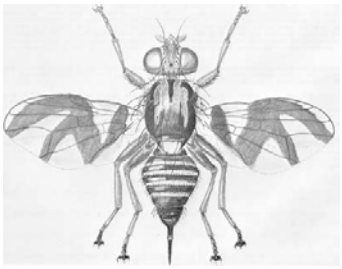


Rhagoletis pomonella

Native to North America
Males hang around fruit and mate with females
Females oviposit eggs on hawthorne fruit
Larvae grow up on fruit, spoiling it

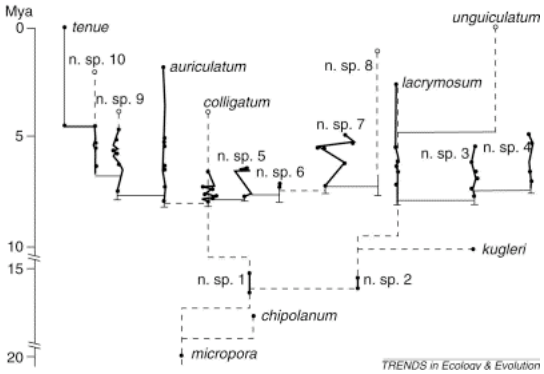
About 100 years ago, Rhagoletis started to lay eggs on apples, and also on cherries, pears and roses.

Now is a major agricultural pest.

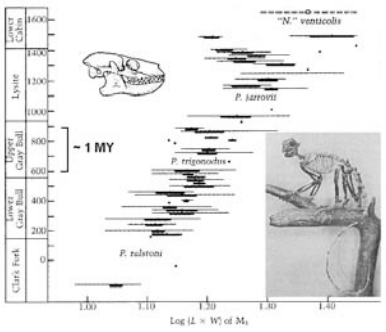
Assortative mating (hawthorn males mate with hawthorn females; apple males mate with apple females)

The two races (apple/hawthorn) are genetically different (from gel electrophoresis)

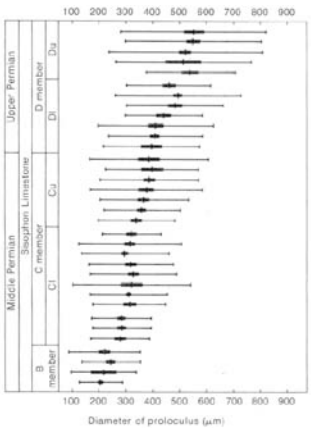
Developmental time is different too (40 vs. 60 days for hawthorn maggots)



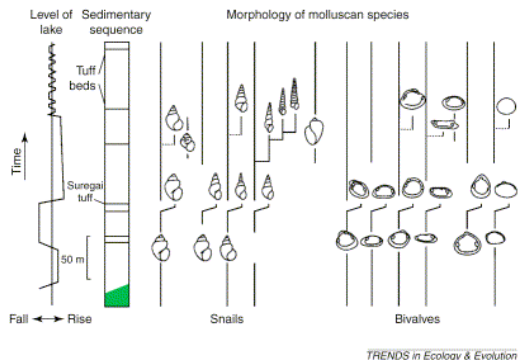
Metrabdotos (bryozoan)

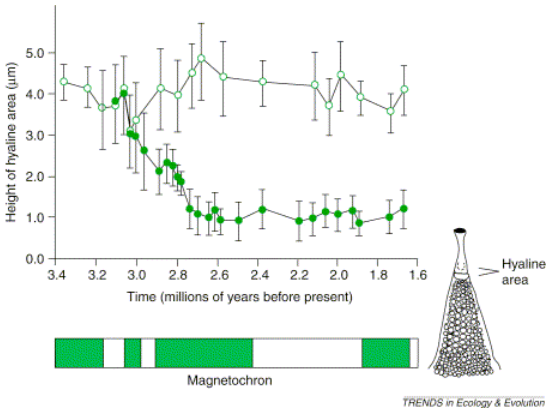


Evolution of the Eocene primate Pelycodus and Notharctus.

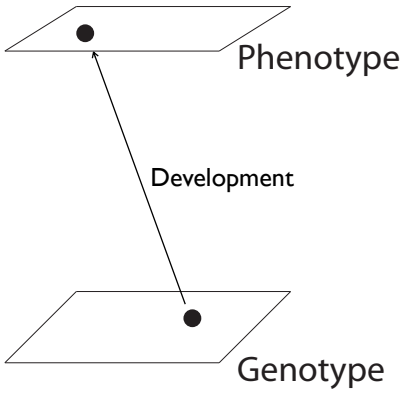


Evolutionary trends in Lepidolina: The increase in the diameter of the prolocus (initial chamber) of the fusulinid foraminiferan Lepidolina multiseptata.





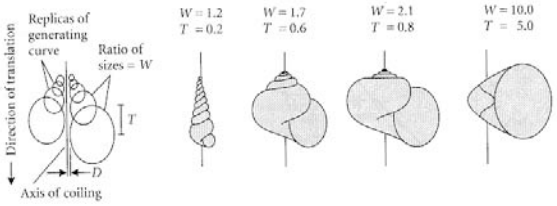
Rhizosolenia (planktonic diatom)



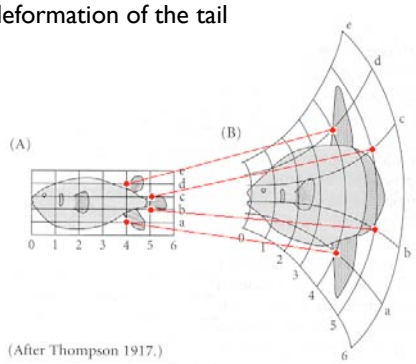
Can small, quantitative changes lead to large qualitative changes?

Raup (1962) model for shell coiling in gastropods.

Real snails occupy one area of the parameter space. Many theoretically possible patterns have not yet evolved.



D'Arcy Thompson (1926) coordinate transformation: pufferfish to sunfish by positive deformation of the tail region



Allometry & Heterochrony

- Allometry: differential rates of growth of different body parts.
- Heterochrony: alternation of relative timing of development in evolution, produced by selection on allometric relationship

Allometric equation

$$y = mx^a$$

x and y are trait measurements

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If m = 1, then...

$$\ln y = a \ln x$$

a is the allometric coefficient

---

a = 1: then y is proportional to x and there is no allometry; y is isometric with respect to x

a > 1: then y grows faster than x (positive allometry)

a < 1: then y grows slower than x (negative allometry)

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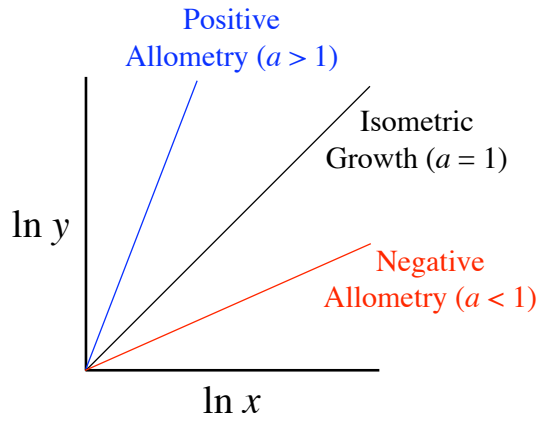

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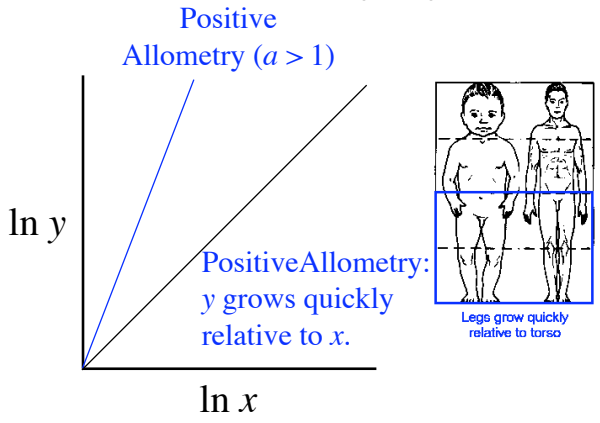
Example of positive allometry



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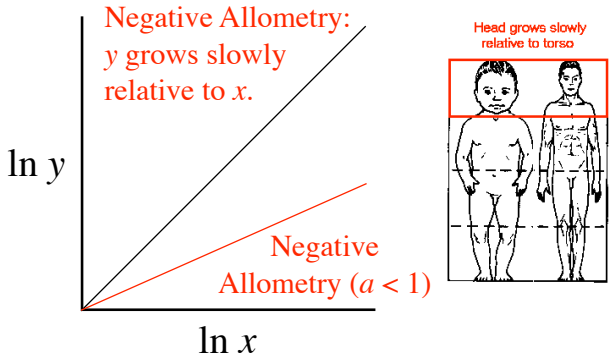
Example of negative allometry



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The allometric coefficient (a) can be shown to be variable, heritable, and adaptive.

Therefore, natural selection can act on it.

The end-point of ontogeny can be altered by selection on initial parameters of development:

(a) change the allometric relationship

(b) change the relative timing of the onset or offset of developmental events

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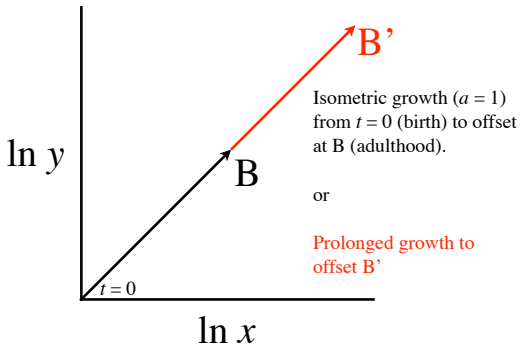

Isometric growth ($a = 1$) from $t = 0$ (birth) to offset at B (adulthood).

or

Prolonged growth to offset B'

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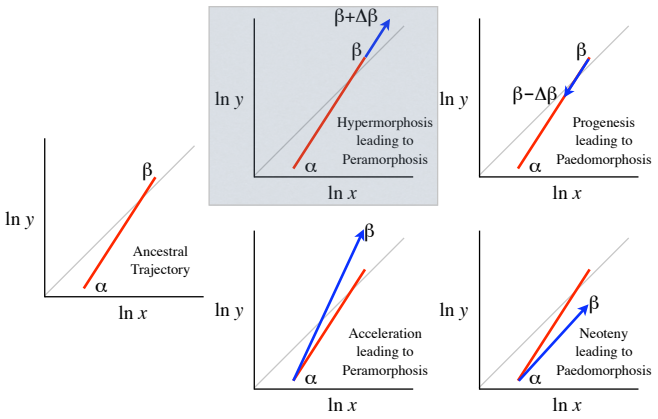
Four heterochronic processes

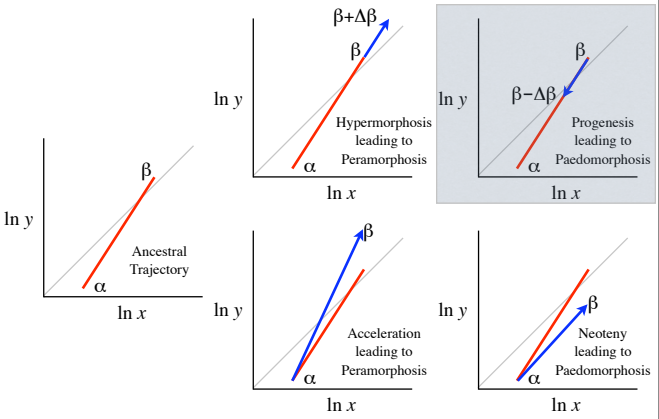
- Acceleration: relative rate changes faster (a increases)
- Neoteny: relative rate changes more slowly (a decreases)
- Hypermorphosis: relative rate is prolonged
- Progenesis: relative growth rate is fore-shortened

20



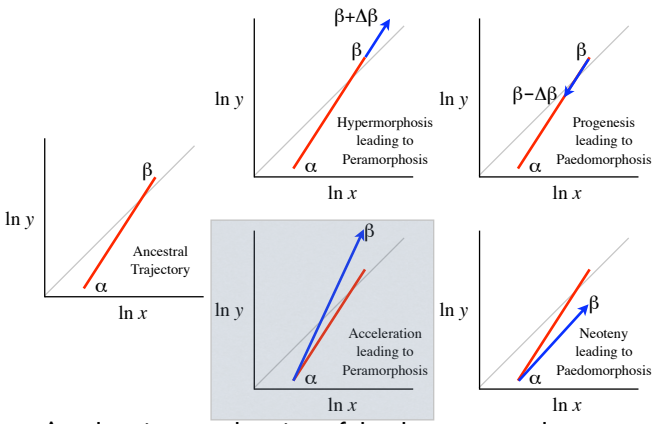
Hypermorphosis: extension of the period of growth results in exaggerated adult features

21



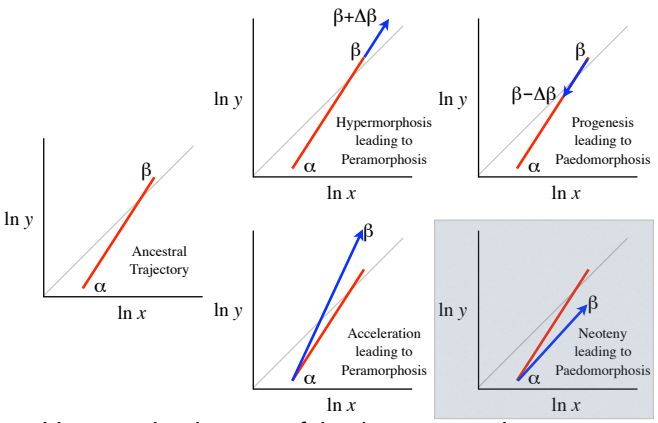
Progenesis: early cessation of growth results in retention of juvenile features

22



Acceleration: acceleration of development results in exaggerated adult features

23



Neoteny: deceleration of development results in retention of juvenile features

24

Progenesis and/or neoteny produce paedamorphosis (child form): the retention of juvenile characteristics into adult organisms

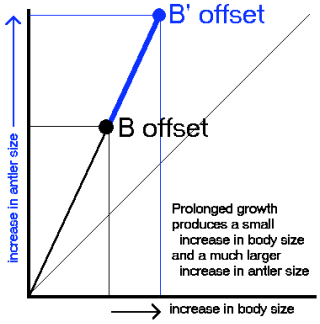
Hypermorphosis and/or acceleration produce peramorphosis (elder form): exaggeration of adult characteristics in larger organisms

25

Example of hypermorphosis: the extinct Irish Elk

26

Hypermorphosis: positive allometry and delayed offset



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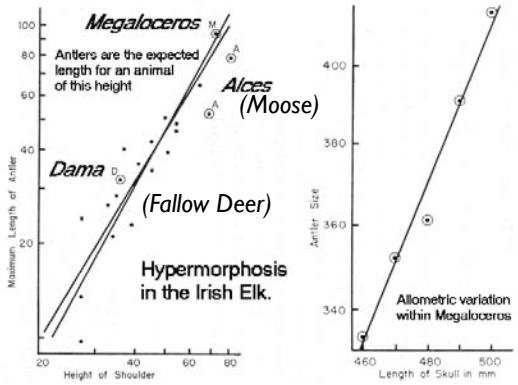
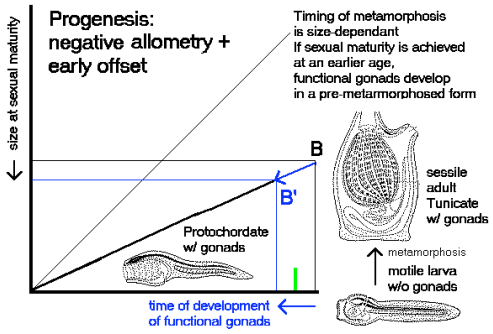


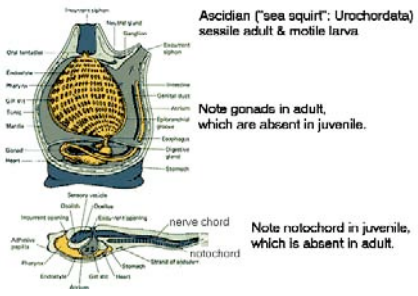
Antlers are positively allometric with respect to body size

28



Progenesis can be produced by negative allometry and early offset

29



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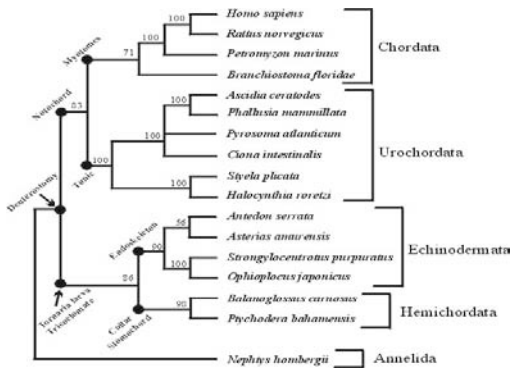
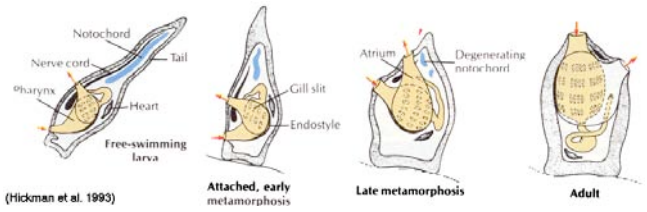
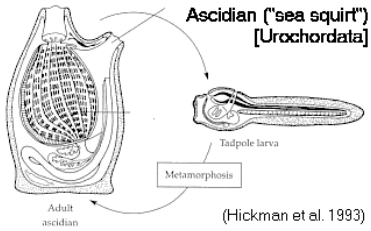
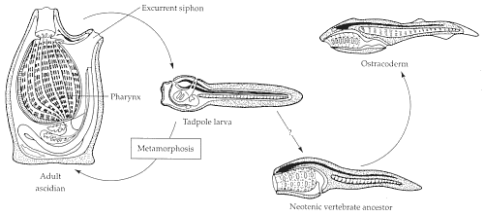




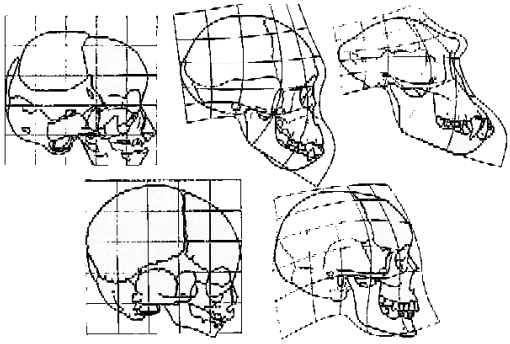




Garstang Hypothesis

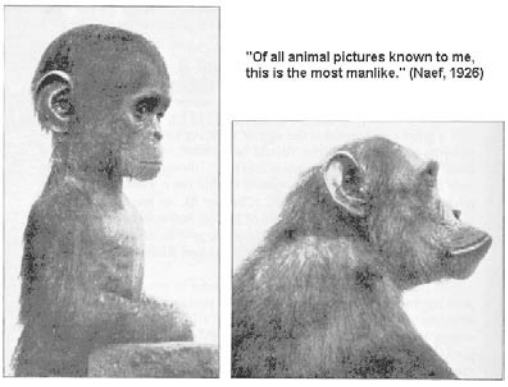
Chordates evolved from motile juvenile urochordates with a notochord through progenesis (fore-shortening of growth).

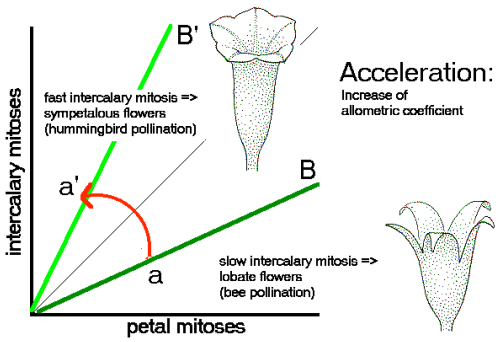
Ascidian tadpole has notochord, pharyngeal gill slits, and a post anal tail.



Homo as a neotenic ape

Mandibular portion of skull grows more slowly with respect to cranium (negative allometry)





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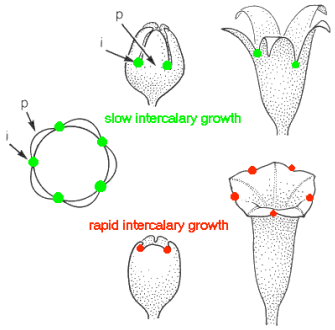

Effect of acceleration of cytodifferentiation on floral tube form

Petal primordia (p) are separated by intercalary cells (i).

If intercalary mitoses are slow, lobate floral tubes result.

If intercalary mitoses are rapid (wrt petal mitoses), sympetalous floral tubes result.

(after Futuyma 1986)

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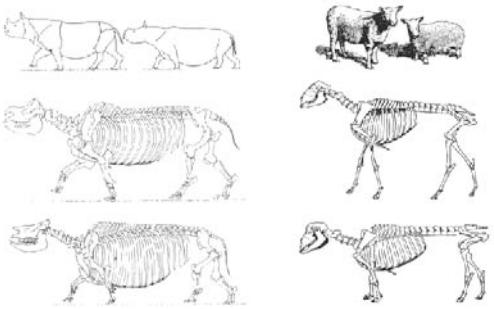
Hopeful Monsters (Goldschmidt, 1940)

Dachshund from Beagle through achondroplasia

39

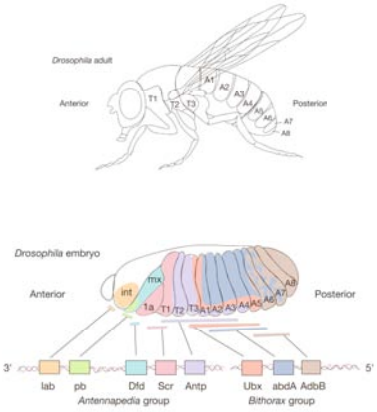


Recent Indian and Miocene dwarf rhinoceros

Standard and Ancon varieties of sheep

Achondroplasia: limb growth is slow relative to the rest of the skeleton

40



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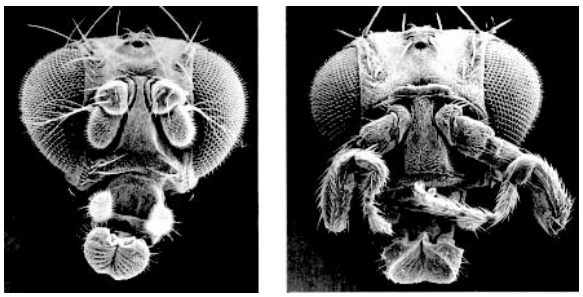
T3 to T2

42



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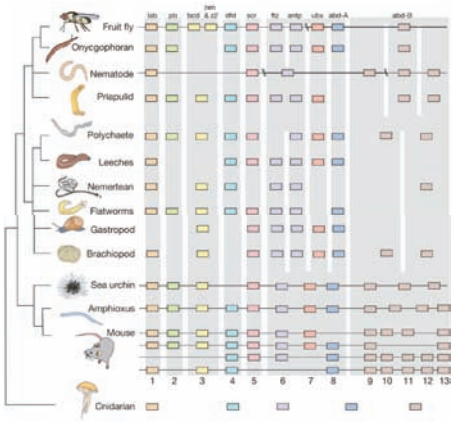
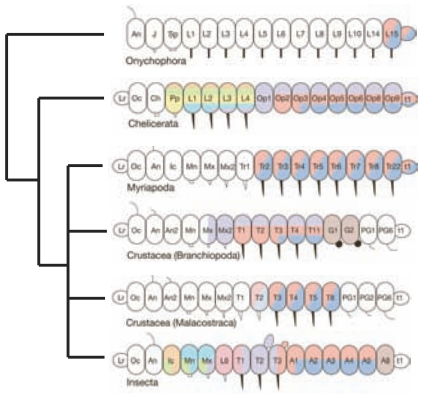

Fruit fly
Onycgophoran
Nematode
Priapulid
Polychaete
Leeches
Nemertean
Flatworms
Gastropod
Brachiopod
Sea urchin
Amphioxus
Mouse
Cnidarian
1 2 3 4 5 6 7 8 9 10 11 12 13

44


Onychophora
Chelicerata
Myriapoda
Crustacea (Branchiopoda)
Crustacea (Malacostraca)
Insecta

45