Developmental Biology

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Development

Differential cell behaviours
\(\text{division, differentiation, growth, patterning, movement}\)

\[\downarrow\]

the emergence of organised structures
\(\text{tissues, organs}\)
Basic Principles of Development

1- Cell Division

Cleavage

2- Pattern Formation

- Defining the Axes: Body Plan
- initiating Germ Layer Formation

Gastrulation

3- Morphogenesis

- Formation of 3 Germ layers
- Neural Crest Cell Migration

Organogenesis

4- Cell Differentiation

- Blood, Muscle, Nerves ...

5- Growth
## Organisms used in Developmental Biology

<table>
<thead>
<tr>
<th>Org.</th>
<th>Latin name</th>
<th>genomic size</th>
<th>contribution to DB</th>
<th>Nobel Prize</th>
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</thead>
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<td>Yeast</td>
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<td></td>
<td>(zebrafish)</td>
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Development is controlled by differential gene expression, which drives cascades of gene-regulatory events, which define differential cell behaviours, which underlie major developmental processes to study gene expression & protein function enhances understanding of development significantly!!!
Origin of differential gene expression patterns often can be traced back to the asymmetric localization of morpho-genetic information in the egg.
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Cleavage  
Cell division and body axes formation  
Drosophila (Fruit Fly)

Localisation of morphogenetic information  
\[ \downarrow \]
Cytoplasmic factors  
(specific mRNAs and proteins)  
\[ \downarrow \]
maternal vs zygotic genes  
\[ \downarrow \]
A–P & V–D axis  
\[ \downarrow \]
segmentation
Legs and wings form at parasegmental borders.
Similarity between invertebrates and (higher)vertebrates:
- many common genes
- maternal determinants in oocyte
- overlap in cascades of gene-regulatory events driving development
Gastrulation
Morphogenesis and formation of 3 germ layers
Frog/Chicken

GASTRULATION is the re-arrangement of the blastula to form:

- **Outer ectoderm**: skin and (central) nervous system
- **Inner mesoderm**: most of the organs
- **Endoderm**: linings of digestive and respiratory system
During gastrulation and cell differentiation:

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<th>Genes encoding transcription factors</th>
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<tr>
<td>goosecoid</td>
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<tr>
<td>Pintallavis</td>
<td>Hnf-3β</td>
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<tr>
<td>Xlim-1</td>
<td>Lim-1</td>
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<th>Genes encoding secreted proteins</th>
<th>Xnr-3</th>
<th>Nodal</th>
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<tr>
<td>chordin, Xnot2, noggin, Shh</td>
<td>Shh</td>
<td></td>
</tr>
<tr>
<td>Cerberus</td>
<td>Cerberus-related</td>
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‘Autonomous’ signals or cell conditioning signals
Organizers or signalling centres underline importance of genes regulating crucial developmental events

A-Gastrulation: Spemann organizer

Hensen’s node
B- Cell differentiation

Limb formation: **Apical Ectodermal Ridge**

Brain compartmentalization: **Isthmus**
(defines boundary between mid- and hindbrain)
Mouse/zebrafish

Models for genetic manipulation of vertebrate species!
→ Loss/(gain) of function studies

e.g.
stable manipulations
knockin reporter mice
Gene knockout mice
Conditional gene knockout mice

temporary manipulations
RNA-interference
mRNA blockade with morpholinos
Why are there five fingers on our hands?