Endocrinology of Fish

MS I (Semester-II)

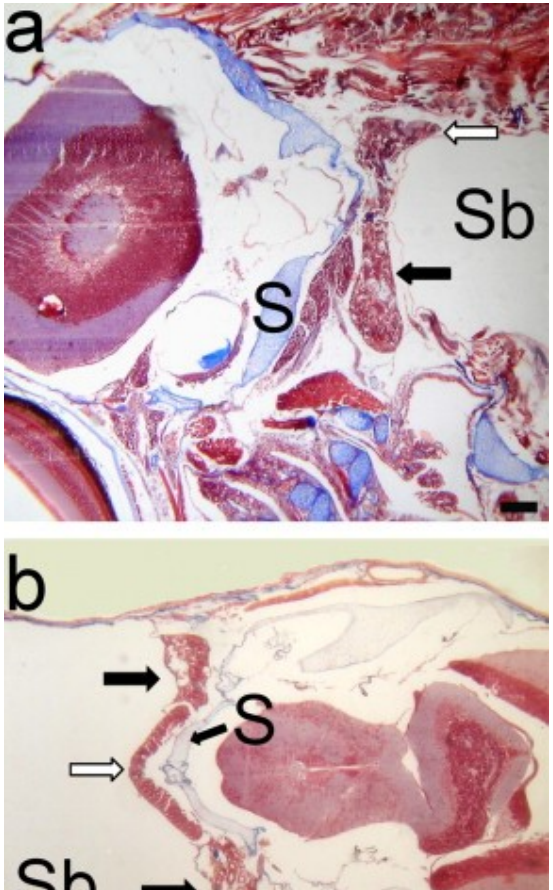
Maj/Zoo-S-406

Lecture – 16

Inter-renal Gland

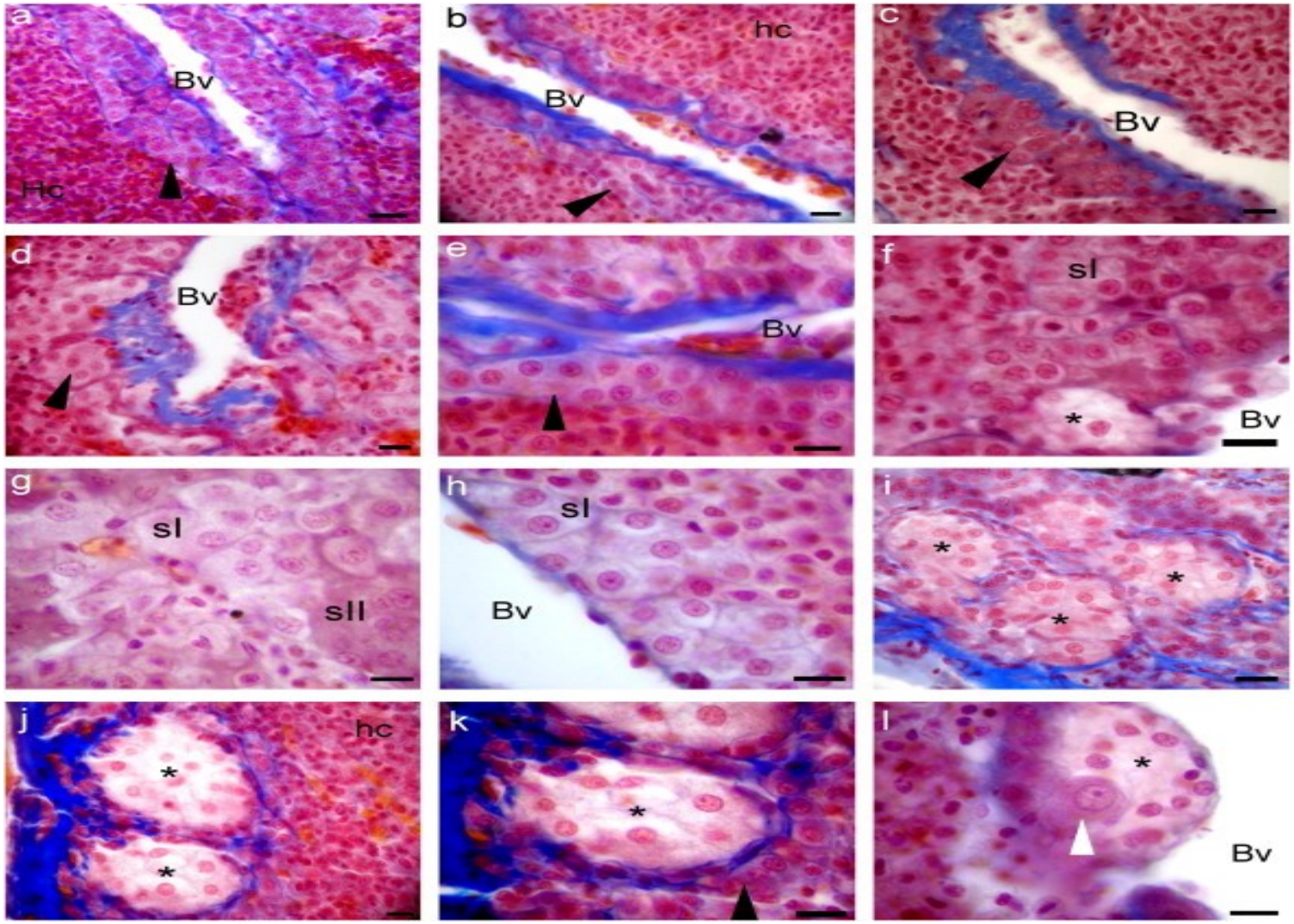
Interrenal Gland

- Adrenal homolog-2 types of cells



- Corticosteroid producing steroidogenic cells
- Mesodermal in origin
- Catecholamine producing chromaffin cells
- Neuroectodermal in origin
- Both cells are scattered along posterior cardinal vein of cephalic kidney (bony fish, cyclostomes)
- In elasmobranch, located near dorsally between two lateral lobes of kidney
- in lampreys and hagfishes, present along post cardinal vein in kidney or walls of heart and big veins
- Both cells can be intermingled or separate among different fish taxa

- Steroidogenic cells are arranged in groups or chords, separated from each other and fromthe parenchyma of hematopoietic cells by a thin layer of connective tissue
- smaller than chromaffin cells – are polygonal in shape (Fig. e–h).
- The nucleus is mostly spherical and basophilic, exhibiting at least one conspicuous nucleolus.
- cytoplasm appears acidophilic and spongy in varying degrees.
- In this sense, it is possible to distinguish two types of steroidogenic cells
- (1) large and polyhedral cells with spongy cytoplasm and clear cellular limits (Fig. e–h)
- (2) small and irregular cells, with little spongy cytoplasm and fuzzy cellular limits (Fig. g).



Interrenal gland in the posterior portion of the cephalic kidney (CK) of adult male Cichlasoma dimerus. (a–e) Cells arranged in chords (arrowheads) at the margins of some blood veins (Bv) – post-cardinal vein and their tributaries – surrounded by hematopoietic components (hc) are present in this portion of the CK; these chords are separated from the rest of the parenchyma by a thin layer of connective tissue. (f–h) Steroidogenic cells are arranged in chords; in particular, two types of steroidogenic cells could be detected: type I (sI), with spongy cytoplasm and clear cellular limits and type II (sII), exhibiting a less spongy cytoplasm and diffuse cellular limits. (i–l) Chromaffin cells are arranged in groups (⁄), also at the margins of blood veins (Bv) and surrounded by a thin layer of connective tissue that separates them from the hematopoietic components (hc); chromaffin cells are larger than the steroidogenic cells (black arrowhead), present fuzzy cellular limits and a pale cytoplasm

- Chromaffin cells are situated in groups of fewer than 10 cells just below the main veins (Fig. i–l).
- These cells are larger than the steroidogenic cells and exhibit a pale cytoplasm with very fuzzy cell boundaries; a large basophilic and spherical nucleus with a prominent nucleolus is a salient characteristic of these cells (Fig. k)

catecholamines

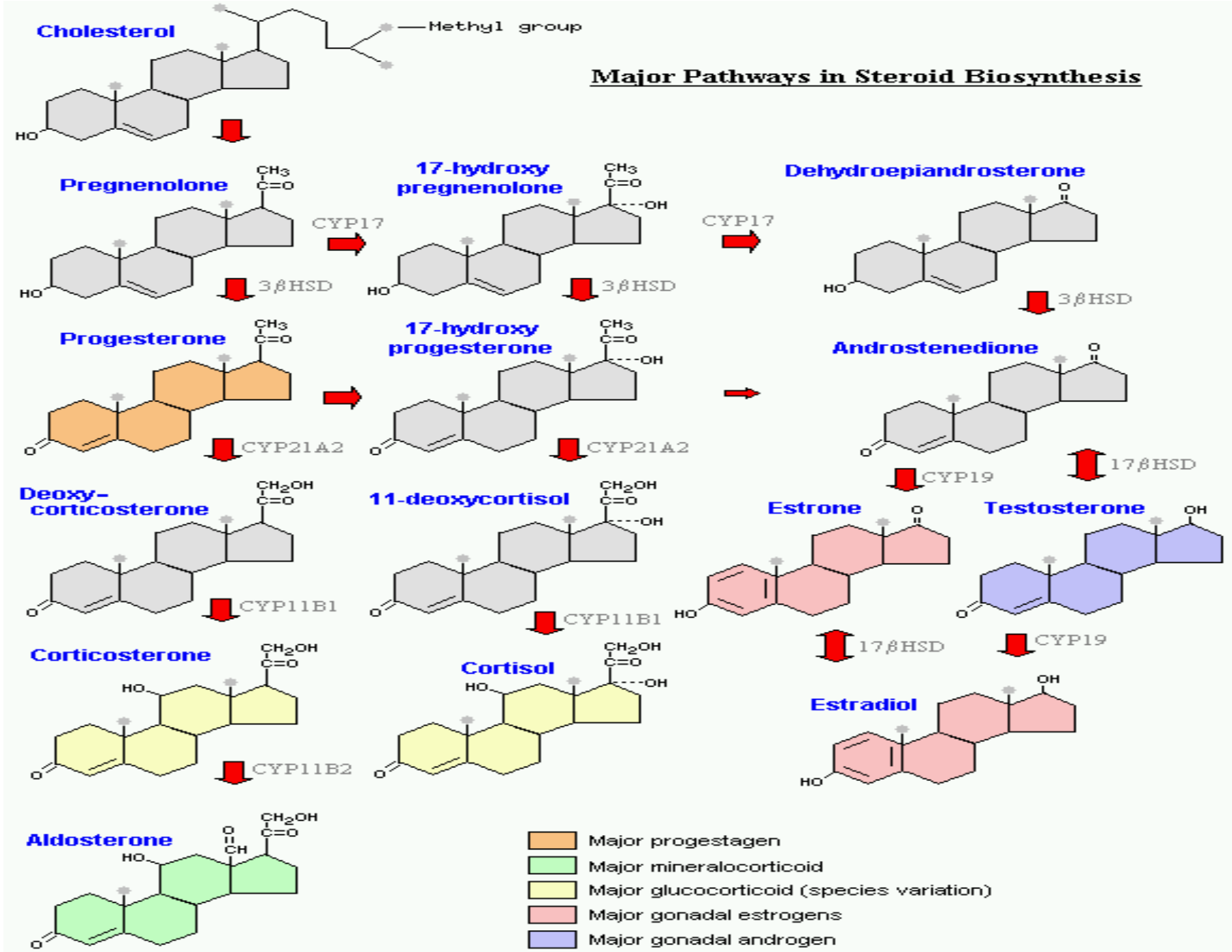
- Two catecholamines: adrenalin and nor adrenalin
- Dopamine is substrate.
- Tyrosine is hydroxylysed to form dihydroxyphenylalanine (DOPA) by action of enzyme tyrosine hydroxylase
- DOPA is converted into dopamine by enzyme DOPA-decarboxylase
- dopamine is Converted to noradrenalin by enzyme dopamine beta monooxygenase
- Phenylethanolamine N-methyl transferase converts noradrenalin to adrenalin
- Noradrenalin acts through alpha adrnergic receptors
- Adrenalin acts through both alpha and beta adrenergic receptors

Catecholamine action in osmoregulation

- in teleosts, plasma catecholamines increase the permeability of gill to water.
- act on ionic transfer across the gills
- most of the effects of stress on osmotic balance are mediated by adrenergic secretion that, in a short time, results in water or ionic overload, depending on whether fishes are held in fresh water or sea water.

Cortisol: dual action

- Cholesterol is the substrate
- Cholesterol can be made within the cell from acetyl CoA
- Cholesterol is also taken up by the cell in the form of low density lipoprotein
- LDL is a complex composed of cholesterol, phospholipids, triglycerides, and proteins (proteins and phospholipids make LDL soluble in blood).
- LDL is taken into cells via LDL receptors, and broken down into esterified cholesterol, and then free cholesterol


Cholesterol
Methyl group
Major Pathways in Steroid Biosynthesis
Pregnenolone
CYP17
17-hydroxy pregnenolone
CYP17
Dehydroepiandrosterone
3βHSD
3βHSD
3βHSD
Progesterone
17-hydroxy progesterone
Androstenedione
CYP21A2
CYP21A2
17βHSD
CYP19
Deoxy-corticosterone
11-deoxycortisol
Estrone
Testosterone
CYP11B1
CYP11B1
17βHSD
CYP19
Corticosterone
Cortisol
Estradiol
CYP11B2
Aldosterone
Major progestagen
Major mineralocorticoid
Major glucocorticoid (species variation)
Major gonadal estrogens
Major gonadal androgen

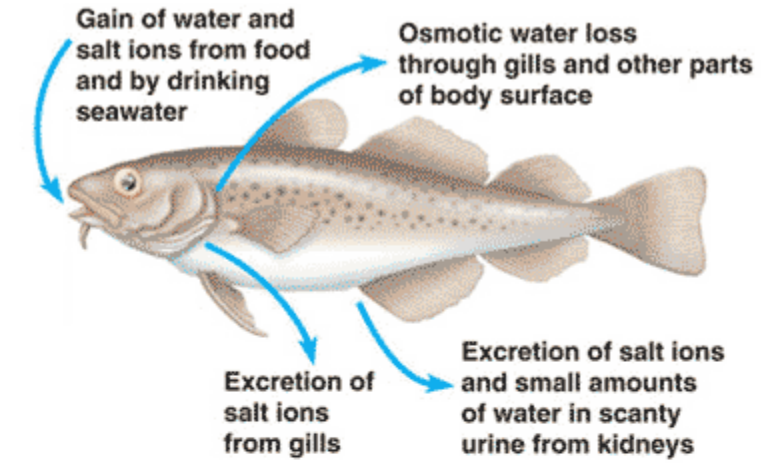
Cortisol: dual action

- most of the actions of ACTH are exerted through cortisol
- Act both as glucocorticoid and mineralocorticoid
- Mainly responds to stress and osmoregulation
- Teleosts have multiple copies of corticosteroid receptors, including two glucocorticoid receptors
- magnitude and duration of this hormonal response is influenced by various factors, including type and intensity of the stimulus
- Response is species specific

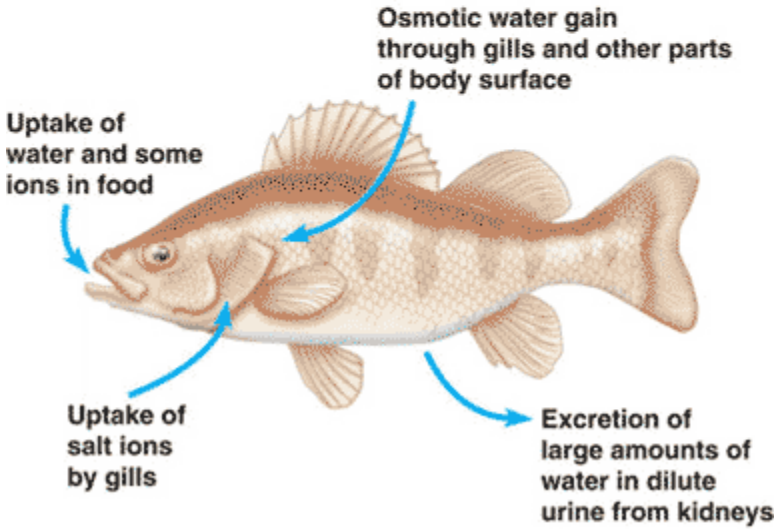
Glucocorticoid action

- Ligand unbound glucocorticoid receptor resides in the cytosol complexed with a variety of proteins including heat shock protein 90 (hsp90)
- cortisol diffuses through the cell membrane into the cytoplasm and binds to the glucocorticoid receptor resulting in release of the heat shock proteins
- A direct mechanism of action involves homodimerization of the receptor, translocation via active transport into the nucleus, and binding to specific DNA responsive elements activating gene transcription
- regulates the expression of anti-inflammatory proteins in the nucleus

Mineralocorticoid action



(a) Osmoregulation in a saltwater fish



(b) Osmoregulation in a freshwater fish

Mineralocorticoid action

- Role of other hormones
- growth hormone/insulin-like growth factor I axis is also important in seawater adaptation
- growth hormone acts in synergy with cortisol to increase seawater/salinity tolerance, at least partly through the upregulation of gill cortisol receptors.
- GH increases the number of chloride cells
- cortisol acts primarily on differentiation of chloride cells

- IGF-I and cortisol together stimulated gill Na+, K+ATPase activity to a greater extent than either hormone alone, but that this interaction was weaker than that for GH and cortisol
- Cortisol under some conditions may promote ion uptake and interacts with prolactin during acclimation to fresh water.
- In some species, thyroid hormones support the action of growth hormone and cortisol in promoting seawater acclimation

- Cortisol in FW increased the surface area of gill chloride cells and the influx of sodium and chloride
- individual chloride cells of tilapia in fresh water can rapidly develop the morphology characteristic of seawater chloride cells (Hiroi et al., 1999)
- suggesting that chloride cells are ‘bifunctional;’ that is, capable of rapidly changing from an ion uptake to an ion secretion mode.
- Similar changes are assumed in case of sodium pumps
- The absence of cortisol through interrenalectomy or hypophysectomy, will result in reduced levels of gill Na+, K+ATPase that is likely to result in partial or complete loss of capacities for both ion secretion and uptake

- Epinephrine acting through α2-adrenergic receptors is probably the most physiologically relevant inhibitor of chloride secretion in teleosts
- urotensin II , acetylcholine and prostaglandin E2 decrease chloride secretion in the opercular membrane
- Stimulation of β-adrenergic receptors results in a moderate increase in chloride secretion in opercular membrane