CEDB30003: Developmental Biology **[Notes]**

L1 Introduction to Developmental Biology

Cell potency: *What are the outcomes of the cell? What can a cell become?*

- All cells have the same genetic content, yet there are many different types.
- ∴ The **potency of cells become restricted during development** as different fates are fulfilled.

Fertilised egg (one cell) -> Cleavage -> Gastrulation -> Organogenesis

- Fertilised cell: **egg** cytoplasm (mt & organelles): maternal descendent. Sperm nucleus gives $^1/_2$ genetic material.
- Undergo **cleavage**: cell divides into many cells. Cells must determine their spatial arrangement.
- **Gastrulation**: rearranges & reorganises cells around the embryo & lays down the three primary germ layers.
- Once ectoderm, mesoderm, endoderm are laid, can start to form organs (**organogenesis**).

Totipotent -> Differentiated cell (no more potency).

- Fertilised egg is **totipotent**, capable of giving rise to the whole living organism.
- As development progresses, cells lose potency until eventually becomes one cell type (differentiated cell).

Totipotency genes in **active** chromatin -> Totipotency genes in **repressed** chromatin

- A combination of genes are in open chromatin (euchromatin) & operate to create **totipotency**.
- Upon **differentiation**, those genes are compacted into heterochromatin & become inactive.
- Other genes of differentiation are turned into open chromatin (euchromatin) & become active.

Developmental biologists study embryonic & other developmental processes

- Process begins at the **fertilised egg** but continues through life: [Skin replacement, Regeneration, Metamorphosis].
- Cells are not static. Processes that occur all the time are part of developmental & management processes.
- Foetus starts to form organs AND feed itself AND breathe (O_2 from mother) AND survive as it changes.
    - [Unlike machines that do not change as they operate]: Have to build in changes.

Developmental biologists want to know processes from Zygote ----> ~7 month foetus (or any stage embryo)

- How does the fertilised egg give rise to the adult body? How does the adult body produce another body?
- Epigenesis: Embryos are formed *de novo* by a preformed genetic manual. This drives shape, form & characteristics.
    - Genome is combination of genes from father's sperm (n) & mother's egg (n).
    - Works **mostly**: minor differences among individuals. Developmental defects occur when it doesn't work well
- Development accomplishes two main objectives:
    - Generates cellular diversity & order with each organism: >200 different cell types => tissues, organs etc.
    - Ensures continuity of life (sperm & egg) to give rise to the next generation.

Development involves:

1. Emergence of pattern: A framework **to build** (e.g. head, tail, legs, V, D). Homologs of Hox genes conserved.
    - In same arrangement from head to tail: organise & regulate same processes across organisms.
2. Change in form: Moulding of body form & cells to different types of cells. Morphogenesis.
3. Growth: **Proportional** growth & must be **regulated**. For (2) & (3):
    - Embryonic day 3 chick: AER on limb buds: Solid blocks of tissues --> arms --> hands.
    - Apoptosis in interdigital region: Limb bud -> bones form -> apoptosis between to create hand.
4. Cell differentiation: ~Every cell has **same** genetic information but can lead to differences in shape, function & size.
    - Zygote => Blastula => Gastrula =>
    - Ectoderm: Outer surface (-> Epidermal cells of skin), CNS (-> Neuron of brain), Neural crest (-> Pigment cell).
    - Mesoderm: Dorsal (-> Notochord), Paraxial (-> Bone tissue), Intermediate (-> Tubule cell of kidney), Lateral (-> RBCs), Head (Facial muscle).
    - Endoderm: Digestive tube (-> Pancreatic cell), Pharynx (-> Thyroid cell), Respiratory tube (-> Lung cell).
    - Germ Cells: Male (-> Sperm), Female (-> Egg).

Development is a central element in **evolution** (e.g. Hox genes). Environmental factors can affect developmental processes e.g. Developmental anomalies caused by an env agent: **Phocomelia** (disorder) **& Thalidomide** (drug).

Why study developmental biology?

- Knowledge: Molecular basis for cellular diversity; Organ development & regeneration; How genotype gives rise to phenotype; How germ cells give rise to new individuals.
- Applied research: Stem cells, cell transplantation therapies; Human developmental defects & teratology; Destructive environmental agents; IVF: Assisted Reproductive Technologies; Cancer, Disease & New Drugs.

Approaches to Developmental Biology: Requires ALL three factors.

- Anatomical embryology: A **description** of what is seen.
- Experimental embryology: Manipulation of embryos e.g. to determine function.
- Developmental genetics: Genes to manipulate & KO etc.

Why study different species?

1. More is known about a particular process in a particular species
    - May be easier to study that process in that animal, **or**
    - More amenable to certain types of experimentation, **or**
    - Less complex process than in other species (can be easier)
2. Processes & general principles similar in all vertebrates.
3. Despite obvious differences, there is a conservation of genes: **at the level of both structure & function**.