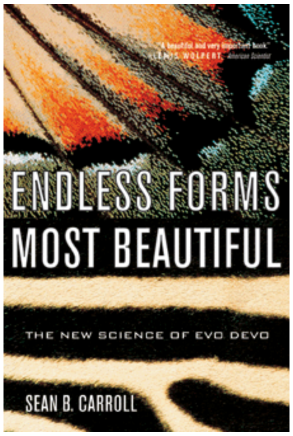
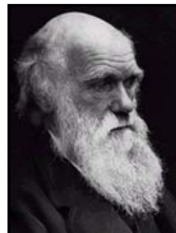



recommended reading

- available at Chapters, Amazon, etc.



"There is grandeur in this view of life... whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved."

*- Charles Darwin*
*On the Origin of Species* (1859)

life on earth is diverse... how did it get that way???

understanding evolution and the diversity of life

3 revolutions in modern biology:

1. Darwin's theory of evolution
2. The Modern Synthesis
3. Evo - Devo

Darwin's "Dangerous Ideas"

- species develop from ancestors with similar features
- the process that causes this is "natural selection"

- over time, natural selection gives rise to new species

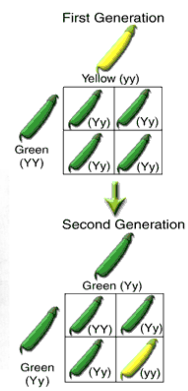
Species affect each other's evolution

the history of life is a family tree, with each fork in the tree's limbs being a common ancestor

- descent relationships

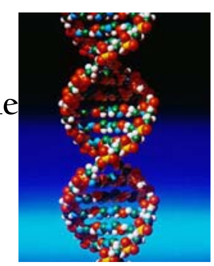
- problem: what is the mechanism of inheritance?

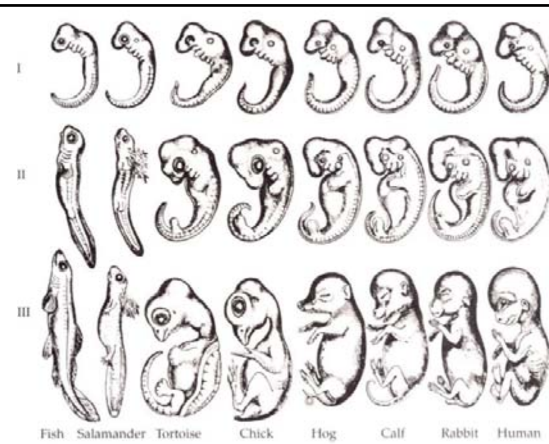
The Second Revolution: Genetics


# The Modern Synthesis

- 1930's: connection between the units of evolution (genes) and the mechanism of evolution (natural selection) was made



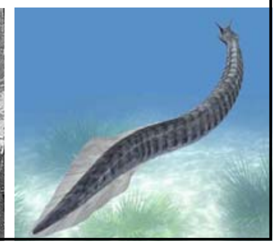


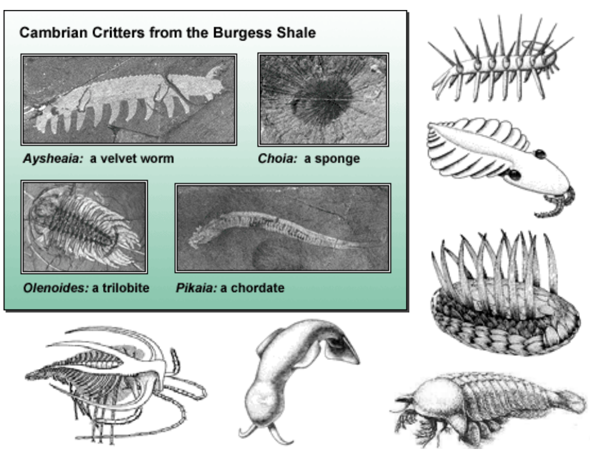
## The 3rd Revolution: Evo - Devo

- evolutionary change in appearance, function, organization & performance of the organism involves development
- study of development helps answer the question: how do diverse descendents arise from a common ancestor?

## Cambrian "explosion"

~ 570 – 510 million years ago: all major groups of animals appear – even vertebrates!



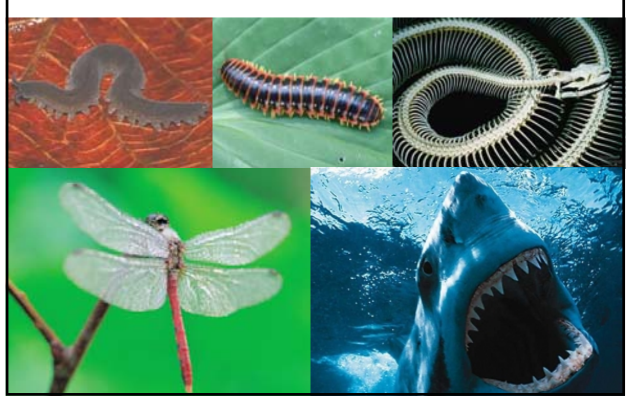


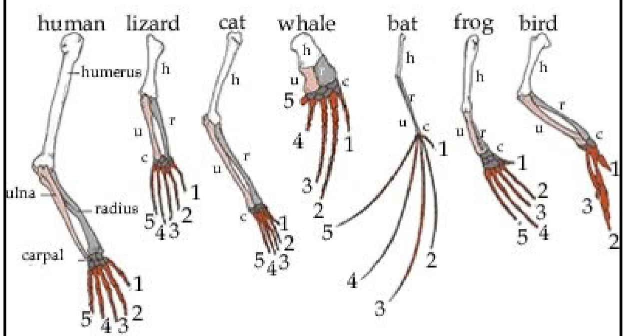

## how are animal bodies constructed?

- animal bodies are symmetrical

- animal bodies are usually made up of modular parts

## serially homologous elements






serially homologous structures
may diversify


Reduction & loss is common, too!

loss of complex teeth

loss of wings

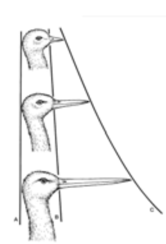
loss of legs

reversal common because of potentialities of developmental systems

- *Gastrotheca guentheri* has re-evolved true teeth in lower jaw

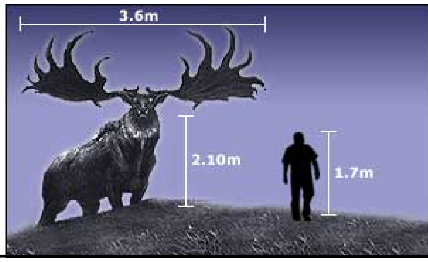
simple ≠ primitive
complex ≠ recent

- developmental plan very important in creating new features
- altering the rate & length of development can produce radically different forms



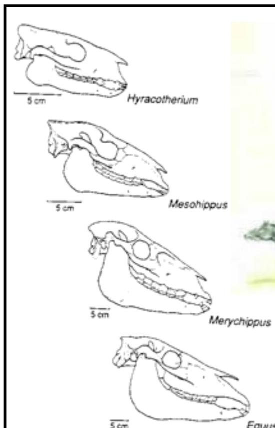

## peramorphosis: “elder form”

- more developed adults in descendent than in ancestor




dik dik elk

modern diversity in body & antler size in the deer family




## neoteny

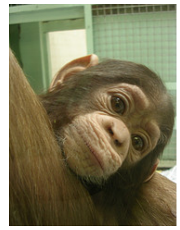
- less developed adults in descendent than in ancestor

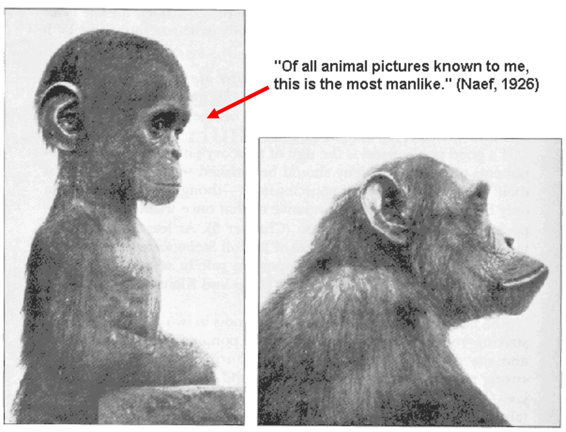
## neoteny in salamanders:

- **tiger salamander:** metamorphoses from larva → adult; reproduces

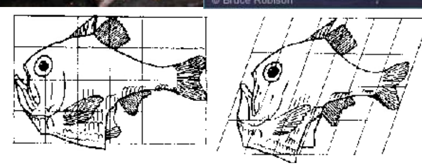
Neoteny: never undergoes metamorphosis → stays a "giant juvenile"

- humans look like juvenile apes

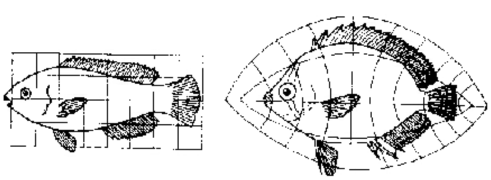




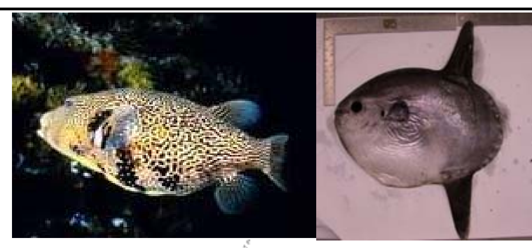

major changes in form are relatively simple!

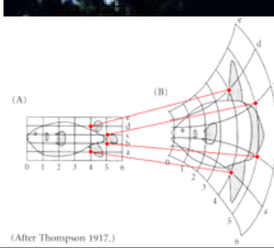



hatchetfishes



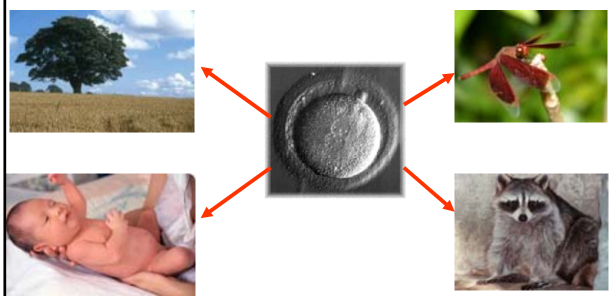
wrasse → angelfish



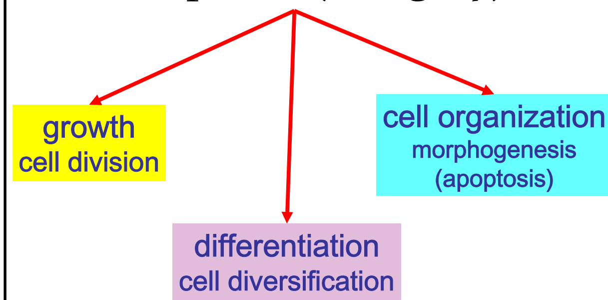



puffer fish → sunfish

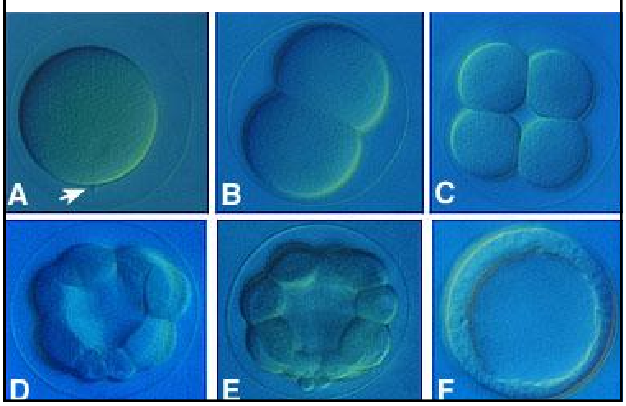
## how do we go from a single cell to an adult?



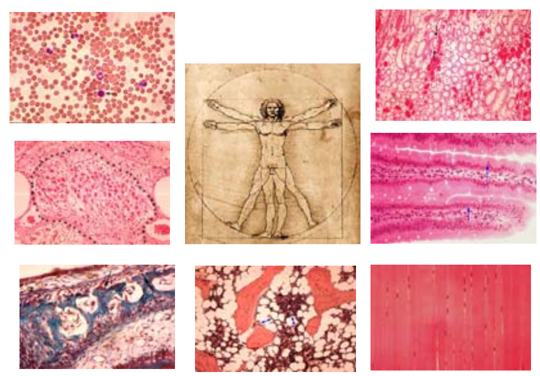
## development (ontogeny):




## growth = cell division




## differentiation = cell specialization

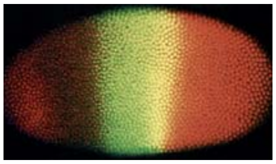


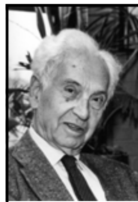
## morphogenesis = “creation of form

organization of differentiated cells into structures

for normal development:

- genes must be activated in appropriate sequence broad patterns → parts of pattern → details
- cells need positional information
- cells interact with each other





"If there is only one efficient solution for a certain functional demand, very different gene complexes will come up with the same solution, no matter how different the pathway by which it is achieved. The saying "Many roads lead to Rome" is as true in evolution as it is in daily affairs."

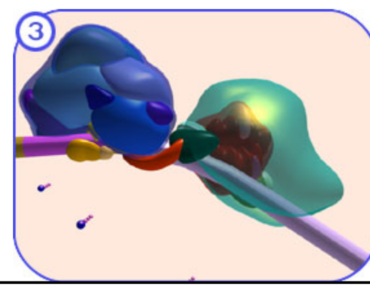
*--Ernst Mayr*

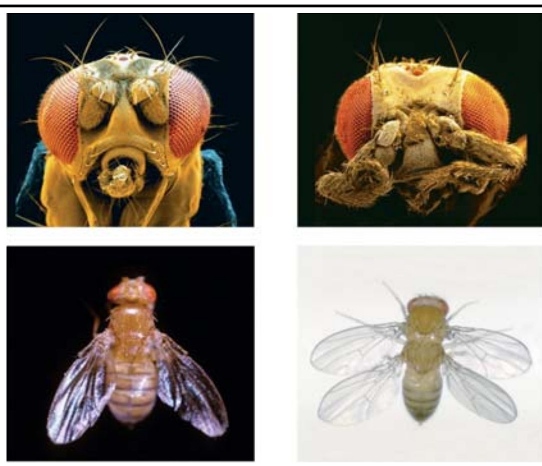
## HOX genes: the animal toolkit

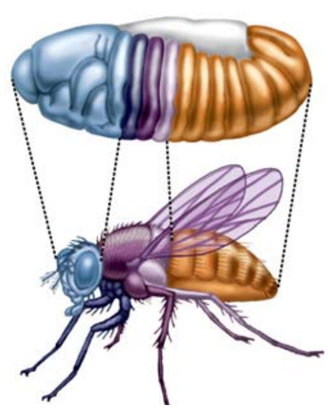
- transcription factors discovered in fruit flies
- control the identity of each body segment, and what structures will be produced
- found in all animals

## transcription factors

- are proteins that bind to DNA
- their activity turns genes "on" or "off"

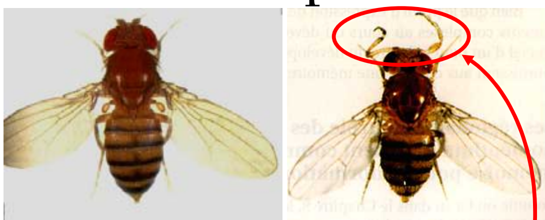




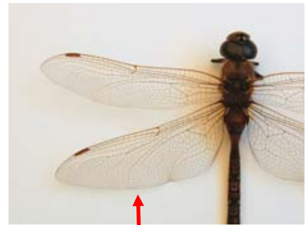
## development of legs & wings

# antennepedia:

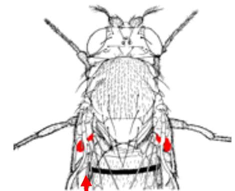


*Antp:* normally "on" in thorax; "off" in head

- mutation causes legs on head

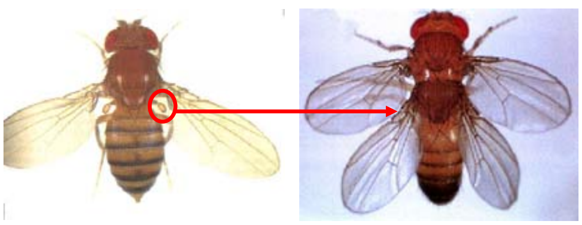


$T_2$ & $T_3$ have wings

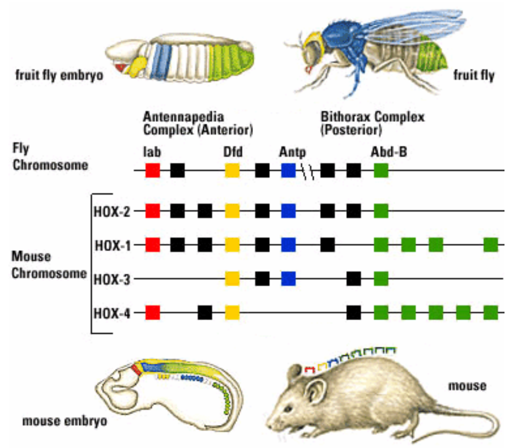


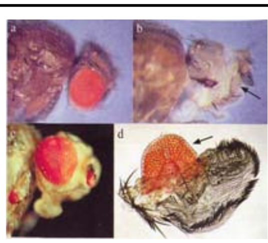
$T_2$ has wings, $T_3$ has halteres

# ultrabithorax:

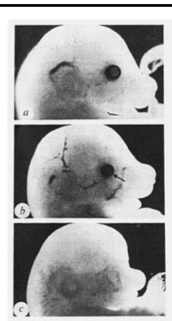


- mutation in *Ubx:* halteres develop into wings!



ey (eyeless)



*Pax* - 6

*Pax* - 6

- virtually identical genes affect eye development in fly, mouse and human

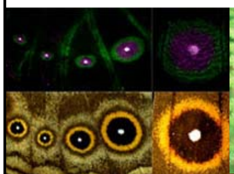
Hox genes important in human speech also control bird song

FOXP2: mutation in humans causes dyspraxia

mutation in zebra finches affects ability to learn songs

## innovations:

- e.g. a gene controlling body segmentation in insects acts later in development in butterflies to produce eyespots on wings



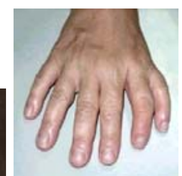
## teratogens interfere with Hox genes

- cyclopic lamb

## HOX genes & human development

- high amounts of retinoic acid alter the normal function of HOX genes in humans


## polydactyly


## thalidomide