Monotremes and Marsupials

Mammals that “took a different route”

BIOL212 – Development
### Common Mammalian Characteristics
- Mammary glands & mammae (2 – 19)
- Sweat glands
- Sebaceous glands
- Hair (or fur)
- Differentiated teeth
- (And many more, but above are “key”)

### Eutherian Mammals
- Placental Mammals
- More complex placentas
- Embryonic development completed \textit{in utero}
- Intimate & long lasting association between mother and her developing young

### Early Development
- Cleavage
- Blastula
- Gastrulation
- Blastopore formation
- Gastrula
- Common to all animals
- Conservation of developmental genes
Early development
Monotremes

- Five extant species
- Australia & New Guinea
- Platypus & Echidnas
- Hair & lactation
- (But reptilian, avian & mammalian characteristics)

Marsupials

- Placenta minimal
- Embryonic development begins in utero
- Mammae (nipples)
- Offspring born very early in development
- Embryonic development completed in marsupium (pouch) while nursing
- Australia, North & South America
Convergent Evolution

- Opossums
- Examples of convergent evolution essentially complete between niches for marsupials and eutherians

Figure 34.40a

<table>
<thead>
<tr>
<th>Marsupial mammals</th>
<th>Eutherian mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantigale</td>
<td>Deer mouse</td>
</tr>
<tr>
<td>Marsupial mole</td>
<td>Mole</td>
</tr>
<tr>
<td>Sugar glider</td>
<td>Flying squirrel</td>
</tr>
</tbody>
</table>

20/05/12
Figure 34.40b

Marsupial mammals

Wombat
Tasmanian devil
Kangaroo

Eutherian mammals

Woodchuck
Wolverine
Patagonian cavy

Figure 34.41a

Monotremata

Orders and Examples

Main Characteristics

Lay eggs; no nipples; young suck milk from fur of mother

Lay eggs; no nipples; young suck milk from fur of mother

Long, muscular trunk; thick, loose skin; upper incisors elongated as tusks

Aquatic; finlike forelimbs and no hind limbs; herbivorous

Reduced teeth or no teeth; herbivorous (sloths) or carnivorous (anteaters, armadillos)

Chisel-like incisors; hind legs longer than forelegs and adapted for running and jumping; herbivorous

Sharp, pointed canine teeth and molars for shearing; carnivorous

Hooves with an even number of toes on each foot; herbivorous

Aquatic; streamlined body; paddle-like fore-limbs and no hind limbs; thick layer of insulating blubber; carnivorous

Figure 34.41b

Monotremata

Monotremes

Marsupiala

Monotremata

Marsupiala

Proboscidea

African elephant

Sirenia

Manatees, dugongs

Xenarthra

Sloths, anteaters, armadillos

Lagomorpha

Rabbits, hares, pikas

Primates

Lemurs, monkeys, chimpanzees, gorillas, humans

Carnivora

Dogs, wolves, bears, cats, weasels, otters, seals, walruses

Cetartiodactyla

Artiodactyls

Sheep, pigs, cattle, deer, giraffes

Cetaceans

Whales, dolphins, porpoises

Marsupialia

Kangaroos, opossums, koalas

Tubulidentata

Aardvarks

Hyracoidea

Hyraxes

Rodentia

Squirrels, beavers, rats, porcupines, mice

Chiroptera

Bats

Eulipotyphla

Insectivores

Star-nosed mole

Adapted for flight; broad skinfold that extends from elongated fingers to body and legs; carnivorous or herbivorous
• Although animals display different body plans, they share many basic mechanisms of development and use a common set of regulatory genes
• Biologists use **model organisms** to study development, chosen for the ease with which they can be studied in the laboratory
• **Fertilization** is the formation of a diploid zygote from a haploid egg and sperm
• Development occurs at many points in the life cycle of an animal

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**Chordate Characteristics**

• The **notochord** is a longitudinal, flexible rod between the digestive tube and nerve cord
• The nerve cord of a chordate embryo develops from a plate of ectoderm that rolls into a tube dorsal to the notochord
• The nerve cord develops into the central nervous system: the brain and the spinal cord
• **Hollow dorsal nerve cord**
In most chordates, grooves in the pharynx called **pharyngeal clefts** develop into slits that open to the outside of the body.

**Functions of pharyngeal slits**
- Suspension-feeding structures in many invertebrate chordates
- Gas exchange in vertebrates (except vertebrates with limbs, the tetrapods)
- Develop into parts of the ear, head, and neck in tetrapods

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**Muscular, Post-Anal Tail**

- Chordates have a tail posterior to the anus
- In many species, the tail is greatly reduced during embryonic development
- The tail contains skeletal elements and muscles
- It provides propelling force in many aquatic species

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**Table 21.1**

<table>
<thead>
<tr>
<th>Organism</th>
<th>Diploid Genes</th>
<th>Haploid Genes</th>
<th>Genes per Mb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>1,786</td>
<td>893</td>
<td></td>
</tr>
<tr>
<td>Archaea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mesophiles</td>
<td>2,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Eukaryotes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drosophila</td>
<td>12,600</td>
<td>6,300</td>
<td>525</td>
</tr>
<tr>
<td>C. elegans</td>
<td>1,000</td>
<td></td>
<td>208</td>
</tr>
<tr>
<td>Yeast</td>
<td>120</td>
<td>60</td>
<td>225</td>
</tr>
<tr>
<td>Drosophila melanogaster</td>
<td>1,600</td>
<td>800</td>
<td>25</td>
</tr>
<tr>
<td>D. melanogaster</td>
<td>650</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Maize</td>
<td>2,300</td>
<td>1,150</td>
<td>14</td>
</tr>
<tr>
<td>Arabidopsis thaliana</td>
<td>2,500</td>
<td>1,250</td>
<td>10</td>
</tr>
<tr>
<td>Arabidopsis thaliana (non-functional)</td>
<td>2,500</td>
<td>1,250</td>
<td>9</td>
</tr>
<tr>
<td>D. melanogaster (non-functional)</td>
<td>5,000</td>
<td>2,500</td>
<td>7</td>
</tr>
<tr>
<td>D. melanogaster (pure family)</td>
<td>100,000</td>
<td>50,000</td>
<td>492</td>
</tr>
<tr>
<td>D. melanogaster (fertile family)</td>
<td>100,000</td>
<td>50,000</td>
<td>493</td>
</tr>
</tbody>
</table>

**Genes**

- Highly conserved genes have changed very little over time
- These help clarify relationships among species that diverged from each other long ago
- Bacteria, archaea, and eukaryotes diverged from each other between 2 and 4 billion years ago
- Highly conserved genes can be studied in one model organism, and the results applied to other organisms

**Hox Genes**

- Molecular analysis of the homeotic genes in *Drosophila* has shown that they all include a sequence called a **homeobox**
- An identical or very similar nucleotide sequence has been discovered in the homeotic genes of both vertebrates and invertebrates
- Homeobox genes code for a domain that allows a protein to bind to DNA and to function as a transcription regulator
- Homeotic genes in animals are called **Hox** genes
Small Changes

- Sometimes small changes in regulatory sequences of certain genes lead to major changes in body form
- For example, variation in Hox gene expression controls variation in leg-bearing segments of crustaceans and insects
- In other cases, genes with conserved sequences play different roles in different species

<table>
<thead>
<tr>
<th></th>
<th>Bacteria</th>
<th>Archaea</th>
<th>Eukarya</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genome size</td>
<td>Most are 1-6 Mb</td>
<td>Most are 10-4,300 Mb, but a few are much larger</td>
<td></td>
</tr>
<tr>
<td>Number of genes</td>
<td>1,500-7,500</td>
<td>5,000-40,000</td>
<td></td>
</tr>
<tr>
<td>Gene density</td>
<td>Higher than in eukaryotes</td>
<td>Lower than in prokaryotes (within eukaryotes, lower density is correlated with larger genomes.)</td>
<td></td>
</tr>
<tr>
<td>Introns</td>
<td>None in protein-coding genes</td>
<td>Present in some genes</td>
<td>Unicellular eukaryotes: present, but prevalent only in some species. Multicellular eukaryotes: present in most genes</td>
</tr>
<tr>
<td>Other noncoding DNA</td>
<td>Very little</td>
<td>Can be large amounts; generally more repetitive noncoding DNA in multicellular eukaryotes</td>
<td></td>
</tr>
</tbody>
</table>

Fertilization

- Molecules and events at the egg surface play a crucial role in each step of fertilization
  - Sperm penetrate the protective layer around the egg
  - Receptors on the egg surface bind to molecules on the sperm surface
  - Changes at the egg surface prevent polyspermy, the entry of multiple sperm nuclei into the egg
The Acrosomal Reaction

- The acrosomal reaction is triggered when the sperm meets the egg.
- The acrosome at the tip of the sperm releases hydrolytic enzymes that digest material surrounding the egg.