Endocrine System - Pituitary – 3 parts;
  - Neurohypophysis – release chemicals – water loss (vasotocin & isotocin), regulatory (releasing factors effect other parts
  - Pars intermedia
  - Adenohypophysis (pars distalis) – prolactin (osmoregulation), Growth, ACTH (release cortisteroids), MSH (color)

Endocrine System

- Thyroid – small cells makes Thyroxin
- Interrenal cells = adrenal like cells; Two cell types – chromaffin (epinephrine & norepinephrine) and steroid producing cells (controls metabolism w/ costeroids).
- Autonomic Nervous System – poor in agnathans but well developed in teleosts (along either side of spine) – controls involuntary functions

Endocrine System – Chapter 7 - Endocrine

- Hypothalamus – controls pituitary
- Caudal Neuroendocrine System – Urophysis (caudal end spinal cord) – 2 Urotensins (osmoregulation & steroid)
<table>
<thead>
<tr>
<th>Homeostasis – Chapter 7</th>
<th>Homeostasis – Chapter 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Autonomic Nervous System – poor in agnathans but well developed in teleosts (along either side of spine) – controls involuntary functions</td>
<td>• Thermal regulation</td>
</tr>
<tr>
<td></td>
<td>• Cold blooded vs warm blooded</td>
</tr>
<tr>
<td></td>
<td>• Poikilotherm vs Homeotherm – fish change temp but water more stable</td>
</tr>
<tr>
<td></td>
<td>• Ectotherms vs Endotherms - Most = same temperature as water = ectotherms (most fish) v Endotherms (some fish) – temperature vs metabolic rate; eg high metabolic costs</td>
</tr>
<tr>
<td></td>
<td>• Endothermic Fish = Scombrids and Lamnidae (mackeral) &amp; Alopiidae (thresher) Sharks</td>
</tr>
<tr>
<td></td>
<td>• Heat lost at gills; bring body to external temperature; in tunas etc cooled blood to outside; counter-current; Rete mirabile; blood warmed by muscle activity and heat transferred to cool blood moving to muscles; oxygenated blood is warmed; heat not lost but returned to muscle.</td>
</tr>
<tr>
<td></td>
<td>• In thunniform swimming fish – more red cells medial, less heat loss</td>
</tr>
<tr>
<td></td>
<td>• Also rete mirabile on liver associated w/ gut</td>
</tr>
<tr>
<td></td>
<td>• Also warm parts of the CNS especially brains and eyes – &quot;regional endothermy&quot;</td>
</tr>
<tr>
<td></td>
<td>• Eye muscles have lost the ability to contract now produce heat;</td>
</tr>
<tr>
<td></td>
<td>• Also rete system near eyes;</td>
</tr>
<tr>
<td></td>
<td>• Acclimation (coping with temperature fluctuations)</td>
</tr>
<tr>
<td></td>
<td>• Metabolic rate can be dependent or independent on temperature; effects seasonality</td>
</tr>
<tr>
<td></td>
<td>• Heat Shock Proteins; Alternate enzymes systems (isozymes) vs alternate forms of enzymes from alternate gene forms (allozymes);</td>
</tr>
<tr>
<td></td>
<td>• Cellular or Tissue level changes - Muscles/heart/liver villi can all change</td>
</tr>
</tbody>
</table>
Homeostasis – Chapter 7

• Thermal regulation
• High and low temperature (coping with temperature extremes)
  • Water freezes at 0, seawater at –1.87 but densest at 4 degrees; fish freeze at -7 so freshwater fish are protected but salt water fish have problem
  • Supercooled and do not encounter ice crystals
  • Some = biological antifreeze (glycoproteins)
  • INCREASE CONCENTRATIONS OF OSMOLYTES;

Homeostasis – Chapter 7

• Thermal Preferences and habitat selection – select best habitat for growth and reproduction – good link of physiology and behavior/ecology;

Osmoregulation – 4 Strategies

• Osmoregulation; Most fish stenohaline (very narrow salt tolerance) but Diadromous (part freshwater part salt) fish (lampreys, salmon, eels) – Euryhaline (wide tolerance for salt)
• Anadromy – adults spawn in fresh – juvs to salt
• Catadromy – adults spawn at sea, move to fresh and return to sea to spawn
• Amphidromy – Spawning either freshwater or saltwater

Examples of Diadromous Fish

• Anadromous – Lampreys, sturgeons, herring, salmon, smelts, icefice, gobies, sea catfish, soles, sticklebacks, cods, sculpin
• Catadromous – Eels, scorpionfish, galaxiids, temperate basses, snooks, mullets, righteye flounders
• Amphidromous – grayling, whitebaits, galaxiids, herrings, sculpins, sandperches, sleepers, pipefish
Osmoregulation – 4 Strategies

• Four major strategies
• (1) Nothing – Hagfish – all marine and stenohaline (tolerate narrow range); Have salt concentration about equal to seawater – only vertebrate to do so.

2 – Marine elasmobranches and coelacanths
3 – Marine teleosts
4 – Freshwater teleosts

Osmoregulation – 4 Strategies

• Four major strategies
• (2) Marine elasmobranches and coelacanths = Inorganic salt concentrations equal about 1/3 seawater (like most verts) – but organic salts (Urea and trimethylamine Oxide TMAO) brings total salt concentration up to seawater

Freshwater vs. Saltwater
Osmoregulation – 4 Strategies

(3) Marine Teleosts – Internal salt concentration = 1/3 sea water – operates hypsomotically – lose water to diffusion
- Replace water by continually drinking then special cells (Chloride cells) in gill filaments & opercular skin epithelia eliminate salt via active transport

Osmoregulation – 4 Strategies

Marine Teleosts
- 1) Loses water through gills and skin
- 2) gains water and salt by drinking
- 3) Removes salt via chloride cells
- 4) Salt lost via feces
- 5) Salt and little water lost via minute urine
- 6) Fewer and smaller glomeruli; reabsorb glucose/proteins in convoluted tubules

Osmoregulation – 4 Strategies

(4) Freshwater teleosts and some elasmobranches = Hyperosmotically (blood conc greater than H2O) – they gain water by diffusion.
- Well developed kidneys excrete large amounts of dilute urine (0.33 body weight per day) – controlled by blood pressure; Salts are taken up primarily through the gills – ions pumped inwards – chloride cells

Osmoregulation – 4 Strategies

Freshwater teleosts
- 1) absorb water through gills and skin
- 2) obtain salts through “chloride” cells and with food
- 3) removes water via copious, dilute urine (5-12% body weight)
- Numerous large glomeruli and reabsorbs salts along convoluted tubules
Fig. 1 - Histochemical demonstration of Na+/K+ ATPase activity in gill filaments of L. malabaricus. Gill filaments stained with a specific antibody for Na+/K+ ATPase. Scale bar is 20 μm.

Chloride Cells