**A. Course Overview**

1. Dorsal-Ventral axis formation & neural induction
   - How is the NS defined and what distinguishes NS cells from others?
2. Pathfinding
   - How is the NS wired / How cells find and form connections with their targets
3. Experience based modifications of NS & synapses
   - How learning & memory can change those connections

**B. Model Systems**

<table>
<thead>
<tr>
<th>VERTEBRATES</th>
<th>Model Organism</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Humans      | • Self-reporting mutants  
• Genome known  
• Plasticity  
• Detailed knowledge of behavior & critical periods  
• Many cell lines-CRISPR/Cas9 | • No experimental access  
• Fetal material difficult to acquire | |
| Primates (Monkeys) | • Very similar to humans → postnatal development  
• Genome known | • Little experimental access to embryos  
• No genetics  
• Very expensive  
• Ethical concerns to using them | |
| Dogs, Cats, Ferrets | • Mammals w/ postnatal development  
• Visual system immature @ birth → look @ critical per.  
• Dogs: many breeds w/ diff behaviors  
• Genome known | • Slow reproduction  
• Little experimental access to embryos  
• Little genetics for cats/ferrets | |
| Rats & Mice | • Mammals → homologous brain areas/cell types  
• Genome known  
• Powerful genetics → KOs & engineering mutants → CRISPR/Cas9  
• Make mosaics → chimeric embryos | • Embryogenesis inside mother → fetus resorbed  
• Slow development |
### Birds:
- **Experimental → Chicks & Quail**
- **Behavioral → Crows & Parrots**
  - Genome Known
  - Embryos accessible → better manipulation (tissue grafts)
  - Some birds very smart (parrots, crows/ravens)
  - Neural circuitry similar to mammals → reorg. of same circuitry & connectivity of cell types

### Amphibia
- Vertebrate
- Embryos accessible & easy to manipulate
- Rapid development

### Zebrafish
- Good genetics → many mutants, CRISPR/Cas9, morpholinos
- Very rapid develop
- Transparent embryos → optogenetic methods (fluorescent reporters)
- Vertebrate

## INVERTEBRATES

<table>
<thead>
<tr>
<th>Model Organism</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flies: <em>Drosophila</em></td>
<td>Fast develop &amp; greater orders of magnitude → look @ more mutants</td>
<td>Small neurons → mitigated by optogenetics</td>
</tr>
<tr>
<td></td>
<td>Genome known</td>
<td>Not vertebrate</td>
</tr>
<tr>
<td></td>
<td>Very well develop genetic tools → mosaics, CRISPR, Genome wide RNAi, unbiased genetic screens</td>
<td></td>
</tr>
<tr>
<td>Nematodes/Worms: <em>C. elegans</em></td>
<td>Well developed genetics → Systematic RNAi screens</td>
<td>Not vertebrate</td>
</tr>
<tr>
<td></td>
<td>Simple: 302 neurons-959cells</td>
<td>Structurally poor external morphology</td>
</tr>
<tr>
<td></td>
<td>Connectivity known → every synapse mapped</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Invariant lineages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Optogenetics</td>
<td></td>
</tr>
</tbody>
</table>
C. Gurdon Experiment

What were the steps of this experiment? What was the result?
1. Unfertilized frog egg is irradiated to remove nucleus, but cytoplasm is still intact
2. Take skin cells from full grown frogs and remove the nucleus
3. Inject nucleus from skin cells into irradiated egg
4. Embryo allowed to develop

→ Result: Full grown frog was able to develop from the treated egg.

What was concluded from this experiment?
All cells contain the SAME genetic information
→ If that’s the case, what makes them different from each other?
• Gene expression patterns (whether or not different subsets of genes are transcribed into mRNA)
D. Molecular Biology

What is the central dogma of molecular biology?

\[ \text{DNA} \xrightarrow{\text{Transcription}} \text{mRNA} \xrightarrow{\text{Translation}} \text{Protein} \]

What are the two parts of a gene (as discussed in class) and what do they do?

- Regulatory Region - acts as a switch to turn expression of the gene on/off
- Coding Region - contains the information necessary to make the protein

What are transcription factors? What are the two types of transcription factors?

- Sequence specific DNA binding proteins (binds the regulatory region, which is the “switch” for gene expression → the transcription factors flip that switch on or off)
- Activators - turn gene expression on
- Repressors - turn gene expression off → has priority - always wins over activators

What must happen in order for a gene to be expressed (the “rule” for gene activation)?

- All activators that bind to the regulatory region must be present and all repressors must be absent