

Development

(CH. 21)

Summary

- Embryonic Development
 - Mitosis
 - Differentiation
 - Morphogenesis
- Model Organisms
- Genomic Equivalence
 - Variable expression of genes
 - Totipotent plants
 - Animal cloning
- Cytoplasmic determinants (maternal)
- Pattern formation
 - Fruit flies
 - Segmentation
 - Gradients of Morphogens
 - Cascade of Expression
 - Mice
 - Homeotic genes
 - Nematodes
 - Induction
 - Apoptosis
 - Wall Cress (plant)
 - Organ identity genes

Embryonic Development (animal)

- **Growth** (mitosis)
- **Differentiation** (transcription)
- **Morphogenesis** (change form)

Model Organisms

- Easy to breed and maintain
- Short life cycle
- Representative of a group
- Well-suited for answering specific questions
- Simplest → Complex
 - E. coli (bacteria)
 - C. elegans (nematode)
 - S. cerevisiae (yeast)
 - D. rerio (zebrafish)
 - A. thaliana (plant)
 - D. melanogaster (fruit fly)
 - M. musculus (mouse)

Differential Gene Expression

- Expressed = Activated = Transcribed = Turned on
- Genomic equivalence: most cells of an organism contain the same genes
 - Totipotency (plants): ability to regenerate
 - Nucleus (animal cell): can give rise to another animal if transplanted to an egg
- Different cell types utilize different portions of genome via varied regulation of transcription
- Regulation is directed by
 - Maternal factors (**cytoplasmic determinants**)
 - Signals from other cells (**induction**)

Totipotency (plants)

Regeneration of an organism from a few cells proves that all necessary genes for development and growth are already within these cells

Totipotency
(animals)

- No information is lost from cells as they undergo differentiation
- Cytoplasmic environment around a nucleus can modify its fate

- Cloning of mammals

Development is a stepwise process

- Determination: initial signaling even that “determines” the fate of a cell (1st stage)
- Differentiation: through the effect of determinants expression of additional genes is regulated (2nd stage)

Embryonic Development
(Plant)

- Type of structure
 - organ-identity genes (regulation)
- Number of organs
 - Cell-cell signaling (induction)

Embryonic Development (Animal)

Embryonic Development (Animal)

Cytoplasmic Segregation

Embryonic Development (Animal)

Order of Genes expressed : Maternal → segmentation → homeotic

Maternal Effect Genes

- Drosophila: bicoid and nanos
 - Changes due to gradients
- Induction
- Signals from nearby cells
 - Diffusion of chemicals (signals)
 - Cell-surface interactions

Pattern Formation

(*Drosophila*)

- Determined by studying mutants (embryonic lethals)
- Segmentation
 - positional information that stimulates differentiation of different segments
 - 1) Gap genes
 - 2) Pair-ruled genes
 - 3) Segment-polarity genes

- Homeotic genes: direct anatomical identity of parts

Sequence of Gene activation

- Gap genes organize broad slices of the embryo
- Pair rule genes divide the embryo into pairs of segments
- Segment polarity genes determine boundaries and anterior-posterior organization of segments
- Homeotic genes define roles of each segment

Homeotic Transformation

Stem Cell differentiation

- Removed eggs from a female donor
- Enucleate (remove nucleus) an egg
- A cell is removed from a recipient
- Recipient cell (or nucleus) is fused with donor cell
- Egg cell is stimulated to divide

- Embryonic stem cells form (genetically identical to the recipient's)
- Stem cells are induced to differentiate to desired tissue for transplantation

Apoptosis

Programmed cell death

Embryonic Development

(Fertilization)

- Egg and sperm contribute differently
- Rearrangement of egg cytoplasm

Embryonic Development (Determination)

Embryonic Development (Cleavage)

Embryonic Development (Cleavage in mammals)

- Blastula is called a blastocyst, and is made up of an inner cell mass (embryo) and a trophoblast (placenta)

Embryo

Twinning

Gastrulation

(Animals)

- Three layers

Implantation

Neurulation

- Initiation of nervous system

Extraembryonic Membranes

- Yolk
- Allantois: metabolic wastes
- Amnion: compartment for the embryo
- Chorion: outer membrane

Placenta

Human Gestation

- First trimester: rapid cell division and tissue differentiation
- Second trimester: rapid growth and weight gain; limbs and facial features form; first movements
- Third trimester: continued growth, maturation of organs

Resources

- <http://www.blc.arizona.edu/courses/181summer/12.html>