Topic 15: REFLEXES AND AN INTRODUCTION TO THE ENDOCRINE SYSTEM

I Reflexes = afferent – efferent with little or no interneuron activity

A Some examples (more in the lab)

1 stretch reflex
- a Afferent = information from stretch receptors in muscle spindles
- b Efferent = motor neuron (ipsilateral)
- c Allows rapid response to unwanted postural changes (faster than touch!)
- d What if you want or need a postural change?
  - i gamma motor neurons innervate muscle spindles
  - ii they re-set the stretch receptors during a voluntary movement

2 withdrawal reflex
- a Afferent = touch or pain receptor cell
- b Interneuron
- c Efferent = motor neuron (ipsilateral)
- d Allows rapid removal of extremities from hazard

3 crossed-extensor reflex
- a frequently occurs in conjunction with the withdrawal reflex
- b Afferent = touch or pain receptor
- c Efferent = contralateral motor neuron
- d immediately following withdrawal reflex, crossed-extensor reflex allows "catching of balance" when foot was withdrawn, or protection from danger when hand was withdrawn

B "Pattern-generator"

1 repetitive activities such as walking **can** be regulated on a "spinal" level" – no brain input needed

II General Principles of Endocrinology

A Two types of control systems: Nervous system vs Endocrine system

1 Nervous system coordinates rapid, precise responses & is especially important in interactions with external environment

2 Endocrine system tends to control activities that require duration, not speed

3 The two systems interact

B Endocrine system composed of ductless endocrine glands (do not have central cavities where substances accumulate; material is released directly into blood)

1 endocrine glands
- a are invaginations of epithelia
- b release product to inside of body; blood transports the product

2 Although not connected anatomically, constitutes a functional system

3 Response is based on presence of specific receptors for that hormone on the target tissue

4 Features of Endocrine System

- a single endocrine gland may produce more than one hormone
- b single hormone may be produced by more than one endocrine gland
- c single hormone may have more than one type of target cell
- d single target cell can be influenced by more than one hormone
- e a single chemical can be both a hormone and a neurotransmitter
- f some organs only produce hormones others produce hormones and perform other functions too

C Two general types of hormones

1 Tropic: act on another endocrine gland to produce its hormone (hormone regulating release of another hormone)

2 Non-tropic: act on target cell to produce an event

III Major Classification of Hormones

A General hormone chemistry

1 Small difference in chemical structure makes a big differences in function (eg., testosterone vs. estradiol)

2 Chemistry of hormone determine how they are synthesized, stored, secreted, transported, and how they function.

B Peptides

1 Are small proteins (short chains of amino acids)

2 Produced (in the rough ER) of pancreas, digestive tract, kidney, liver, thymus, heart

3 Dissolve in water (hydrophilic)
4 Transport in Blood: dissolved in plasma

C Amines
1 Derived from amino acid tyrosine
2 Two different types of amines
a Adrenal medulla
i catecholamines (epinephrine and NE)
ii *hydrophilic*
iii Transport in Blood: dissolved in plasma
b Thyroid amines
i T3 and T4
ii *hydrophobic*
iii Transport in Blood: bound to protein
3 Did not fall under any category so I'll put it here — melatonin, from the pineal is derived from tryptophan

D Steroids
1 Derived from cholesterol
2 Produced by: adrenal cortex, gonads, placenta during pregnancy
3 hydrophobic
4 Transport in Blood: bound to protein

IV General Function
A Concentration of hormones in blood affected by
1 rate of secretion
2 rate of removal (ie, inactivation by liver)
3 extent of binding to receptors (or binding to blood proteins)
4 rate of metabolic activation (some hormones modified by enzymes to make them active, or make them more active)

B Hydrophilic hormones (peptides and catecholamines and melatonin)
1 Can not pass through lipid bilayer of cell membrane
2 Bind to receptor on membrane
3 Trigger second messenger systems

C Hydrophobic hormones (steroids and thyroid hormones)
1 Are able to pass through lipid bilayer of membrane
2 Bind to receptors in the cell's nucleus

3 These receptors bind DNA and alter gene expression
4 Causes the formation of *new* proteins

Topic 16: ENDOCRINE SYSTEM, CONTINUED

I Brain as an endocrine gland = "central" endocrine system; secretes primarily tropic hormones, primary link between nervous system and endocrine system

A Pineal Gland
1 Located in center of brain, pine-cone shaped
2 Evolutionary origin as a photoreceptive organ
3 Produces melatonin
a Primary function of melatonin: regulate body's biological clock
b Steady decrease in melatonin production throughout lifetime
c Interacts w/ growth hormone, may regulate onset of puberty

B Hypothalamus and Pituitary
1 Pituitary located at base of hypothalamus
2 Hypothalamus and Posterior Pituitary
a Hypothalamus produces two peptide hormones (vasopressin and oxytocin) that are non-tropic and that we will discuss later in the course
b These two hormones made in hypothalamus, are stored in the posterior pituitary, and are released upon stimulation by the hypothalamus

3 Hypothalamus and Anterior Pituitary

a Anterior Pituitary Makes and Secretes 6 hormones; all but prolactin are tropic hormones
i growth hormone (GH; regulates overall body growth)
ii thyroid stimulating hormone (TSH; stay tuned)
iii Adrenocorticotropic hormone (ACTH; stay tuned)
iv follicle stimulating hormone (FSH)
v lutenizing hormone (LH)
vi prolactin (these last three have roles in regulating the reproductive system)

b Hypothalamus produces and releases hormones which stimulate or inhibit the release of the anterior pituitary hormones. We will discuss some of these in future lectures.

II Thyroid Gland

A Review structure

1 Two lobes of endocrine tissue joined by isthmus; looks like bowtie

2 Located over the trachea below the larynx

3 Secretory cells, also called follicular cells, are arranged into hollow spheres called follicles

4 Inside of follicles filled with colloid, which is the thyroid hormone synthesis and storage site.

B Synthesis of T3 and T4

1 Tyrosine, an amino acid, can be synthesized by body

2 Iodine must be ingested

a actively transported against steep concentration gradient into thyroid gland.

3 Two thyroid hormones synthesized within the colloid

a T3: triiodothyronine (triiodo means 3 iodines)

b T4: tetraiodothyronine (tetraiodo means 4 iodines)

C T3 and T4 in the Blood

1 90% of thyroid hormone released is T4, BUT

2 T3 is far more functionally potent

3 Most of secreted T4 is converted to T3 by cells at the site of its activity

4 T3 and T4 in blood are bound to plasma proteins

D Regulation of Thyroid function

1 Hypothalamus secretes Thyrotropin releasing hormone (TRH)

2 TRH stimulates anterior pituitary to produce Thyroid stimulating hormone (TSH) – this is the tropic hormone

3 TSH stimulated thyroid to produce T3 and T4 (which are non-tropic hormones)

4 Increased T3 and T4 reduce production of TSH (negative feedback loop)

E Effects of T3 and T4

1 Tends to be slow acting; takes hours or days to see effects of increased levels

2 Metabolic Rate: Increases

3 Heat Production: Increases

4 In general, very high levels of T3/T4 tend to favor consumption, rather than storage, of fuel
5 Sympathetic nervous system: E and NE are more effective when T3 is around
6 Required for CNS development, and CNS function in adults

F Abnormalities of thyroid function

1 Hypothyroidism from birth

2 Hypothyroidism in adult
a Causes
b Symptoms
c Treatment

3 Hyperthyroidism
a Causes
b Symptoms
c Treatment

III Adrenal Gland: General
A Two adrenal glands, one above each kidney
B Each adrenal actually two glands with different embryonic origins & with different functions
1 adrenal cortex: outer layer, secretes steroids
2 adrenal medulla: inner layer, secretes NE and Epi

IV Adrenal Gland: Adrenal Cortex

A Produces 3 adrenocortical steroids, all derived from cholesterol

B Each steroid synthesized in a separate part of adrenal cortex

C Mineralocorticoids
1 Primary one is aldosterone
2 Regulates electrolyte balance & blood pressure (we'll discuss later in course in detail)

D Glucocorticoids
1 Primary one is cortisol
2 Functions in the "Stress Response"
3 Increases concentration of blood glucose at the expense of protein and fat stores (more later)
4 increases effectiveness of other hormones
5 anti-inflammatory and immunosuppressive effects
6 regulation
a hypothalamus produces corticotropin releasing hormone (CRH); stress increases CRH production (diurnal rhythms also affect CRH production)
b CRH stimulates anterior pituitary to produce adrenocorticotropic hormone (ACTH)
c ACTH stimulates adrenal cortex to produce cortisol
d Cortisol levels inhibit ACTH and CRH production (two negative feedback loops)

E Sex steroids
1 adrenal cortex makes small quantities of both testosterone and estradiol in both males and females
2 also makes dihydroepiandrosterone (DHEA) in larger quantities
a plays a role in development of secondary sex characteristics in females
b can increase lean muscle mass and decrease fat (an "anabolic" steroid)
c is the precursor for both estradiol and testosterone

V Adrenal Gland: Adrenal Medulla

A Review
a epinephrine (80% of total release)
b norepinephrine (20% of total release)

B Effects of epinephrine/NE
1 Fight or flight response

a	increase in rate and strength of heart function; increase in blood pressure
b	blood shifted to muscles and heart
c	breathing more efficient
d	reduces digestive activity
e	Promotes state of CNS arousal/alertness
f	Adjusts eyes for distant vision

Topic 17: PHYSIOLOGY OF DRUG ADDICTION

I Addiction: A chronic, relapsing disease that results from the prolonged effects of drugs on the brain.

- A Affects the health of the individual
- B Affects public health, economics
- C Physical vs. psychological addiction
  - 1 Do dramatic withdrawal symptoms occur when individual stops taking a drug?
  - 2 But many highly addictive drugs are not nearly as likely to cause withdrawal symptoms as heroin, alcohol.
- D Essence of drug addiction: compulsive drug seeking and use, even in the face of negative health and social consequences

II General Principles of Physiological Aspects of Addiction

Disclaimer Any number of psychological and sociological factors contribute to addiction, and reducing such a highly complex behavior to a single gene/single process is an unwarranted oversimplification.

- A Addictive drugs generally act by binding neurotransmitter receptors, or affecting synapse in other ways
  - 1 Upon repeated stimulation, some aspect of cellular response is down-regulated (e.g. fewer receptors) to maintain homeostasis of that synapse (desensitization)
  - 2 In absence of stimulation, down-regulated cellular response is insufficient for normal cell function
  - 3 These effects in the brain can lead to increased CRH release and a generalized stress response
- B However, some addictive drugs do not have a well-defined interaction with specific receptors
- C Non-drugs can be as addictive as drugs

III The Dopamine Pleasure Hypothesis

- A Neurons in the ventral tegmental area (VTA; in brainstem) project to other sites in the brain, including the limbic system and the cerebrum
  - 1 These neurons release dopamine
  - 2 Dopamine is a “pleasure juice” – a variety of addictive drugs, from alcohol to heroin (as well as addictive behaviors), cause a huge release of dopamine from cells in the VTA.

3 Rat studies

a. Works for a variety of addictive drugs, including those that do not themselves affect dopamine neurotransmission

B Dopamine in schizophrenia and attention deficit disorder (ADD)

IV The Dopamine “Attention” Hypothesis