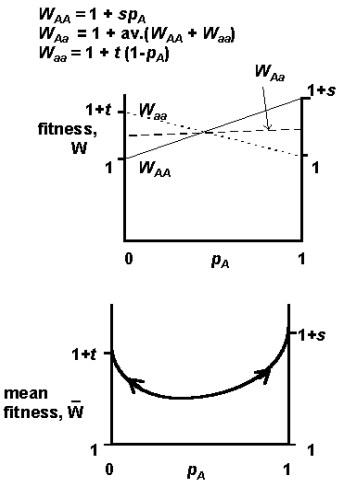
So why do *some* unpalatable caterpillars live in family groups?

Surely this is good evidence for kin selection! **No!**

Some very good ***selfish*** reasons why unpalatable species should live groups:

Predator satiation by groups.
Group defence, coordinated signalling.
By aggregating, avoid some predators entirely.

EVOLUTION OF WARNING COLOURS
after evolution of unpalatability



shifting balance/kin selection
individual selection
preadaptation to signalling:
sexual selection
flash coloration
Batesian mimicry (warning colour before unpal.)
Müllerian mimicry
sensory bias

Evidence
diversity of warning patterns within unpalatable clades: suggests warning colour evolves rapidly.

EVOLUTION OF MIMICRY
Punnett early 20th C., a Mendelian – Darwinian evolution did not explain mimicry

Fisher 1930 proposed gradualistic explanation

Goldschmidt in 1940-1945, proposed "systemic mutation" - single, massive chromosomal mutations that reorganized the whole genome. Suggested that homologous developmental pathways were used in model and mimic.

Modern view: a little of both!

Batesian mimicry

Sir Cyril Clarke and Philip Sheppard: Papilionidae. Goldschmidt was *wrong* on the details.e.g. *Papilio memnon*
1) Mimics: *analogous* resemblance
2) Mimicry not inherited as a single gene:
Major locus + unlinked components
Major locus itself is "supergene"
3) Polymorphism in Batesian mimicry if tight linkage disequilibrium at "supergene"

Müllerian mimicry

Selection AGAINST rarity. Few polymorphisms
Therefore, do not expect "supergenes"
In *Heliconius* a number of unlinked loci
On the other hand, mimicry genes do have large effects, with strong selection ≠ Fisher gradualist theory.
e.g. D^{ry} gene in *Heliconius erato*
Nicholson "two-step" model of Müllerian mimicry:
1) Mimicry provides a "rugged" adaptive landscape
2) A major mutation does help Müllerian adaptation
3) More minor genes do "Tidying up"

MIMICRY AND WARNING COLOUR

Provides examples of more general evolutionary thinking:

Social evolution and kin selection
Linkage disequilibria and evolution at >1 gene
Evolutionary developmental genetics
Drift/shifting balance in evolution
Race formation and speciation
Biogeography