

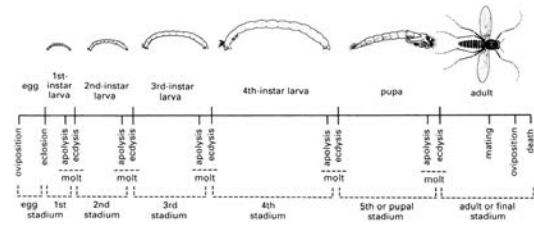
Insect growth

- Kinds of growth
 - Indeterminate
 - Determinate
- Growth through molting
 - Membranes expand *within* instar
 - Growth when exoskeleton is soft just after molting

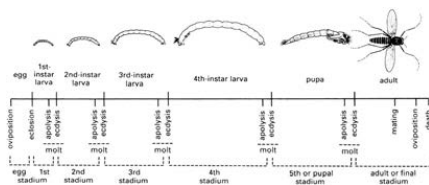


Insect development

- Instar = Stadium
- Imago = Adult

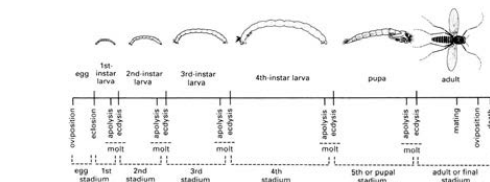


Insect development



- Molt increment: increase in size between instars

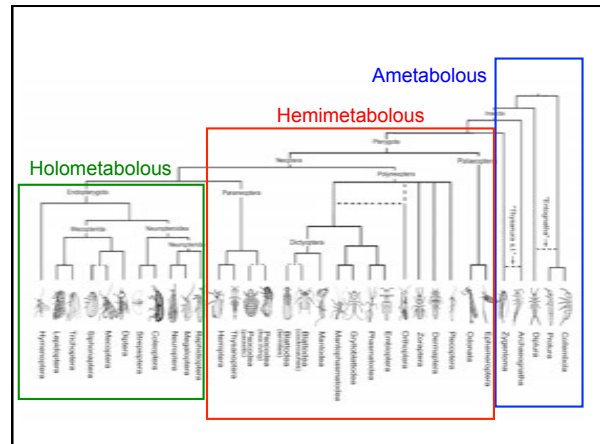
Insect development



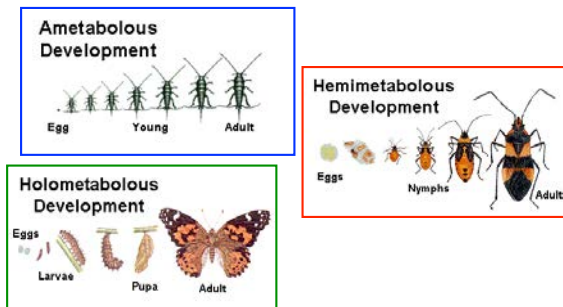
- Factors influencing molt increments, intermolt period, and number of instars
 - Food supply
 - Temperature
 - Sex
 - Interaction between genes and environment

Overall life history patterns

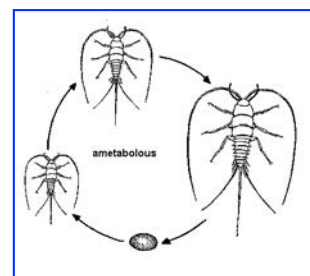
- **Ametabolous**
 - Primitive wingless groups
 - Indefinite number of molts
- **Hemimetabolous**
 - Gradual change towards adult form
 - Wings develop externally
- **Holometabolous**
 - Non-feeding pupal stage present
 - Develop wings and other adult structures internally during immature stages.



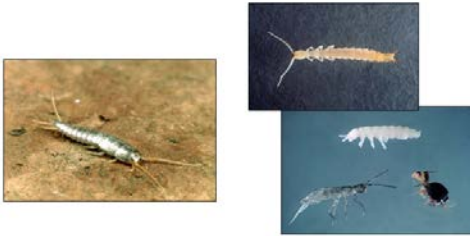
Overall life history patterns



Overall life history patterns

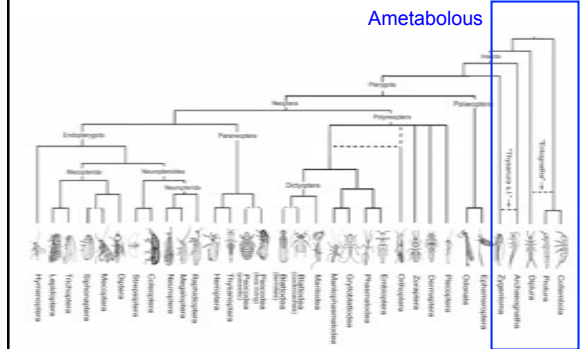


Indeterminate growth



- Continue to molt until death
 - Collembola, Diplura (non-insect Hexapoda)
 - Apterygote insects: Zygentoma (silverfish) & Archaeognatha (bristletails)

Ametabolous

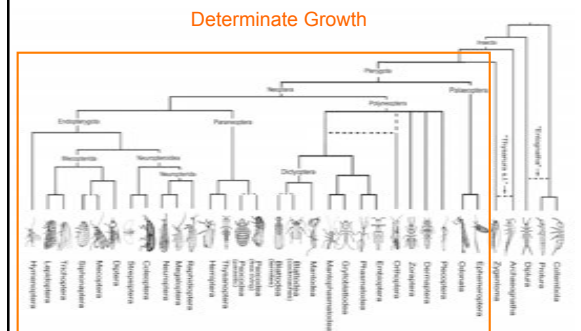


Determinate growth

- Most insects (Pterygota)
- Distinctive instar marks end of growth



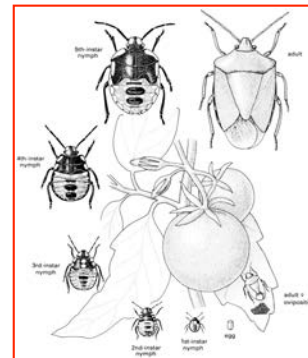
Determinate Growth



Hemimetabolous

- Stages
 - Egg, nymph, adult (no pupa)
 - In aquatic insects, immature called naiad
 - Nymph resembles adult but without wings
- Exopterygote: wings develop on dorsal surface of thorax
- Terrestrial
 - Adults and immatures often use similar habitats and food
 - Examples are crickets, true bugs, cockroaches
- Aquatic: dragonflies, mayflies, stoneflies

Hemimetabolous

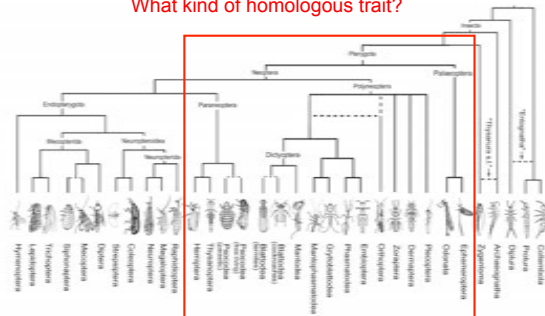


Hemimetabolous

Does this define a monophyletic taxon?

Is this a homologous trait?

What kind of homologous trait?



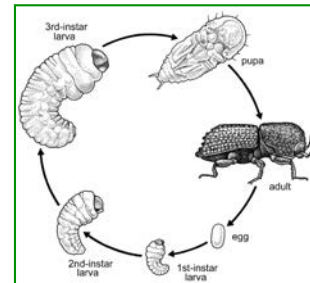
Hemimetabolous nymphs & naiads



Holometabolous

- Stages
 - Egg, larva, **pupa**, adult
 - Larval stages look very different than adult
 - Larvae often use different habitats and eat different food than adults
- Adult structures found in larvae as 'imaginal disks'
- Endopterygote: wings develop in invaginated pockets of integument
- Bees, wasps, butterflies, beetles, flies, caddisflies.

Holometabolous

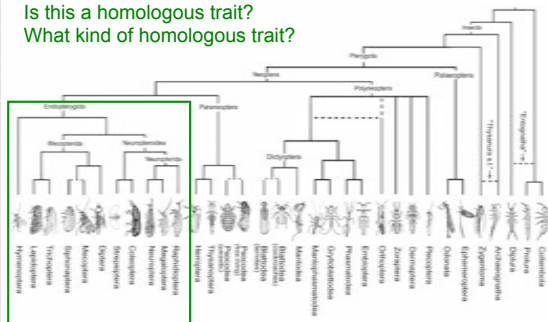


Holometabolous

Is this a monophyletic trait?

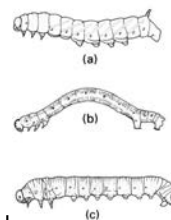
Is this a homologous trait?

What kind of homologous trait?



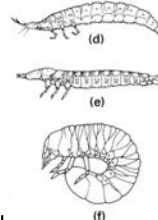
Larval types

POLYPOD LARVAE



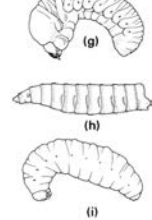
Thoracic legs
Abdominal **prolegs**
Lepidoptera, sawflies

OLIGOPOD LARVAE



Thoracic legs
No abdominal **prolegs**
Prognathous
Many orders, predatory beetles

APOD LARVAE

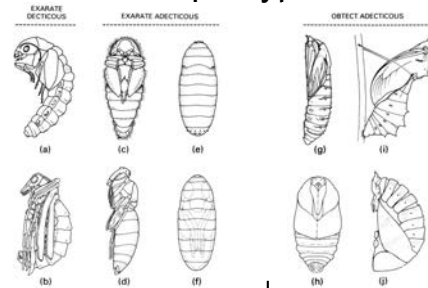


No legs
Flies, wasps, some beetles
Predators, soil, dung, carrion

Pupa

- Resting stage
- Rearrangement of body into adult form
- Sometimes enclosed in cocoon
- At end, pupa encloses adult

Pupal types



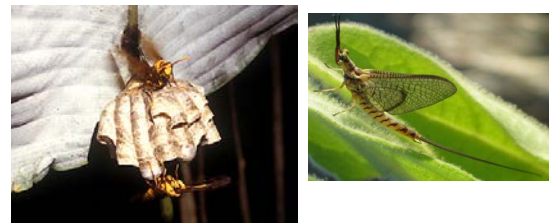
Most pupae
Appendages loosely
pressed to body

Sclerotized cuticle
Appendages
cemented to body

Ecdysis



Adult



- Wings
- Reproductive organs mature
- May be long lived or may lack mouthparts

Voltinism

- Numbers of generations per year
 - Univoltine
 - One generation per year
 - Tends to occur in colder climates, where season length limits time for completion of life cycle.
 - Bivoltine
 - Two generations per year
 - Multivoltine
 - Multiple generations per year
 - Occurs when enough time exists for completion of multiple reproductive cycles.

Diapause

- Arrested development after physiological change
- Inactive and not feeding
- Can last months or years
- Need 2nd physiological change to break diapause
- Induced or terminated by photoperiod, temperature, food quality, food chemistry
- Types
 - Obligatory: required to complete life cycle regardless of environment, often found in univoltine insects
 - Facultative: Dependent upon environmental conditions.

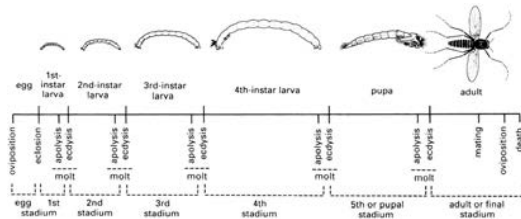
Quiescence

- Halted or slow development during unfavorable conditions
- Activity or slow development during unfavorable conditions.
- Does not involve physiological changes like diapause and is triggered directly by environment (e.g. cool temperature) rather than separate cue
- Difficult sometimes to tell from diapause

Diapause & Quiescence



Diapause can occur in any stage



Evolution of Dispersal

- Principle of allocation
 - Resources are limited
 - Allocation to one trait (e.g. dispersal) reduces other allocation to other traits
 - This generates tradeoffs
- Dispersal has costs and benefits
 - Benefits
 - Ability to leave poor habitats
 - Reduced risk of competition, disease, predation in new habitats
 - Costs
 - Energy required could be invested in egg production
 - Travel time
 - Predation during travel
 - Risk (what kind?)

Salt marsh planthoppers

- Adults polymorphic for wing length
 - Some have reduced hind wings and lay more eggs (**brachypters**).
 - Others have four full wings and can travel long distances (**macropters**).
- Macropter frequency 20-90%
 - Increases under crowded conditions
 - Increases in unpredictable habitats.



Migratory Locusts

- Solitary form
 - Shuns other locusts
 - Large adult with higher fecundity
- Gregarious form
 - Disperses long distances in large groups
 - Induced by crowding and poor habitat



Dispersal: Habitat Differences

- **Crickets & Grasshoppers**
 - Flighted species predominate
 - Pastures, meadows, open areas, trees
 - Flightless species predominate
 - Woodland, beneath stones, caves, in ant and termite nests



Flightlessness

- **Islands**
- Flightlessness often evolves on islands
- Why?
- What kinds of islands?



Flightlessness

- **Large & Cryptic**
- Why be flightless?



Dispersal: Gender Differences



- In which sex would you expect to see flightlessness more often?