# GLG 430/598 Paleontology

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TODAY:

Lecture: Sources of variation

(Chapter 2, Textbook)

NEXT TUESDAY:

Lecture: Speciation (Chapter 3: Textbook)

Lab: Morphological variation in natural populations (Chap. 2: Textbook)

# ➢Sources of Variation in Fossils

1. ***Genotypic (i.e., genes and chromosomes)***
2. ***Sexual (e.g., sexual dimorphism)***
3. ***Ontogenetic (i.e., growth stage)***
4. ***Environmental: "Ecophenotypic" variation arising from differences in the environment.***

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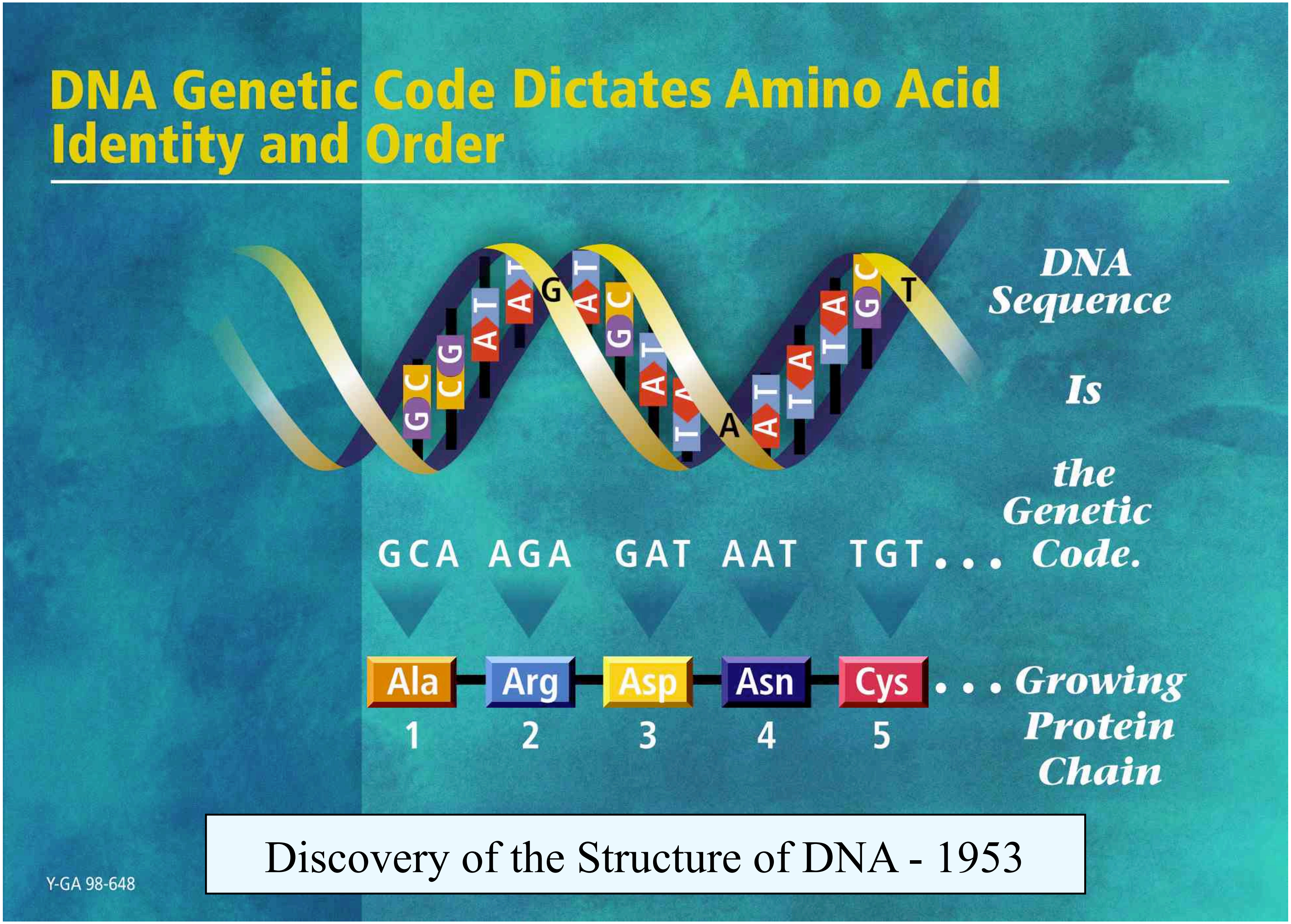
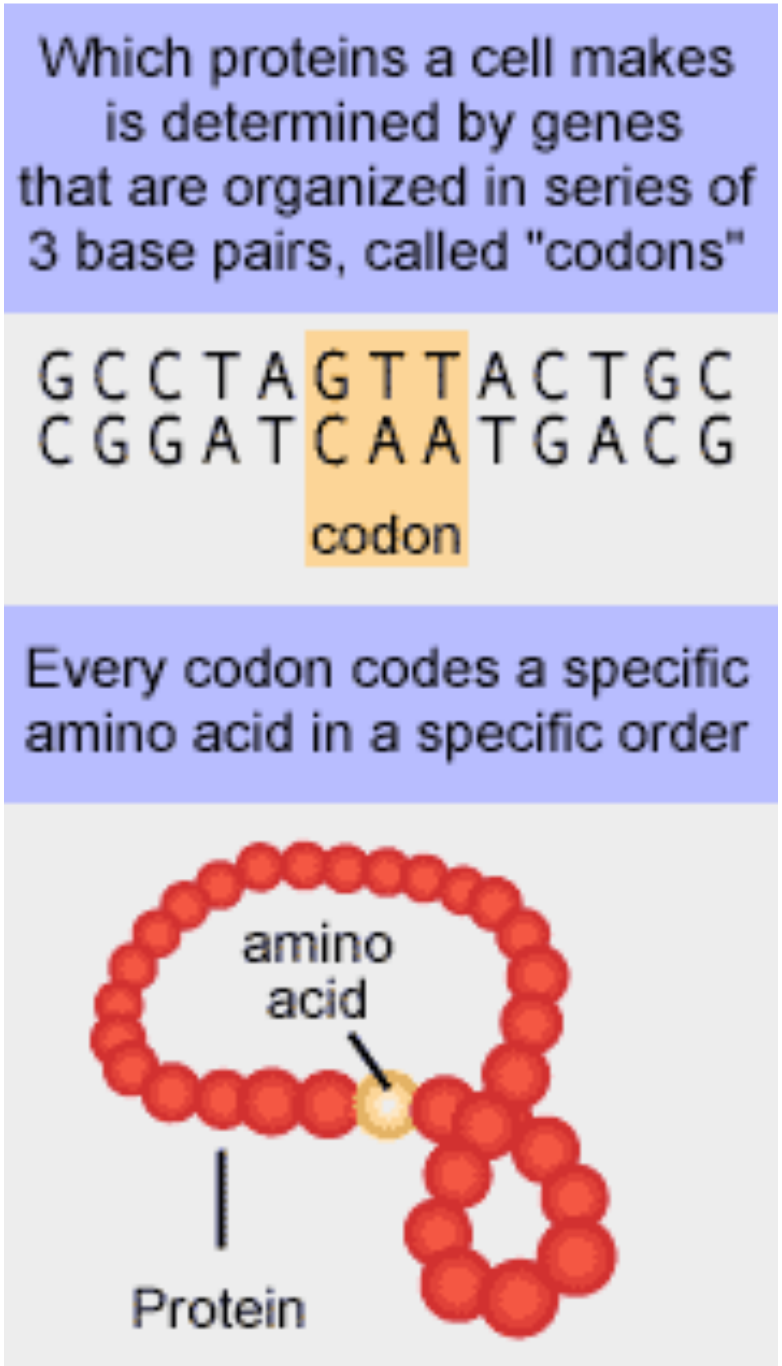
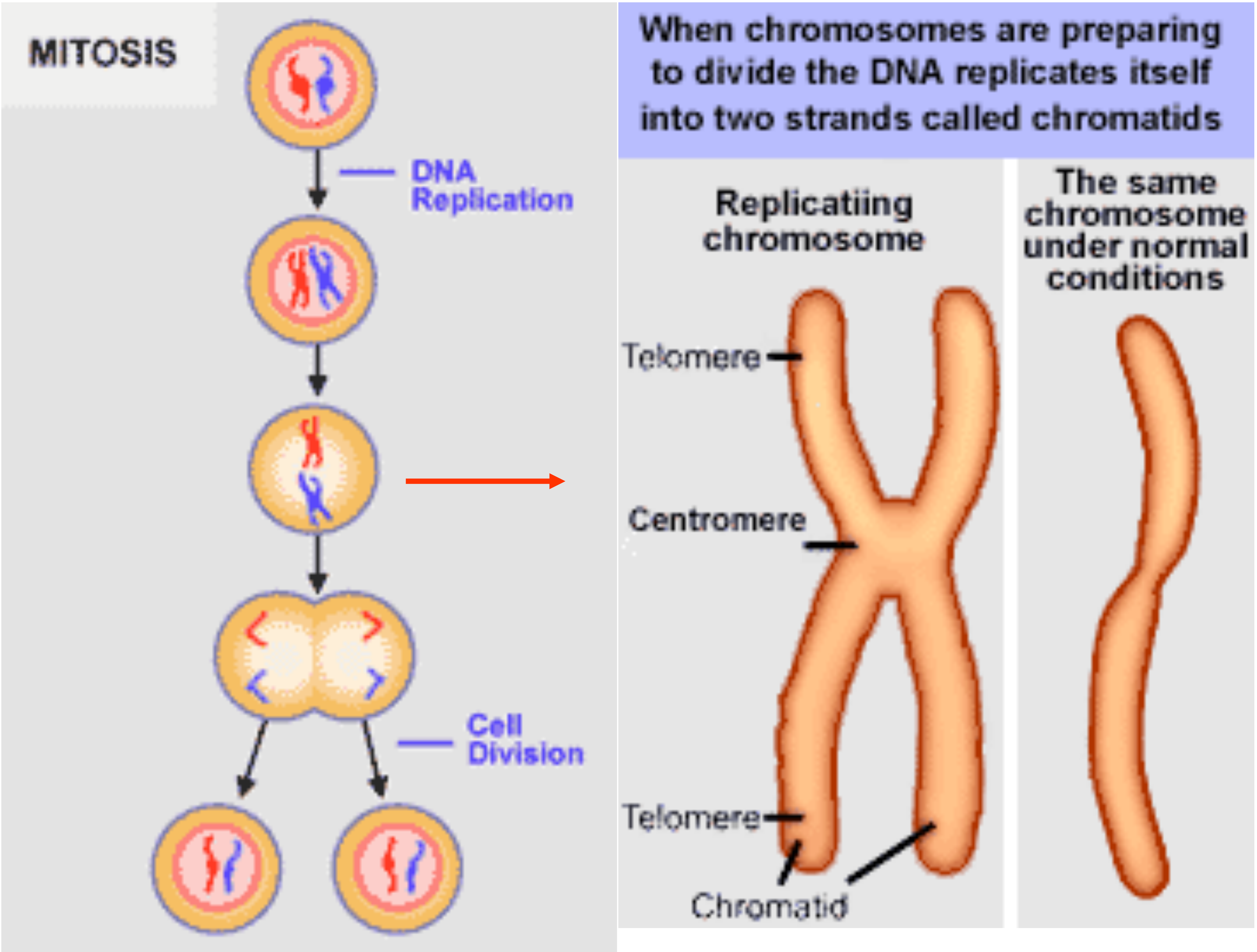
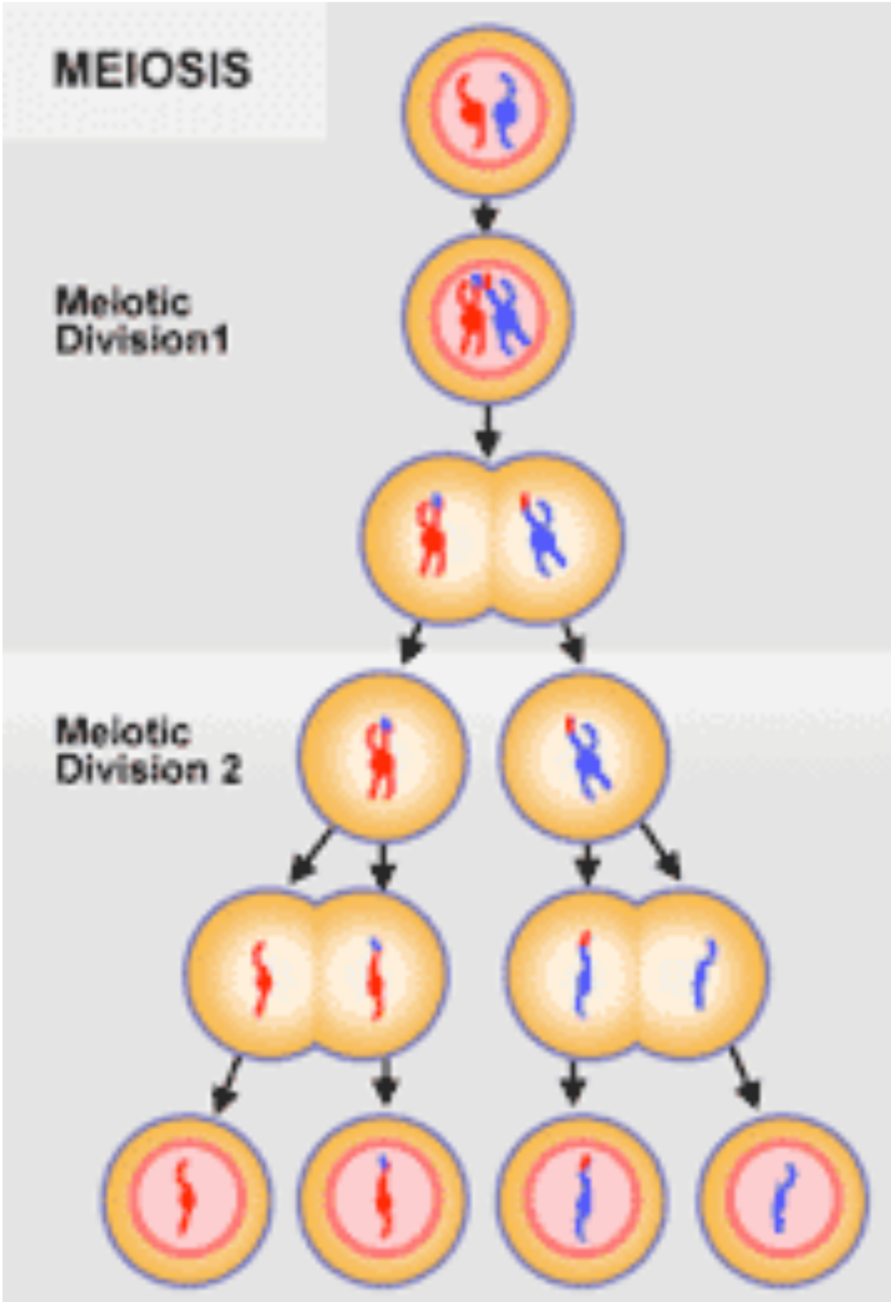



Discovery of the Structure of DNA - 1953

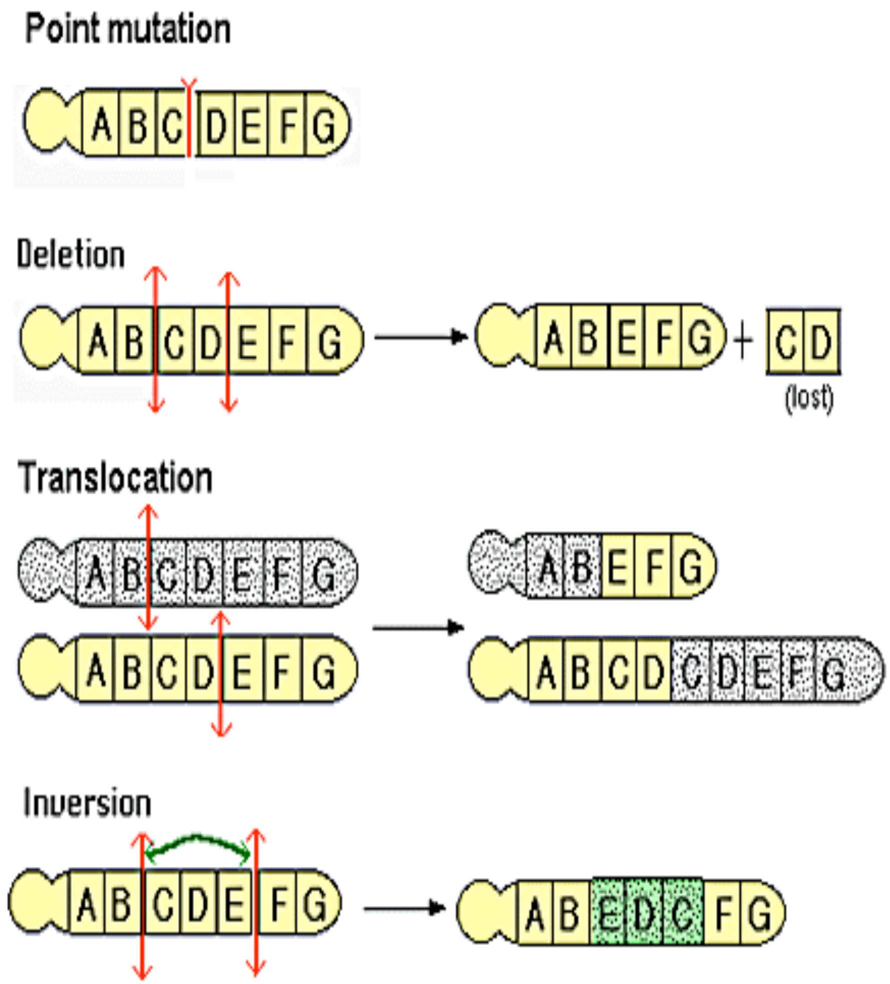


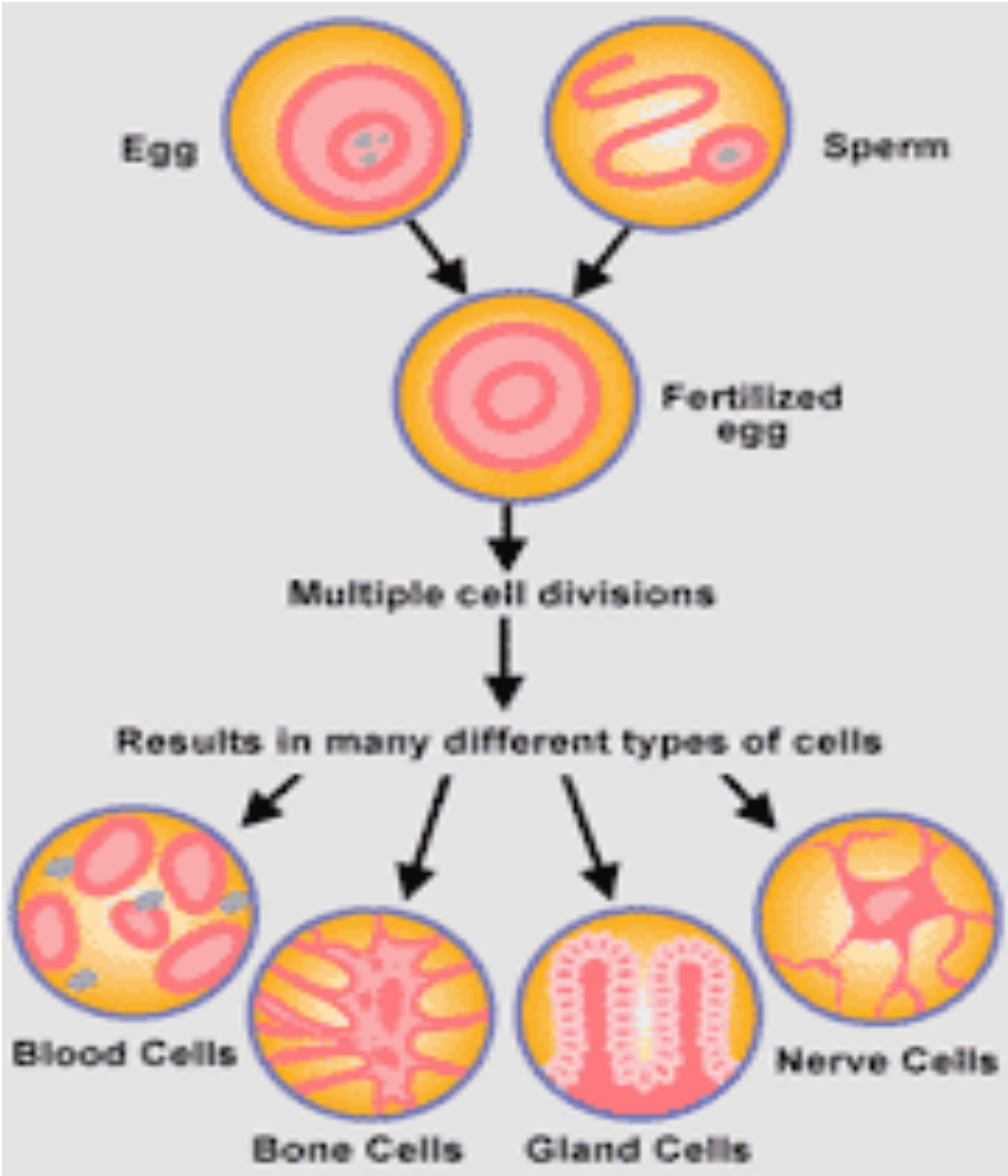

***Genes are organized into Chromosomes…***


MITOSIS
DNA Replication
Cell Division
When chromosomes are preparing to divide the DNA replicates itself into two strands called chromatids
Replicatiing chromosome
The same chromosome under normal conditions
Telomere
Centromere
Telomere
Chromatid


MEIOSIS
Meiotic Division1
Meiotic Division 2

# Mutations


Point mutation
A B C D E F G
Deletion
A B C D E F G
A B E F G
+
C D
(lost)
Translocation
A B C D E F G
A B C D E F G
A B E F G
A B C D C D E F G
Inversion
A B C D E F G
A B E D C F G




**Sexual Reproduction**

↓

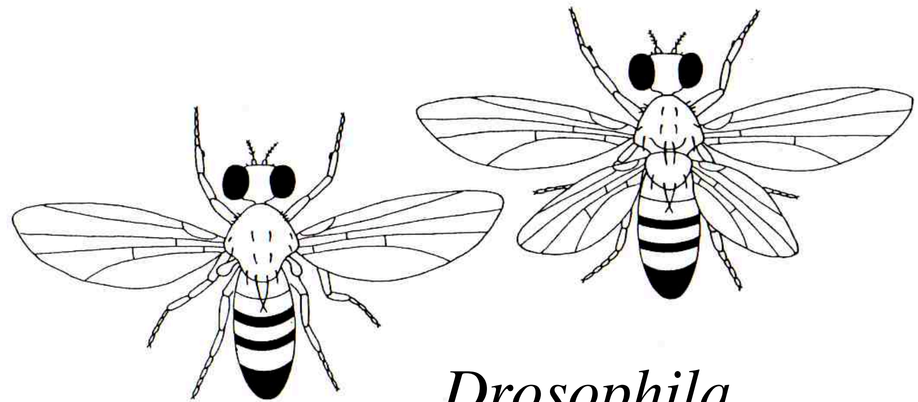
**Cellular Differentiation**

↓

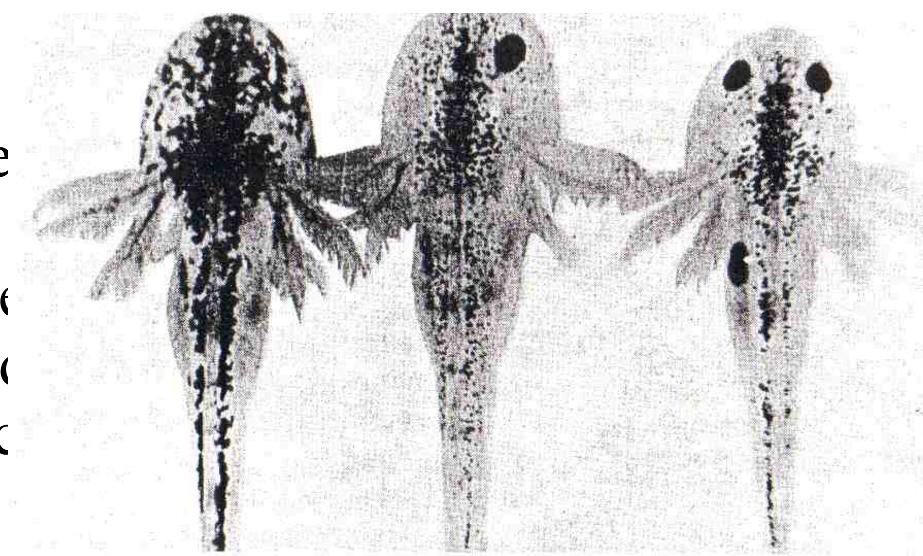
**Regulated Development (ontogeny)**

# Sources of Variation 1: Genetic

- Genetic differences between the individuals of a population.
  - Every genotype includes alternative alleles (i.e., different versions) of the structural genes responsible for protein synthesis.
  - Mutations in regulatory gene that control the timing of expression of structural gene during development can lea to differences in ontogeneti development.

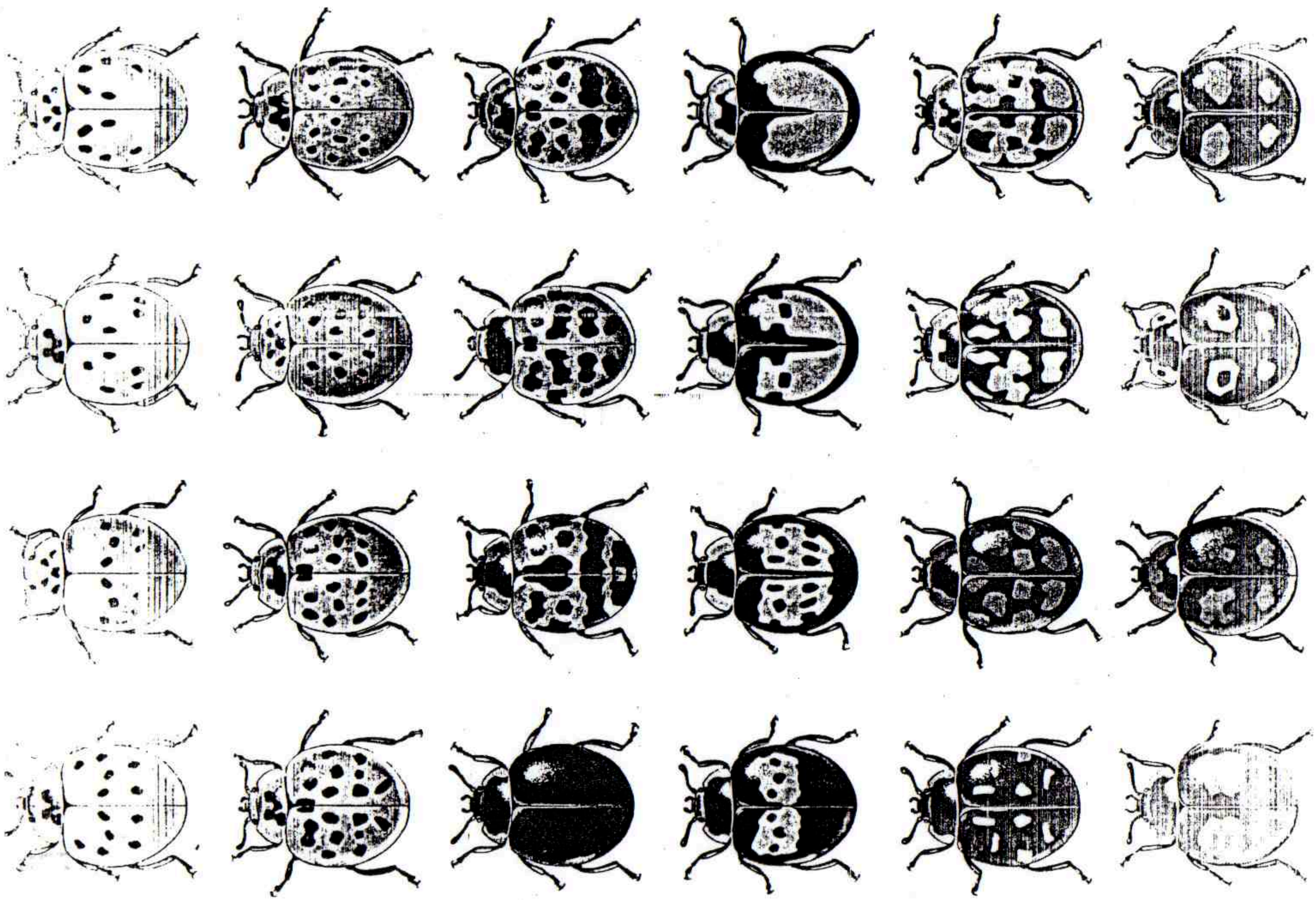


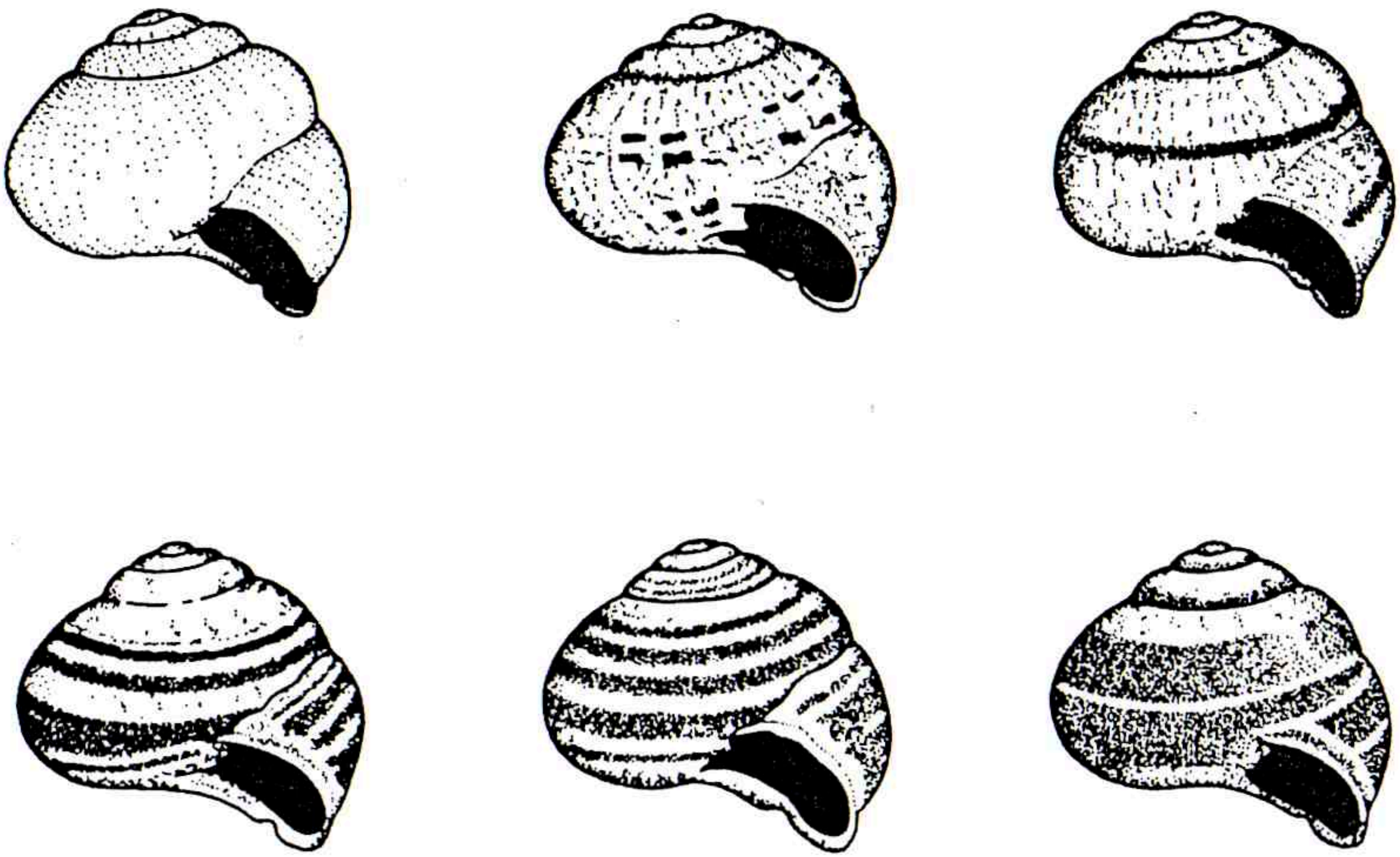
*Drosophila* wing mutants



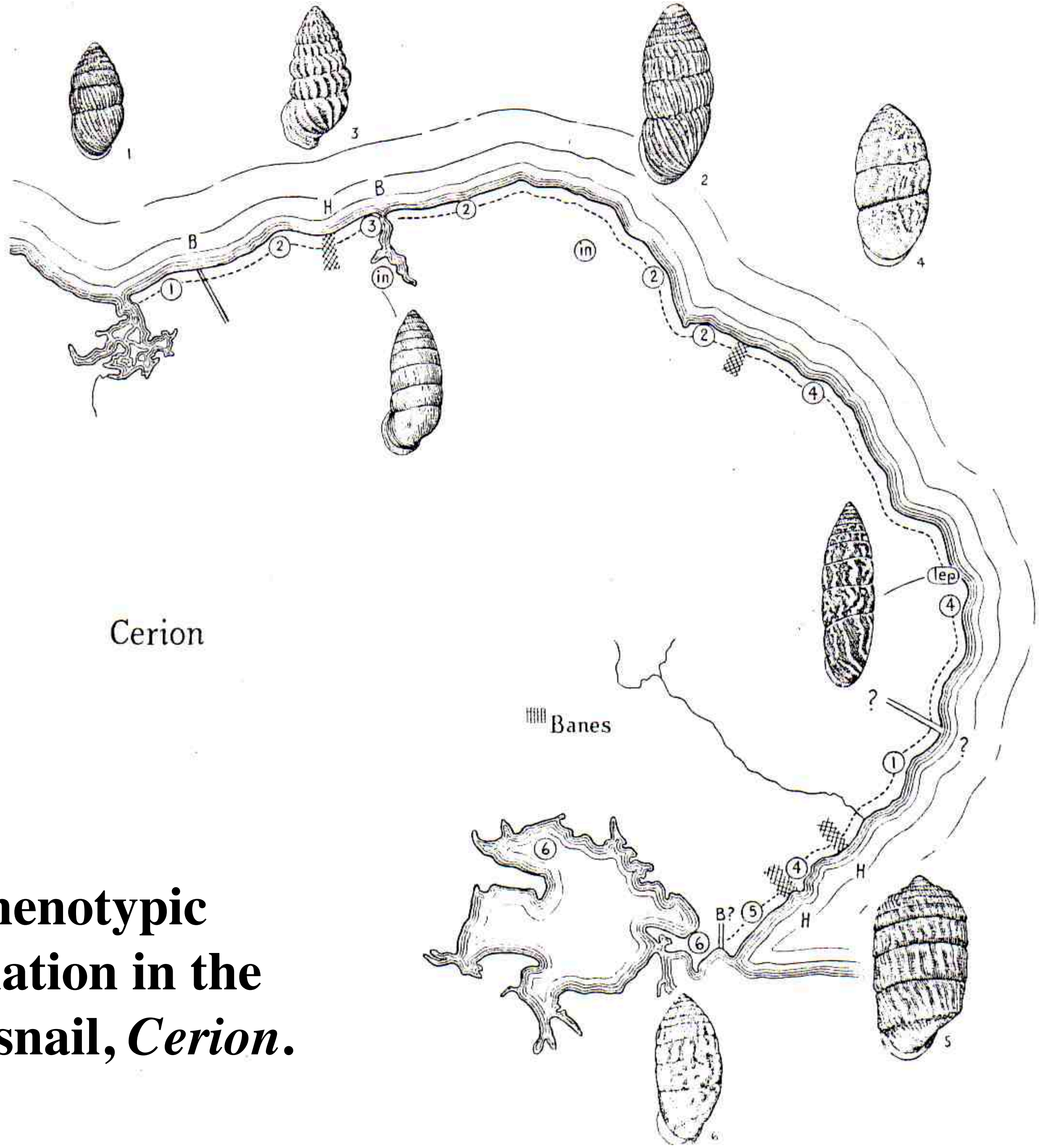
Axolotyl eye mutants

# Color/Pattern Polymorphism in Insects



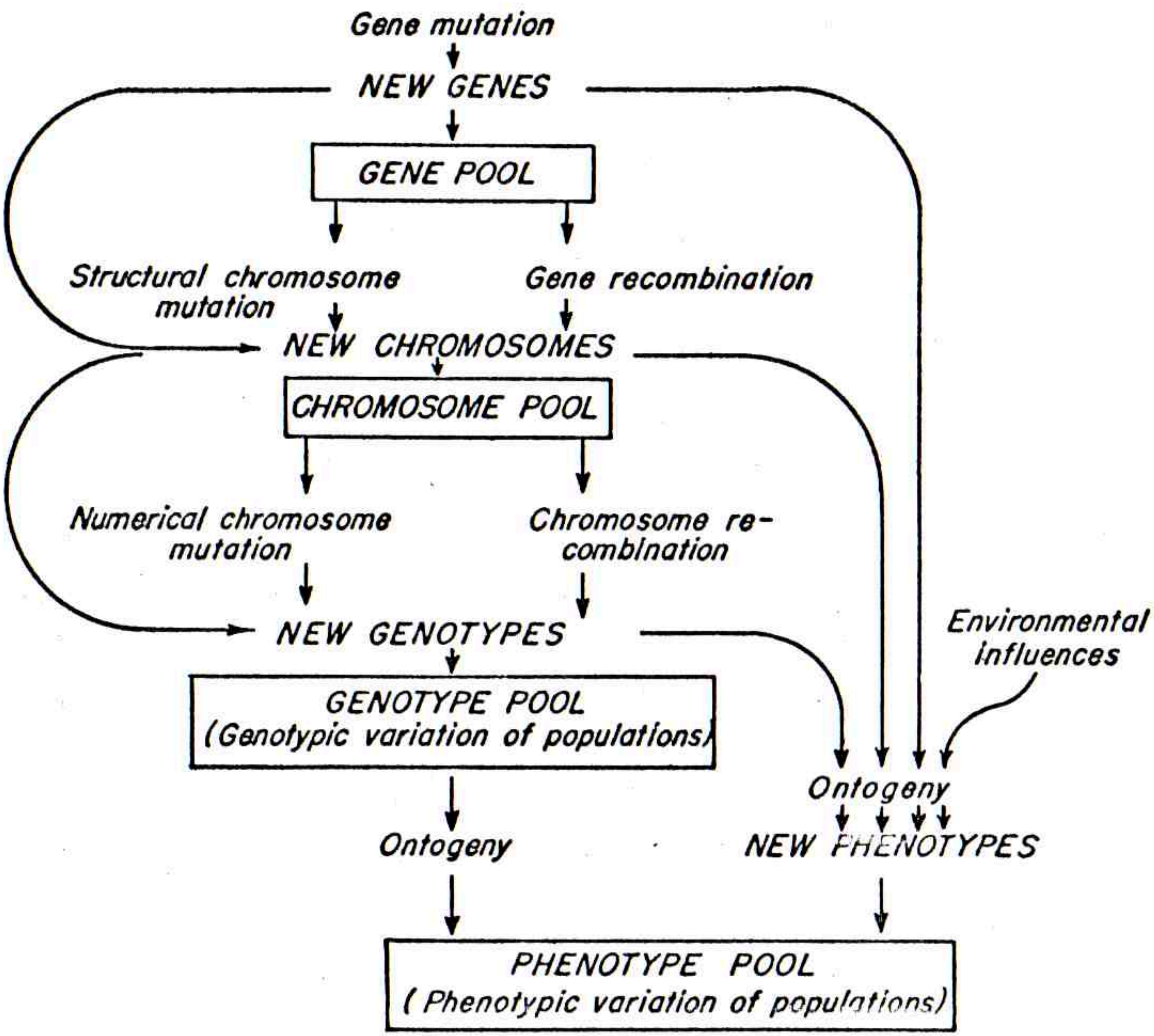


*These snails, whose shells are polymorphic for colour, all belong to the same species (reproductively isolated population). (Illustration after Dowdeswell, 1958).*




**Phenotypic variation in the land snail, *Cerion*.**

# Process-Response Model for Originating Phenotypes



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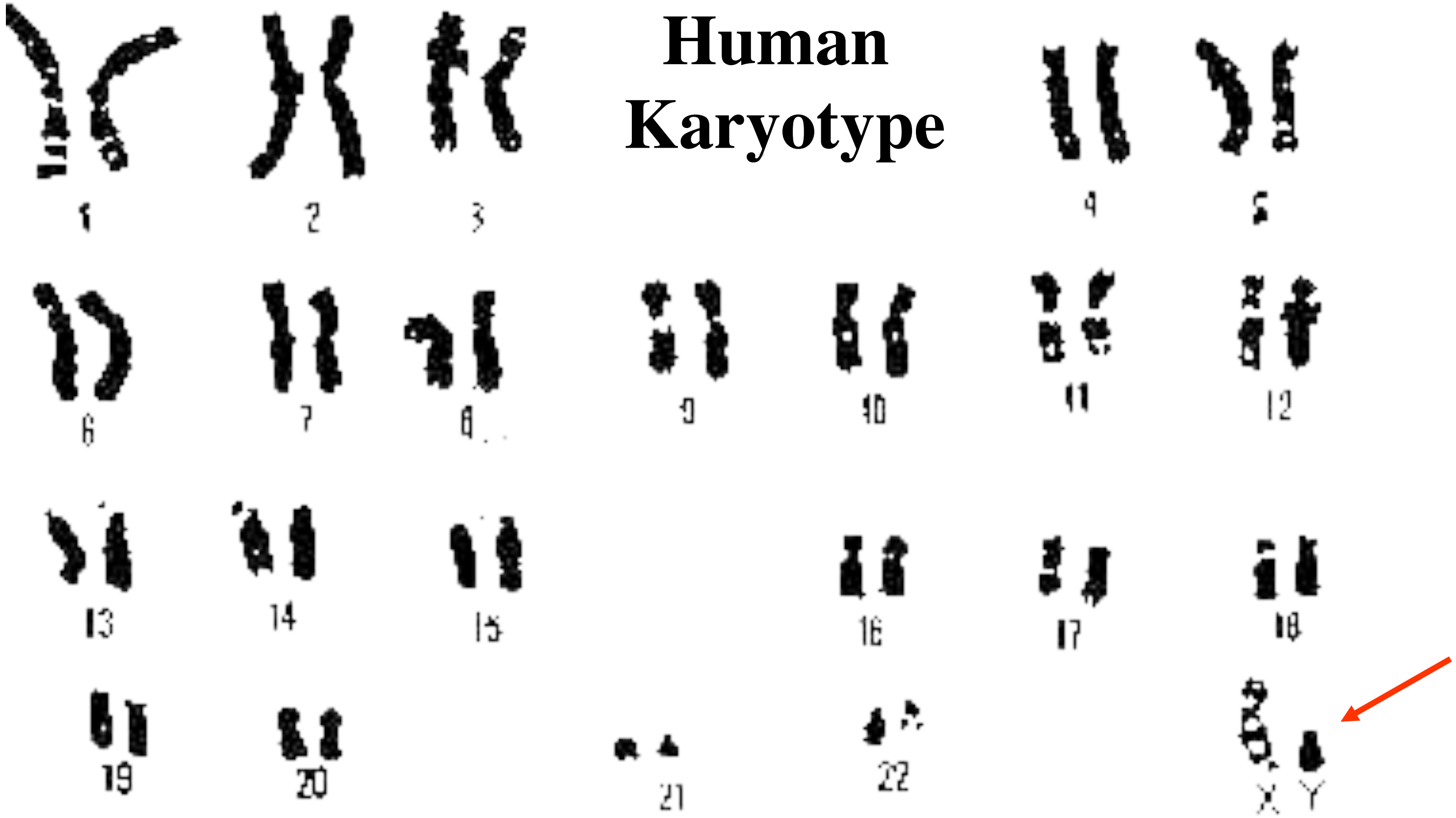
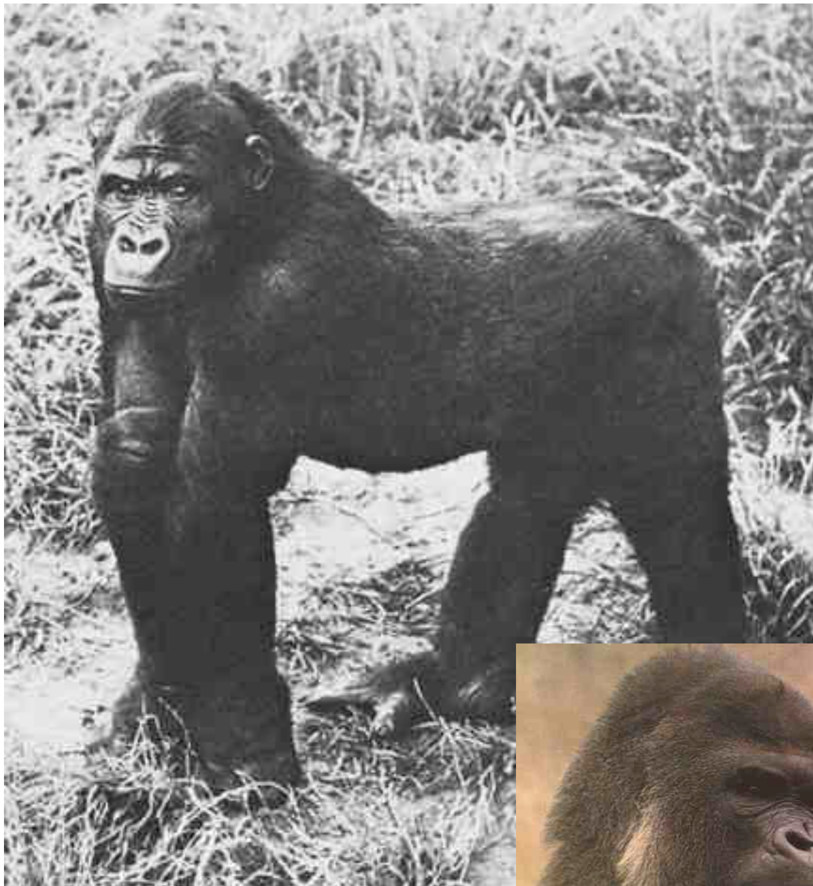
# Sex Determination in Humans: X-Y Chromosomes

- Male gametes (sperm cells) in humans and other mammals contain one of two types of sex chromosomes: X or Y. These cells are called heterogametic.
- The female gametes (eggs) contain only the X sex chromosome and are homogametic.
- The sperm cell determines the sex of an individual in this case.
  - If a sperm cell containing an X chromosome fertilizes an egg, the resulting zygote will be XX or female.
  - If the sperm cell contains a Y chromosome, then the resulting zygote will be XY or male.

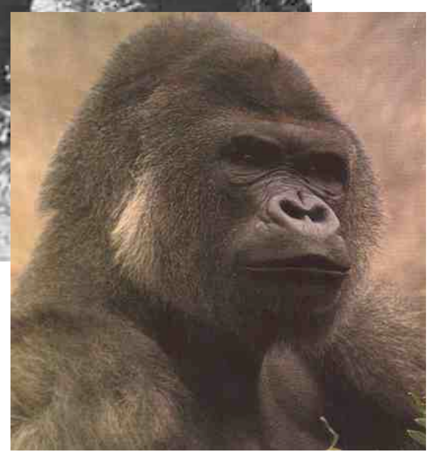



Human cells contain 23 pairs of chromosomes, for a total of 46. There are 22 pairs of autosomes and one pair of sex chromosomes (X and Y) which determine gender.

Sexual dimorphism in the gorilla…

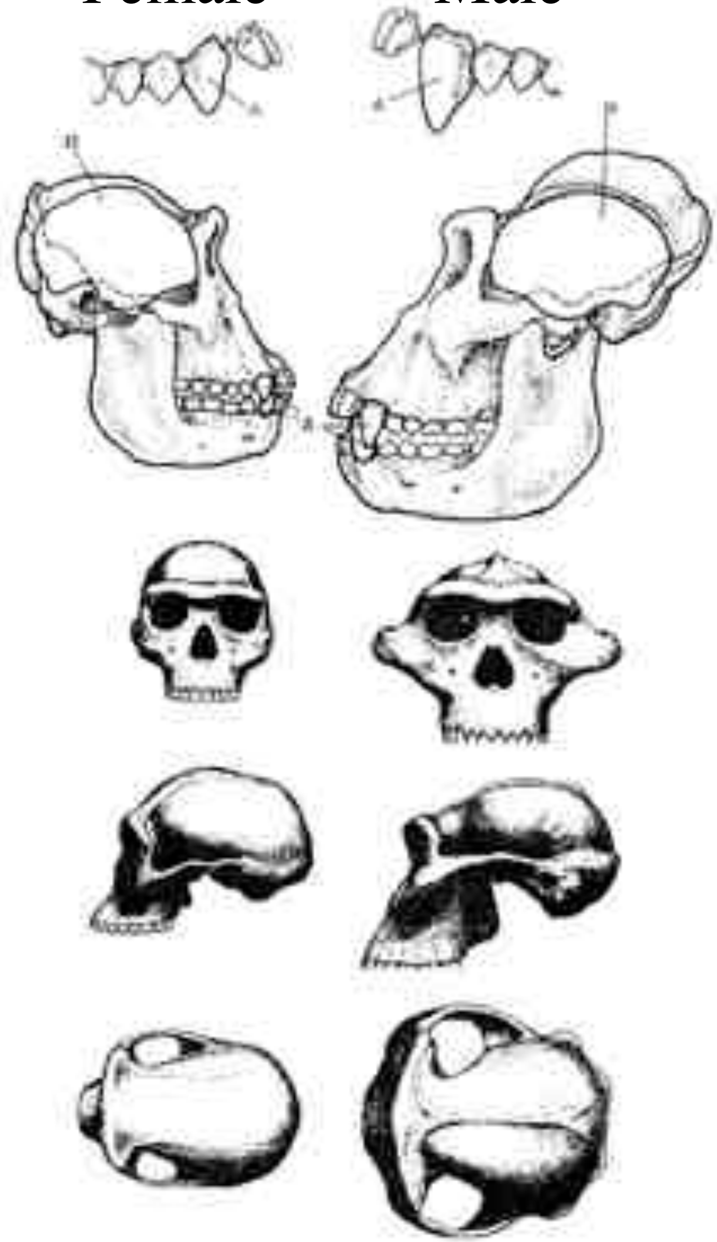


Female



Male

Female Male



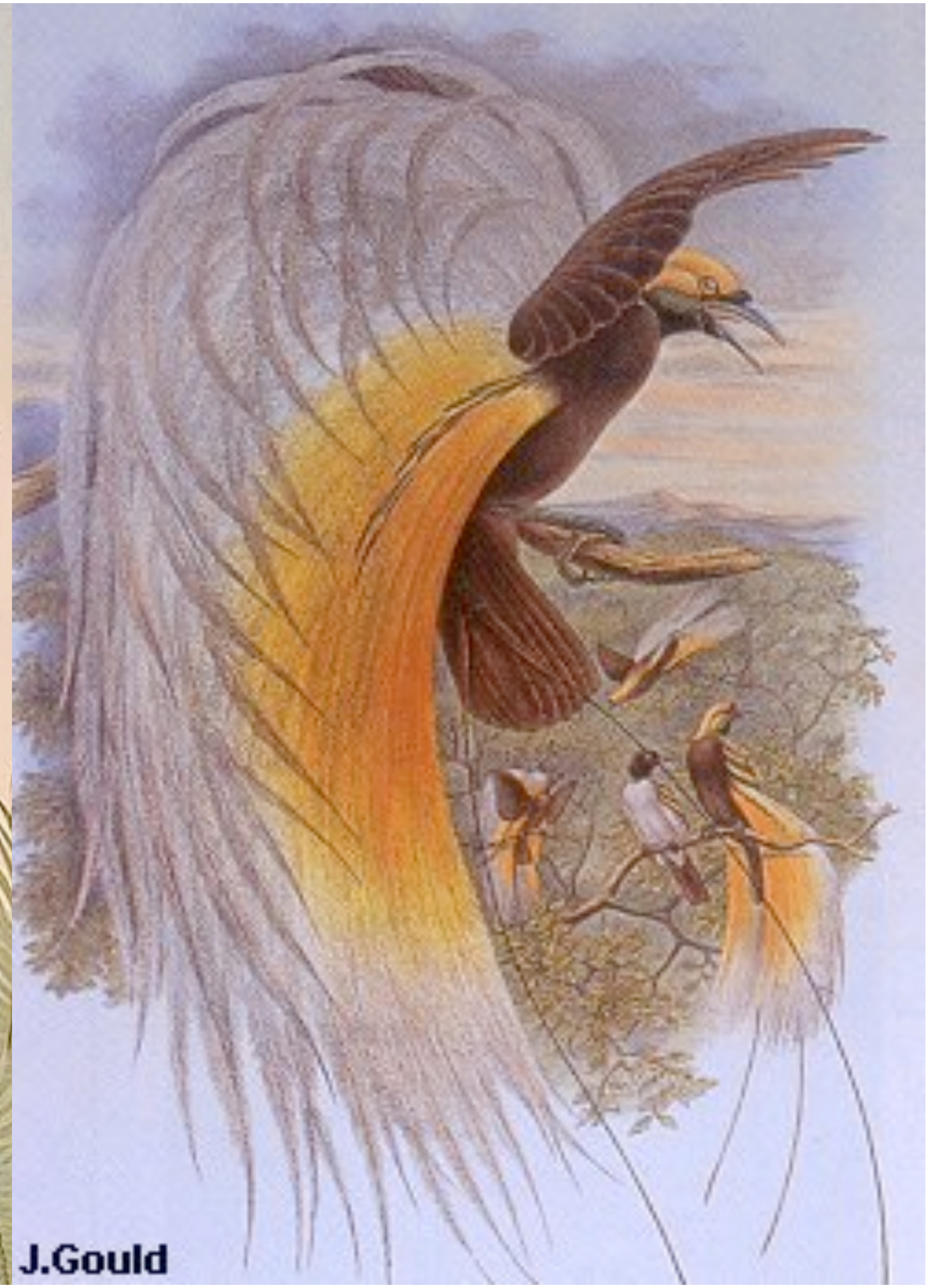
# Sex Chromosomes X-O

- Grasshoppers, roaches, and other insects have a similar system for determining the sex of an individual.
  - Adult males lack a Y sex chromosome and have only an X chromosome.
  - They produce sperm cells that contain either an X chromosome or no sex chromosome, which is designated as O.
  - The females are XX and produce egg cells that contain an X chromosome.
  - If an X sperm cell fertilizes an egg, the resulting zygote will be XX or female.
  - If a sperm cell containing no sex chromosome fertilizes an egg, the resulting zygote will be XO or male.

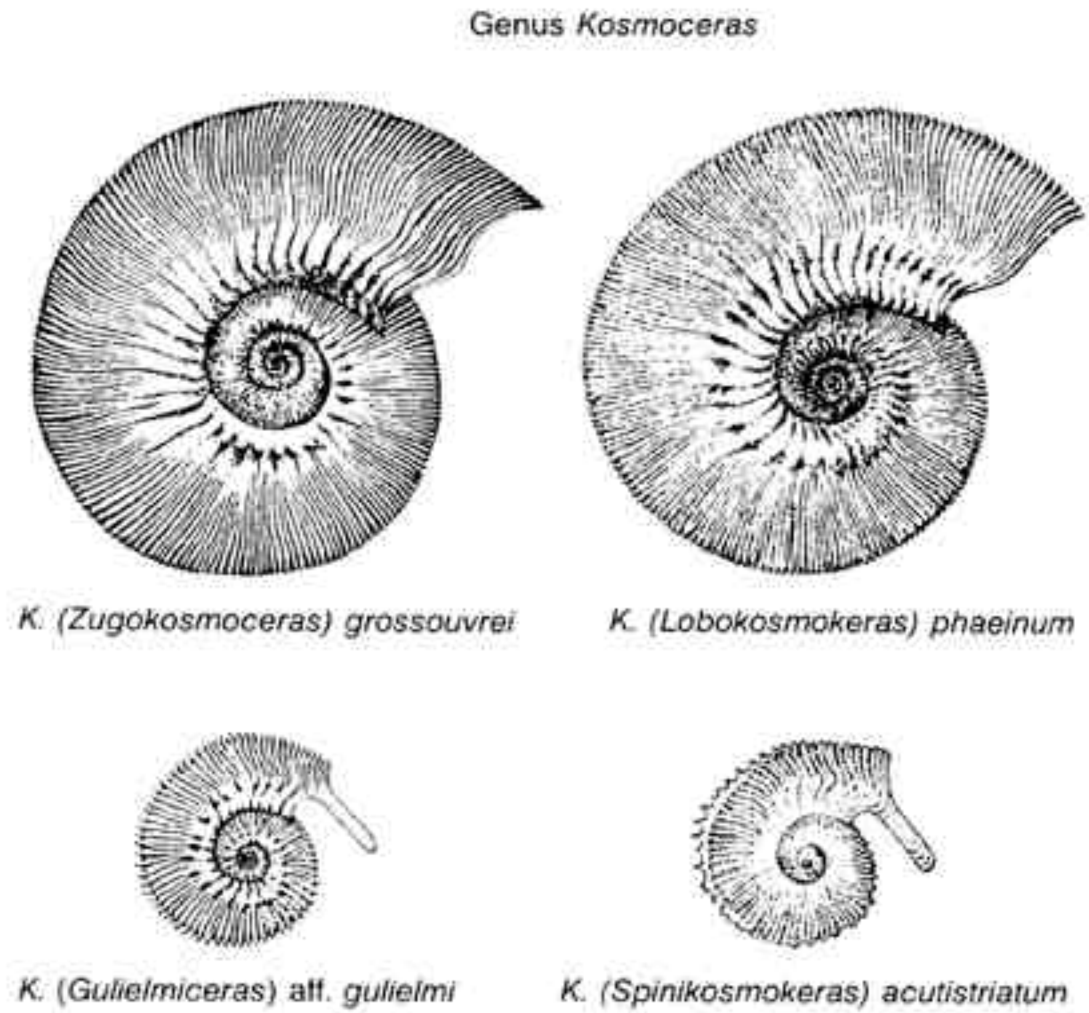
# Sex Chromosomes Z-W

- Birds, insects like butterflies, and some species of fish have a different system for determining gender.
  - In these animals it is the female gamete that determines the sex of an individual.
  - Female gametes can either contain a Z chromosome or a W chromosome.
  - Male gametes contain only the Z chromosome.
  - Females of these species are ZW and males are ZZ.

# Bird of Paradise



# Sexual dimorphism in fossil ammonites



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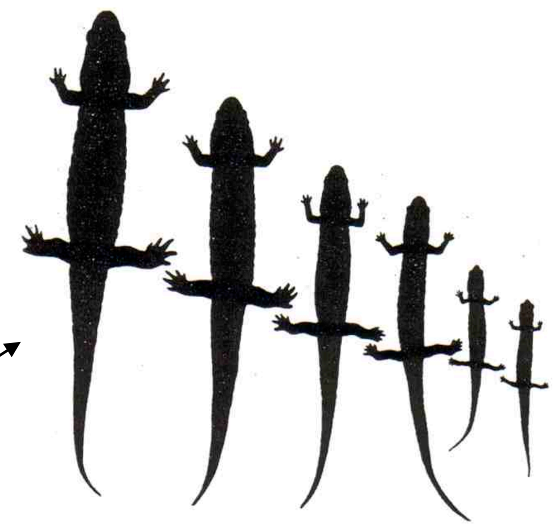
# Ontogeny

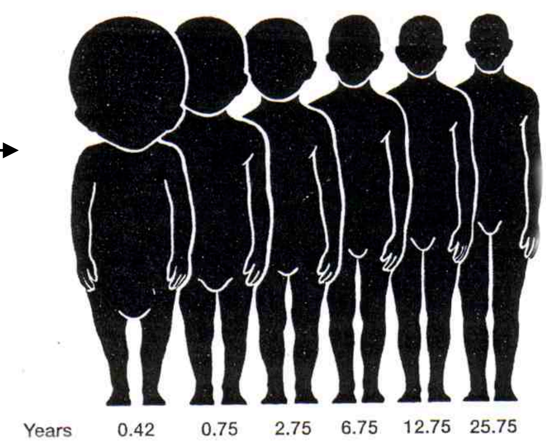
- *Derives from the Greek for "coming into being"*
- *Variation arising from differences in stage (age) of development.*


**- Ontogeny of Charles Darwin**

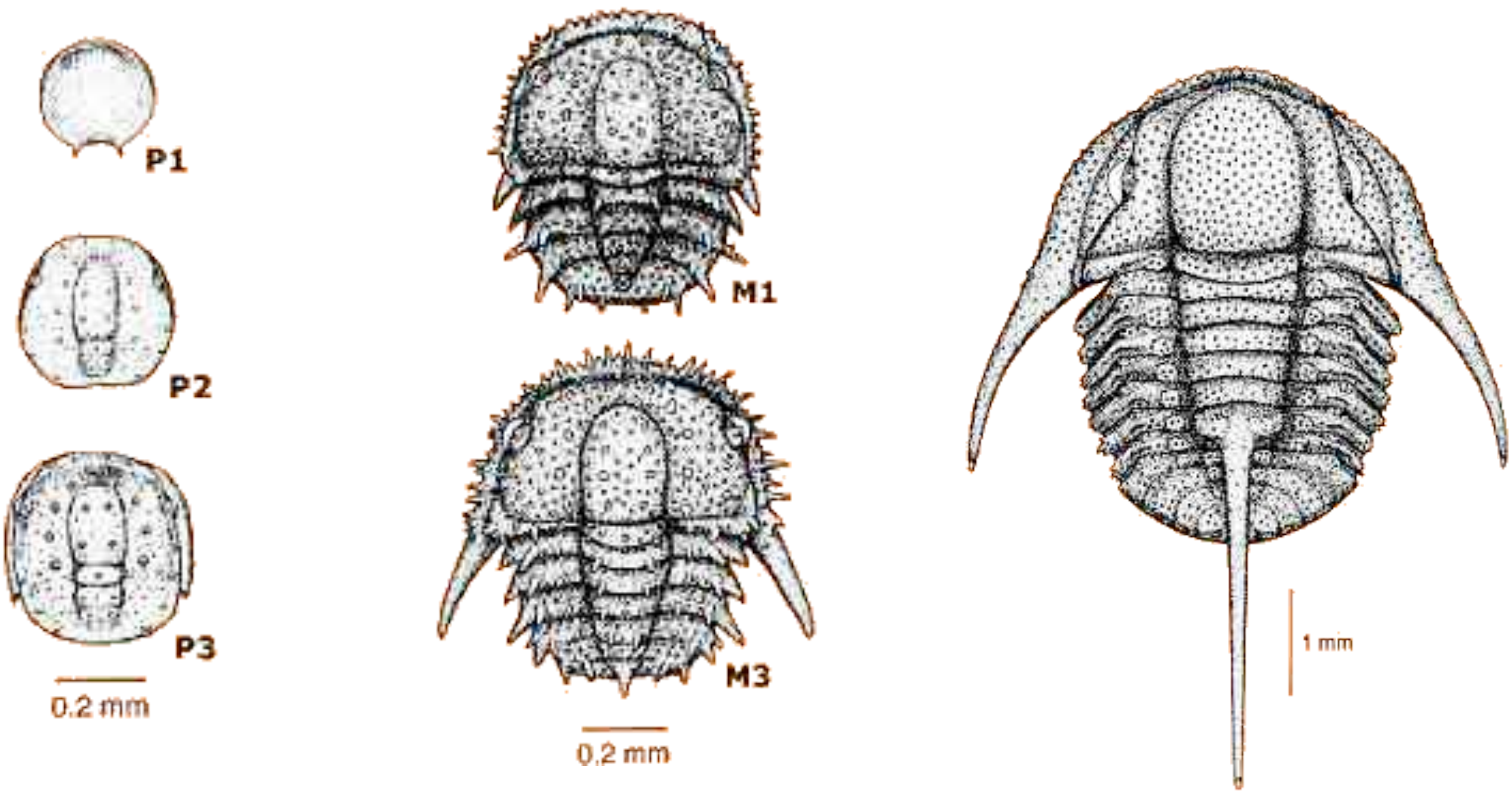
# *Features of ontogeny…*

- Age (stages of development).
- Interactions with environment (e.g. development in twins).
- Growth strategy:
  - Isometric: Proportions between elements of form remain constant during ontogeny.
  - Allometric: Proportions between elements of form change during ontogeny.





# Ontogentic Stages in Trilobites

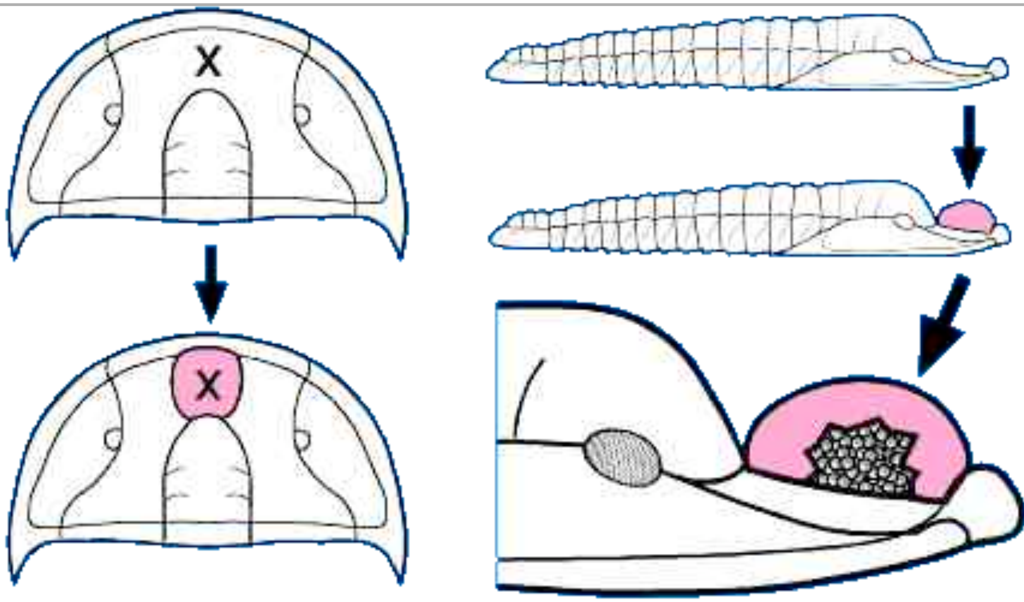



**Three larval stages are recognized: a protaspid period, meraspid period, and a holaspid period.**

**In the protaspid period, the larva (called a protaspis) is composed of a**

# Brood Pouches in Trilobites

see Fortey, R.A. & N.C. Hughes. 1998. Brood pouches in trilobites. *J. Paleontol.* *72*(4):638-49.

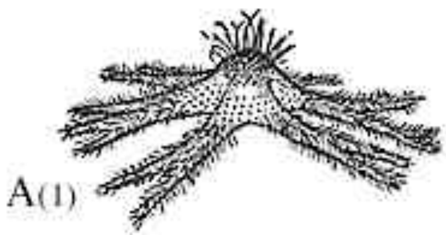


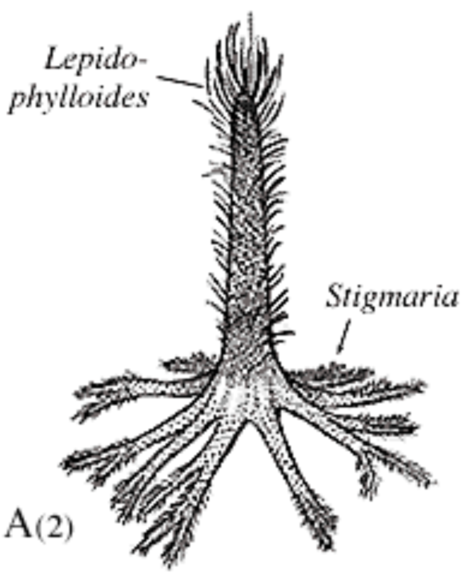


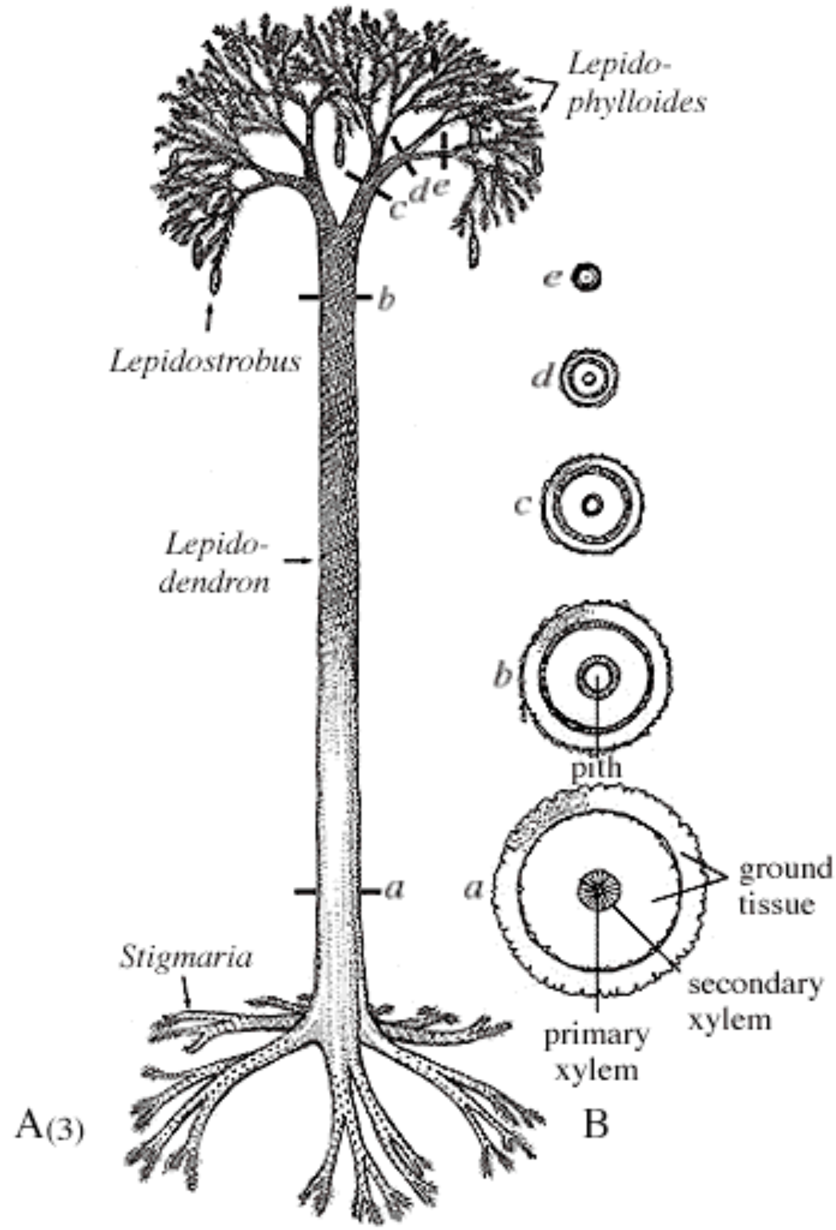

from Fortey & Hughes 1998

**Ontogeny of a typical arborescent lycopsid (*Lepidodendron*).**

Note differences in leaves of immature versus mature grow stages!



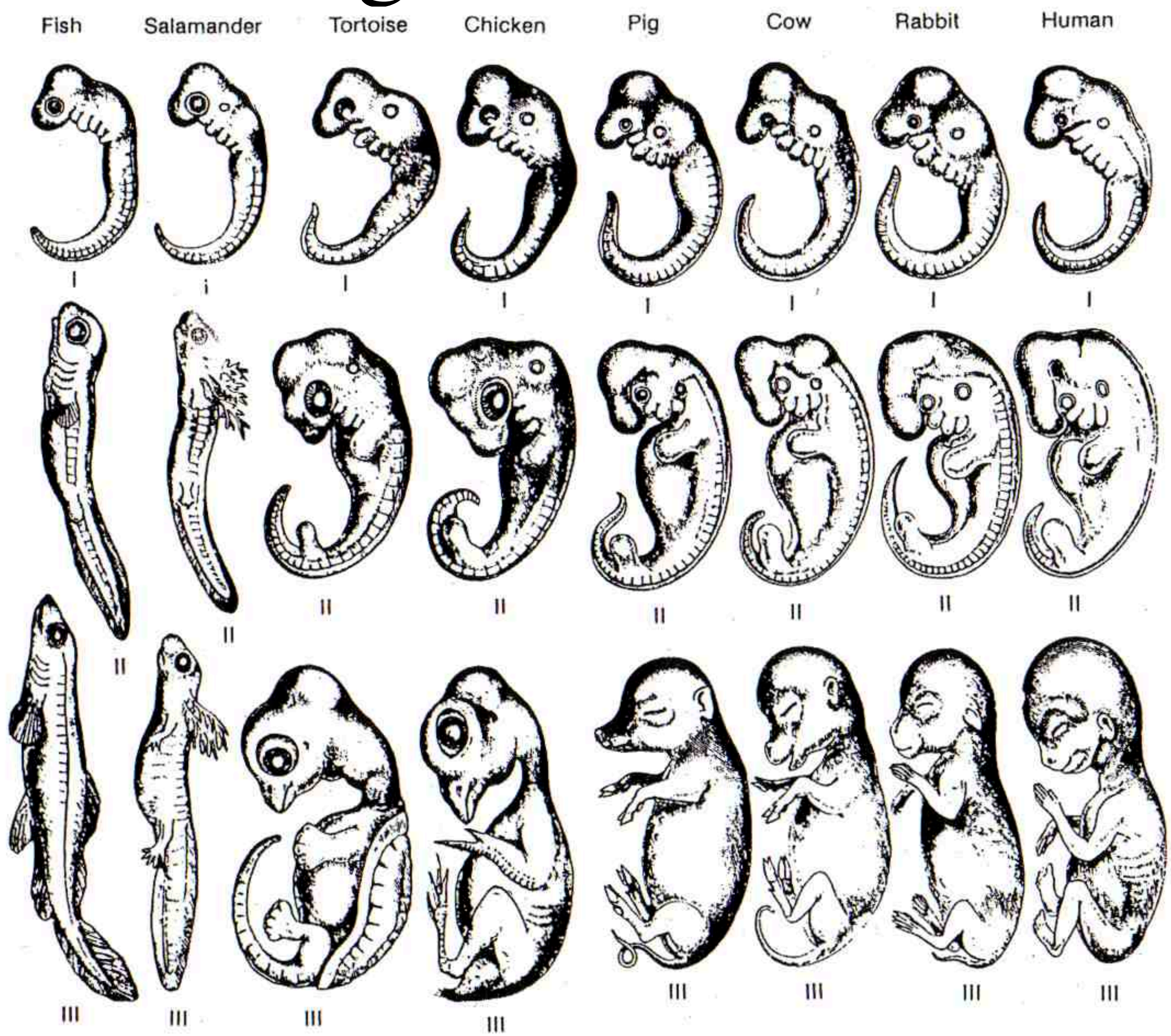



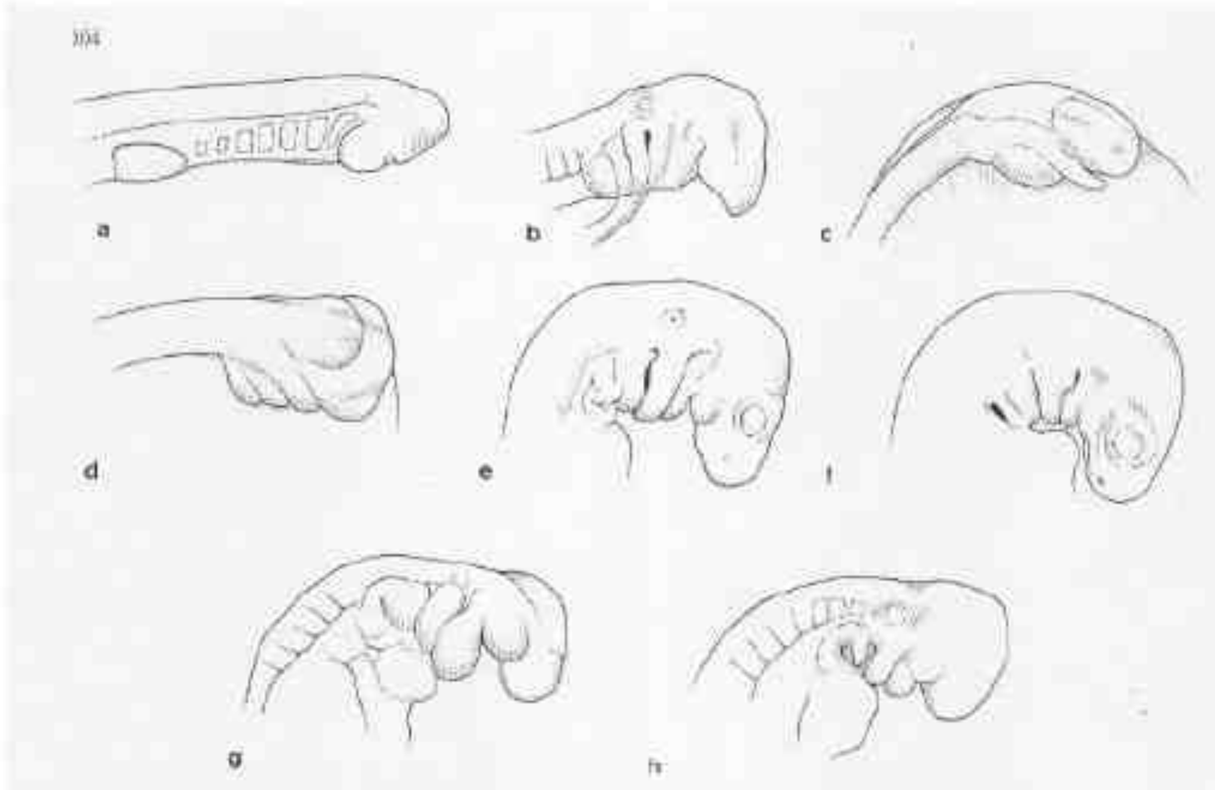



# Ernst Haekel

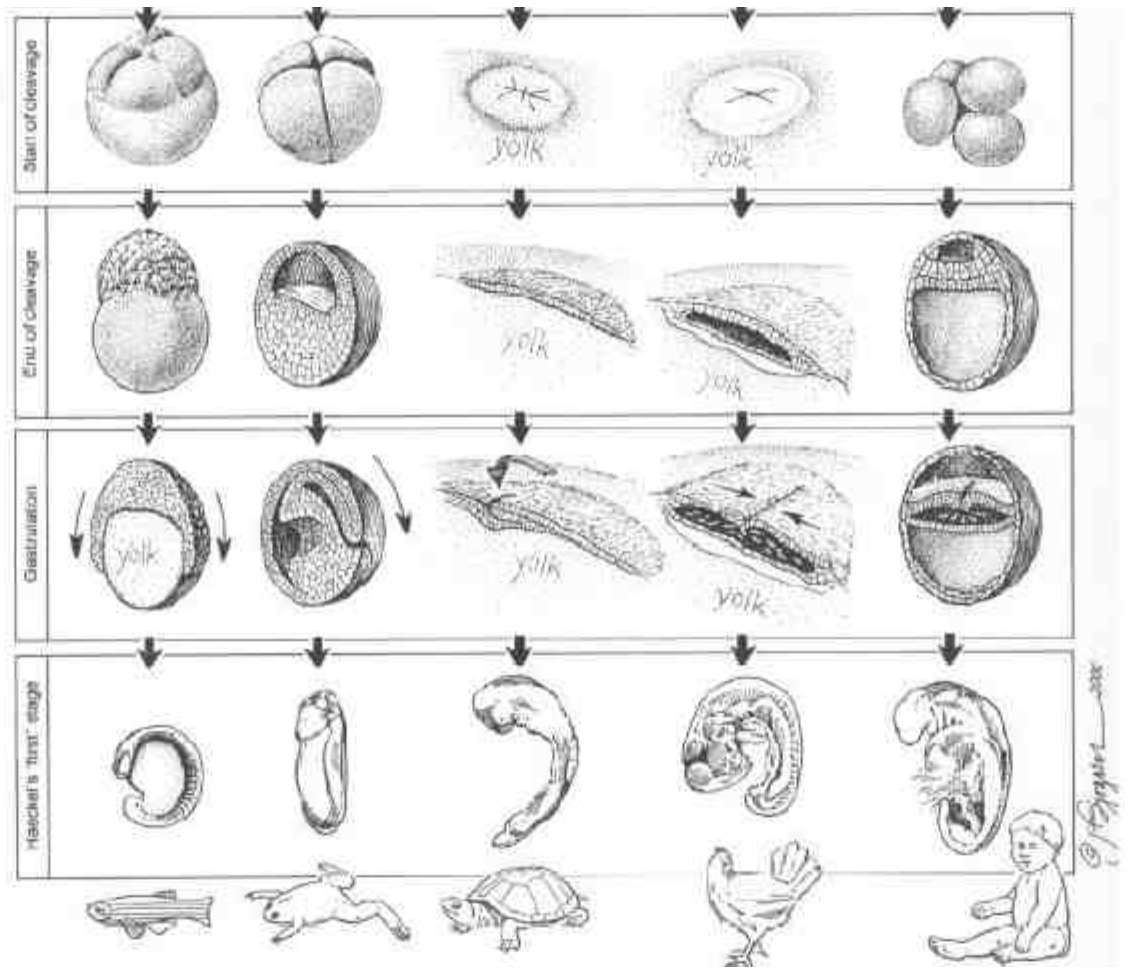
- Darwin's contemporary.
- Proposed the so-called biogenetic law: "Ontogeny recapitulates phylogeny" (see text).
- This "law" suggested that the overall patterns of evolution of species and higher taxa are recorded in their embryological development.
- Interesting notion, but it took the evolutionary importance of embryogenesis to far!

# Biogenetic "Law"

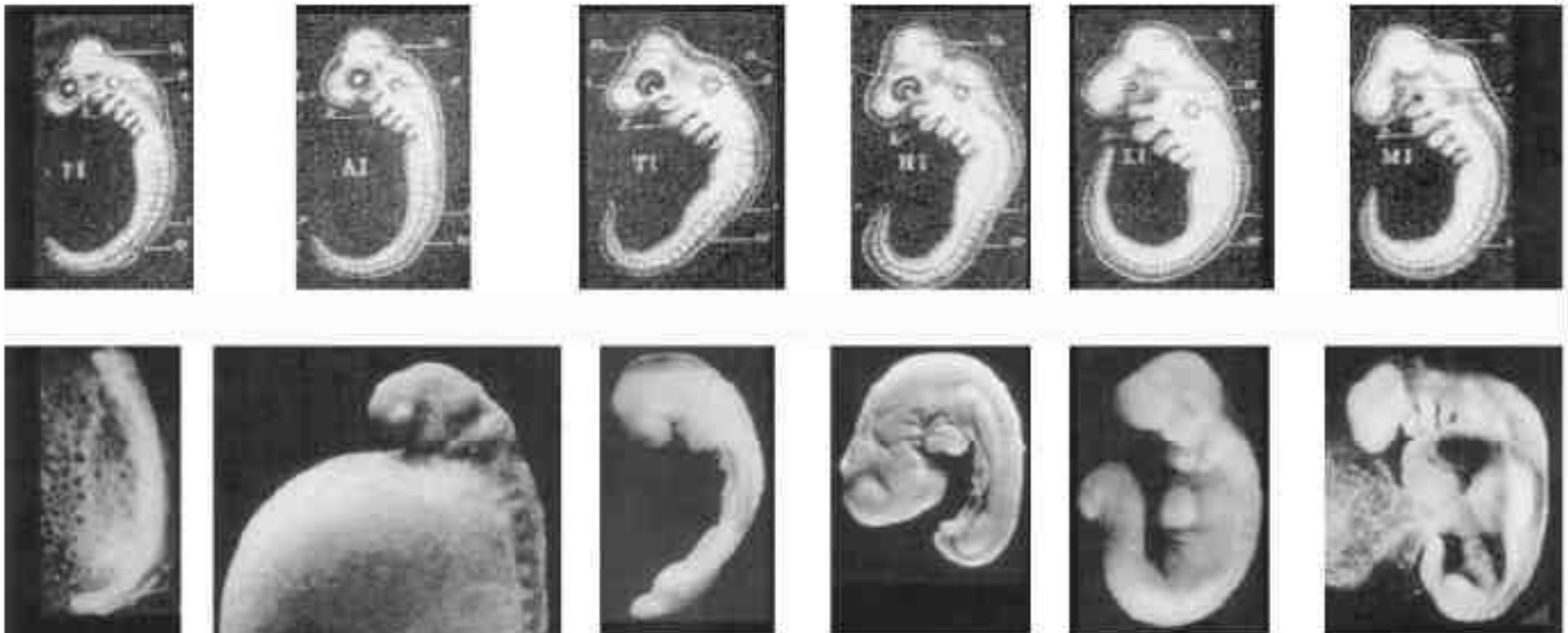





**The dissimilarity of the "gill slits" in various vertebrates.** From Richardson MK, Hanken J, Gooneratne ML, Pieau C, Raynaud A, Selwood L & Wright GM (1997): There is no highly conserved embryonic stage in the vertebrates: implications for current theories of evolution and development. *Anat Embryol* **196**, 91-106. Copyrights Springer-Verlag.




**Earliest stages in vertebrate embryos in the real life.** The fertilized eggs in the upper panel are drawn to scale relative to each other, while the succeeding stages are normalized. The embryos are (left to right): bony fish (zebrafish), amphibian (frog), reptile (turtle), bird (chick), and mammal (human). Reproduced from Jonathan Wells (2000), *Icons of Evolution*, Regnery Publishing, Washington, DC, p. 95. Copyrights Jody F. Sjogren.



**A sample of the correct outlook of the corresponding embryos** (the fish, the salamander, the turtle, the chicken, the rabbit and the human embryo). Adapted from the reproduction by Richardson MK, Hanken J, Gooneratne ML,

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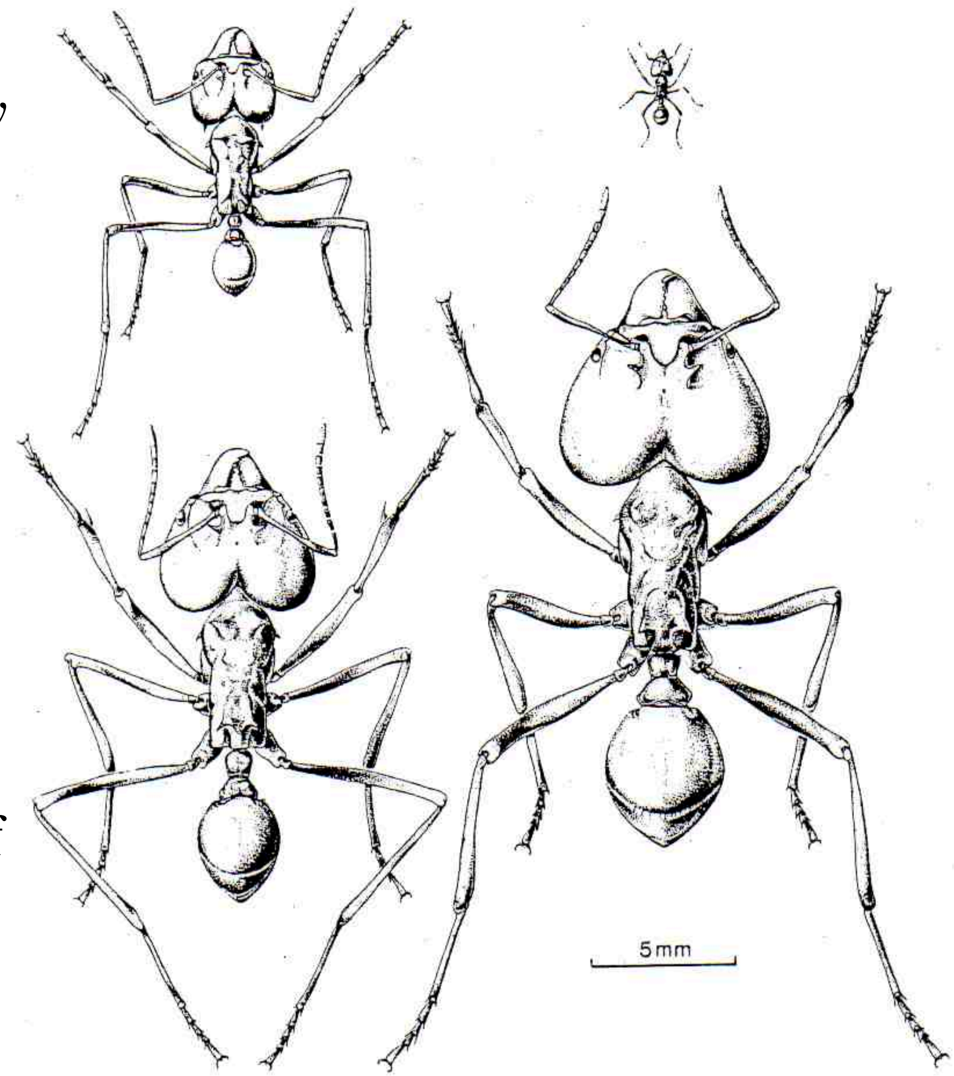
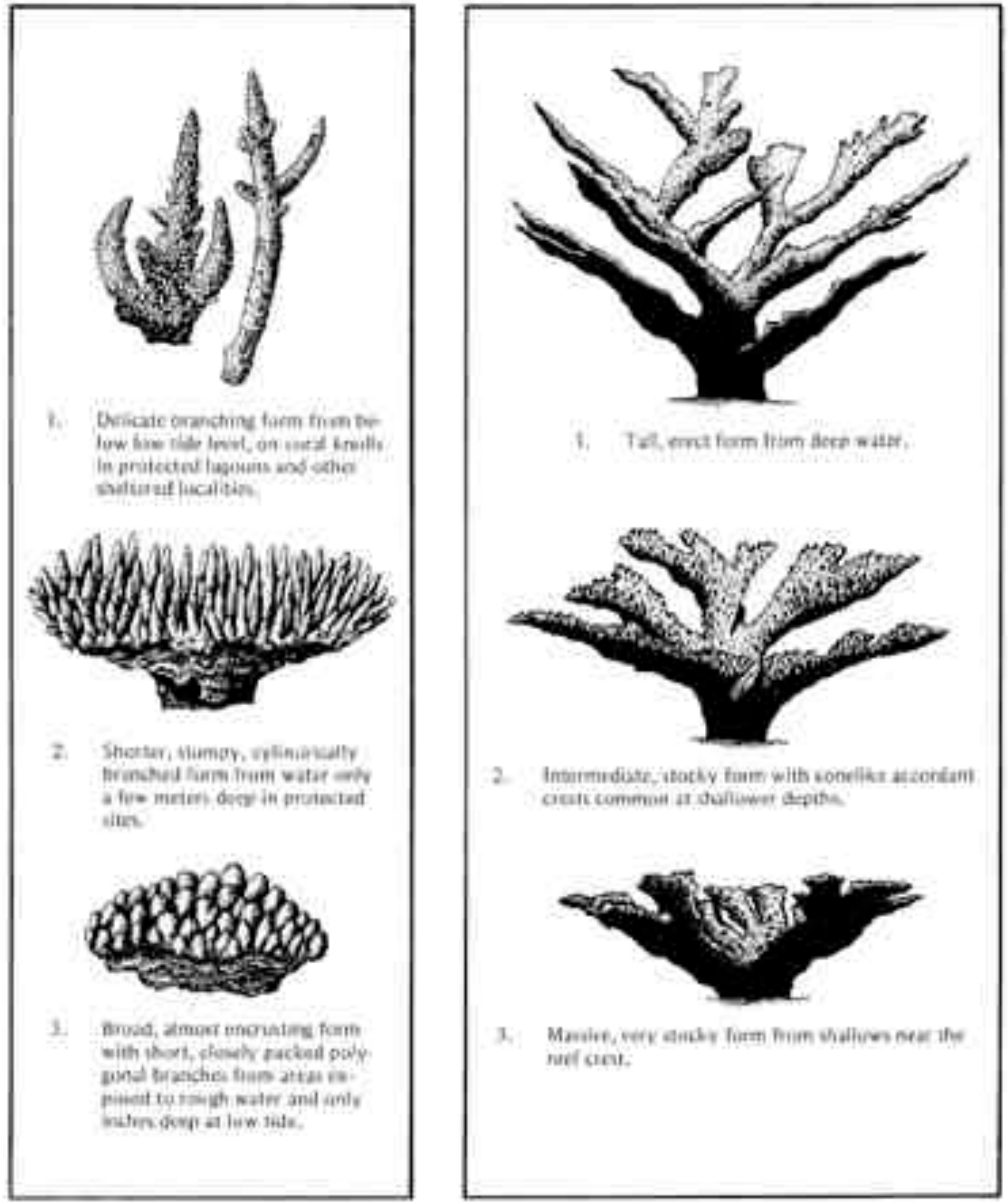
# Sources of Variation: Environmental Factors

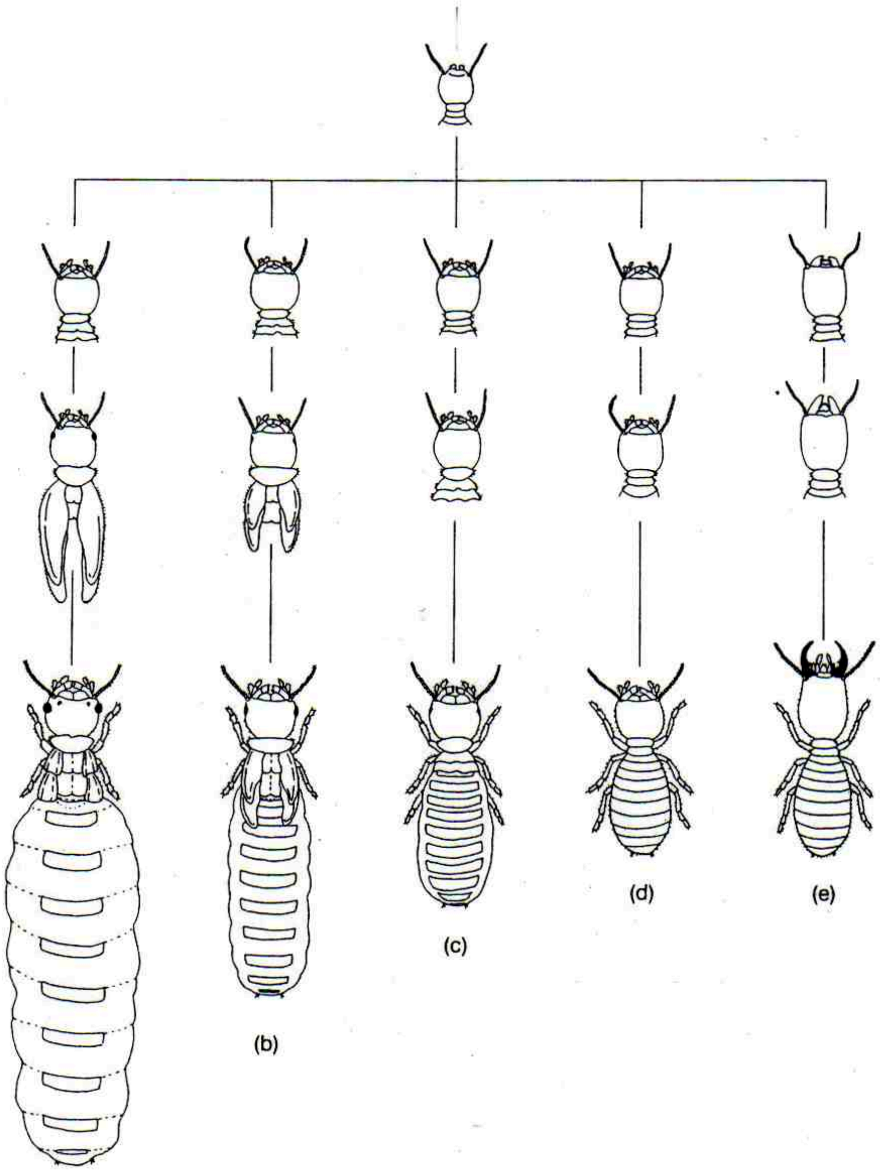
- "Ecophenotypic"
  - *Ecological (i.e., driven by organism-environment interactions)*.
  - *Examples:*
    - Differences in clonal organisms.
    - Reef corals.
    - Caste formation in social insects.
    - Environmental control of shell ornamentation in molluscs (temperature, salinity and nutrition).

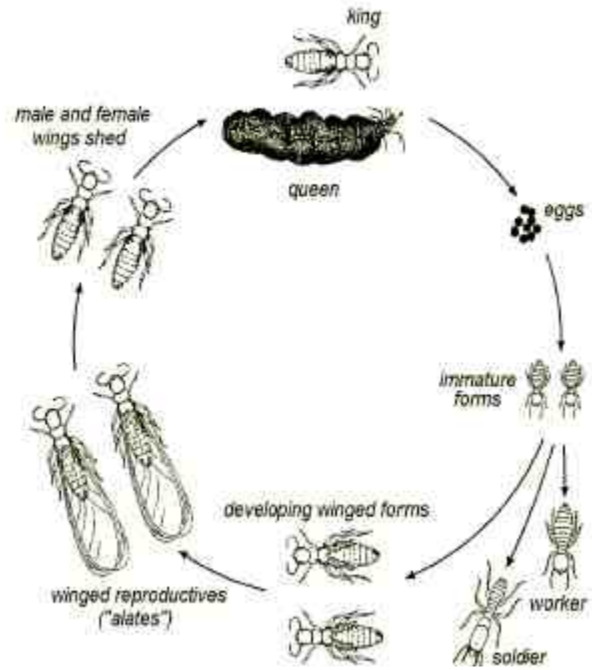


- ***Ecophenotypic (environmentally -induced) variation in reef corals (see text).***



# Variation (cont)



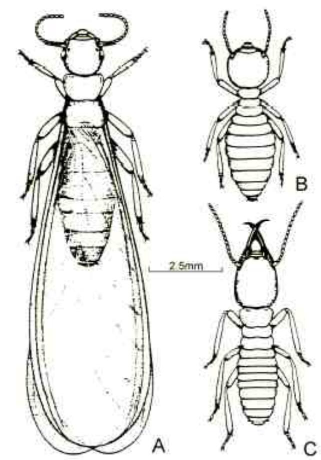




Figure 2: Castes of *Coptotermes acinaciformis* (Froggatt)
A. winged reproductive or alate
B. worker
C. soldier

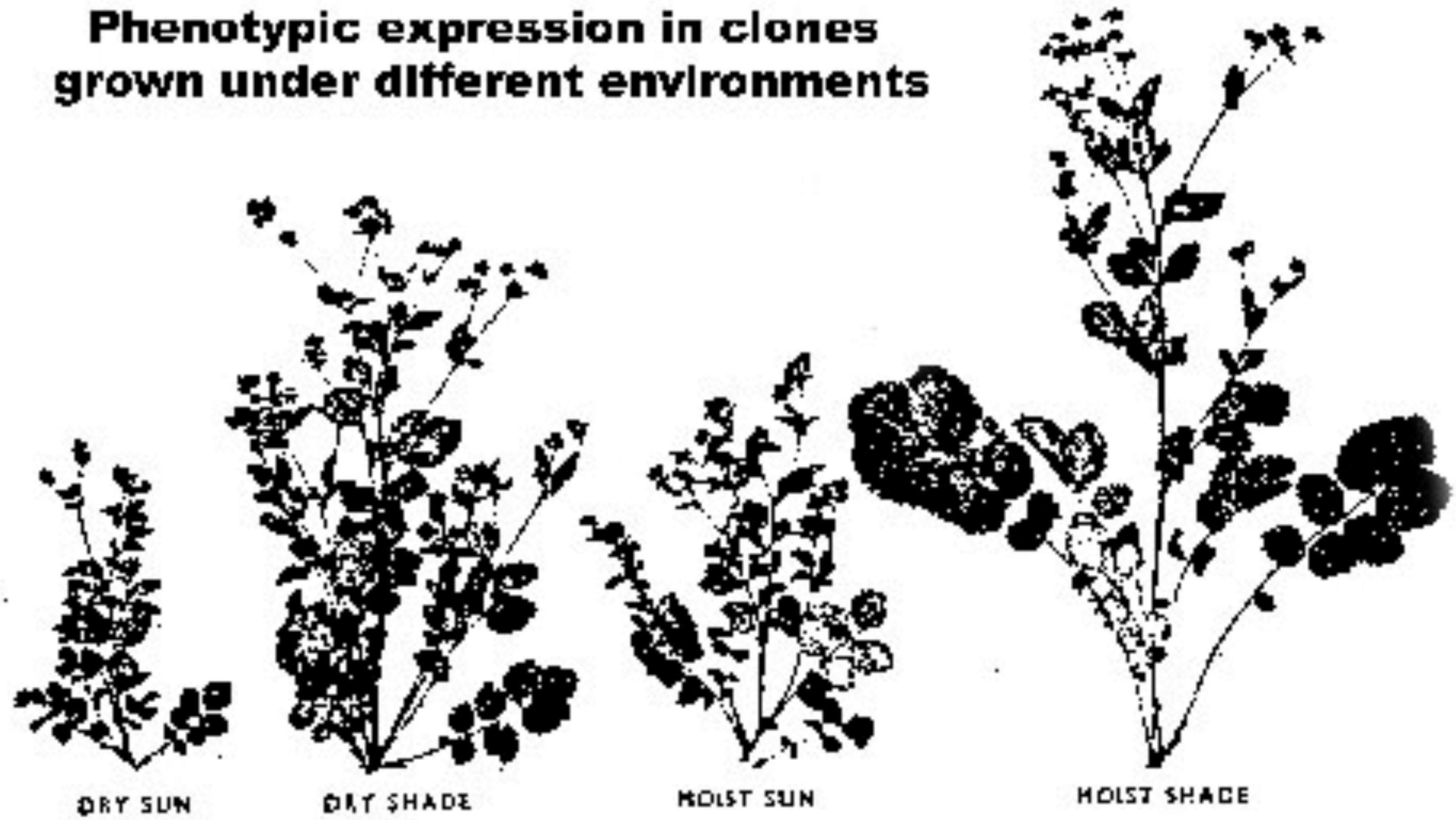
(Illustration courtesy of CSIRO Division of Entomology and Melbourne University Press)

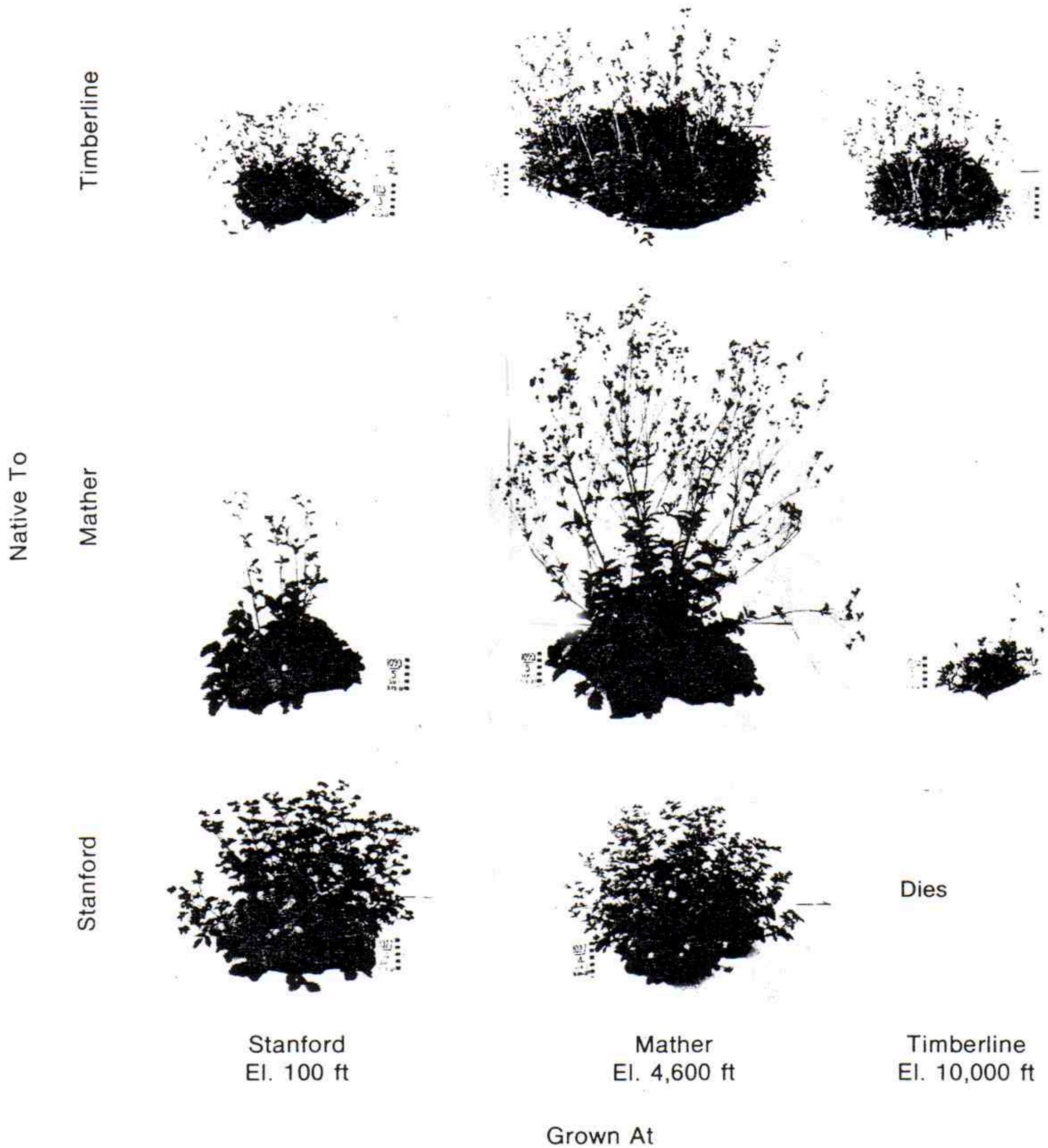
- Termite mounds
- Litchfield park, AU

# Ecophenotypic Variation in Plant Clones

- **The diagram of two ecophenotypic variants of the marsh plant *Sagittaria* reproduced by Schmalhausen (1986). On the left is the 'dry' variant, and on the right the 'wet' variant. How does the plant 'know' which morphology to produce, and how does it do it?**

## Phenotypic expression in clones grown under different environments




Native To
Timberline
Mather
Stanford
Dies
Stanford
El. 100 ft
Mather
El. 4,600 ft
Timberline
El. 10,000 ft
Grown At

# In-class exercise: Assessing morphological variation in natural populations

Divide into four groups. Each group should examine one of the collections provided (snail, butterfly and coral populations). For the snails, begin by arranging individuals according to their body size (ontogenetic series) and next by morphological tyoes within each of the general size categories. For the butterfly population, compare differences in color and wing shape. For the corals, examine the types of variation seen between the individual polyps making up each colony.