# CHAPTER 15:

# EVOLUTION AND DEVELOPMENT

## DEFINTIONS

1. ***Evolutionary developmental biology*** – the study of evolutionary changes in the developmental bases of phenotypic characteristics
2. ***Proximate causes*** – developmental causes of phenotypes that operate within an individual organism
3. ***Ultimate causes*** – such as natural selection, act at the population level across all generations
4. ***Von Baer's Law*** – features common to a higher taxon often appear earlier in development than the specific characters of lower-level taxa
5. ***Ontogeny*** – the development of an individual, from fertilized zygote until death
6. ***Allometry*** – differential rate of growth of different parts or dimensions of an organism during ontogeny. Refers to the shape of the organism or of certain of its parts
7. ***Heterochrony*** – an evolutionary change in the timing or rate of developmental events
8. ***Heterotropy*** – evolutionary change in the spatial position of a features within an organism
9. ***Modules*** - distinct units that have distinct genetic specifications, developmental patterns, locations and interactions with other modules
10. ***Serially homologous*** – when a module is repeated at various sites on the body
11. ***Individualization*** – the acquisition of distinct identities by such modules
12. ***Homeotic mutations*** – mutations that transform a structure into a different structure
13. ***Genetic toolkit*** – set of genes and proteins and the developmental pathways they comprise by which multicellular organisms are constructed during development
14. ***Co-option*** – the evolution for the function of a gene, tissue or structure other than the one it was originally adapted for. At the gene level, used interchangeably with recruitment and exaptation
15. ***Evolvability*** – the ability of a characteristic to evolve, especially under directional selection
16. ***Phenotypic integration*** – correlation between the state of two or more functionally related characteristics so that they are advantageously matched in most individuals
17. ***Canalization*** – evolution of internal factors during development that reduce the effect of perturbing environmental and genetic influences thereby constraining variation and consistently producing a particular phenotype
18. ***Reaction norm*** – set of phenotypic expressions of a genotype under different environmental conditions
19. ***Genetic assimilation*** – a process whereby a phenotype whose development is triggered by an environmental stimulus evolves to be constitutively expressed – no longer requires the stimulus

## EVOLUTIONARY DEVELOPMENTAL BIOLOGY / evo-devo

- Many species are similar as embryos – distinctive features of clade only arriving later in development (Von Baer's Law)

- Early in development a human is virtually indistinguishable from an alligator
- The embryos of birds, anteater's baleen whales develop incipient teeth that are resorbed and are lacking in the adults.
- Human embryos have a tail that stops growing and a coat of hair, which is shed about a month before birth.
- Clearly, the developmental processes by which a fertilized egg becomes a differentiated organism are shared among species.
- A developmental process is shared between sexes or limbs, however the developmental processes ultimately diverge.
- Homologous similarities are often based on shared genes and differences are based on differences in genes.

Evolutionary developmental biology aims to understand how transitions evolve, questions asked include

1) What changes have occurred in developmental mechanisms to give rise to different phenotypes
2) How genetic differences map onto phenotypic differences
3) Role of development in constraining or enhancing evolutionary change
   - ➢ How does development affect Evolvability?
4) How does developmental information help us identify homologous characters?
5) Understanding the origin of novel characteristics

## COMPARATIVE DEVELOPMENT AND EVOLUTION

- Morphogenetic processes in different organisms result in different adult forms
- EBD attempts to understand these processes, such as growth rates and differentiation of the body parts
- Major reason for these changes is alteration of the time, place and level of expression, such as in transcription
- A single genome can produce different morphologies depending on environmental signals such as day length or genetic signals.

Consider proximate and ultimate causes

- **Proximate causes:** mechanisms that operate within an individual organism.
- ➢ Complement the processes that caused these phenotypes and these mechanisms to evolve and differ among species.
- **Ultimate causes:** such as natural selection act at the level of populations across generations.
- ➢ Do not conflict with mechanistic genetic and developmental processes
- Embryonic mammals and birds have webbing between toes but it only remains in the wings of adult bats and feet of ducks – example of how EBD helps to understand evolved differences in species
- Species are often more similar as embryos than as adults.
- Ontogeny recapitulates phylogeny (Haeckel) – the development of the individual organism repeats the evolutionary history of the adult forms of its ancestors and thus could indicate its phylogenetic relationships – this aimed to support Von Baer's Law
- Having said this, ontogeny is not a useful guide to phylogenetic history
- Various features develop at different rates in descendants than in their ancestors and embryos and juvenile stages have stage-specific adaptations of their own

Several common patterns of developmental differences among species were identified

- **Allometry/ Allometric growth** – differential rate of growth of different parts or dimensions of an organism during ontogeny
  - The human head grows at a slower than the body, legs grow at a faster rate