Another Efferent (outgoing) System

The spinal cord also sends out autonomic commands and is involved in autonomic reflexes.

Autonomic Nervous System (ANS)

- Nerves supplying organs, glands and blood vessels
- Function automatically, unconsciously
- Help maintain the internal milieu of body, meeting its moment to moment needs
- AKA “visceral nervous system”

Sympathetic Division - arouses body in response to stress/increased demands

- Increase HR & BP
- Increase respiration
- Dilate blood vessels to heart
- Increase blood flow to muscles
- Release adrenaline
- Release stored energy (glycogen)
- Dilate pupils
- Sweat to cool body
- Decrease blood to skin
- GI tract slows down; mouth dry

Parasympathetic Division - serves non-emergency, body maintenance functions, conserving & replenishing body reserves

- Decreases HR & BP
- Slows breathing
- Lubricates mouth, eyes
- Stimulates digestion and storing energy
- Constricts pupil
- Responsible for elimination

Sending an autonomic message requires a 2 neuron sequence
Sympathetic Nerves

- leave CNS at thoracic or lumbar levels ("thoracolumbar system")
- preganglionic neurons are SHORT, traveling to just outside the spinal column to a long “chain” or “trunk” of sympathetic ganglia.
- postganglionic neurons are long, traveling rest of the way to body organs, glands, & vessels.
- almost all release NE as their transmitter (except those to sweat glands)
- Sympathetic nerves usually respond in unison.

Parasympathetic Division

- leave CNS from the brain or from sacral cord ("craniosacral").
- preganglionic neurons are LONG and go all the way out to body organs to reach ganglia.
- postganglionic neurons are short, going from those ganglia to nearby organ/gland cells.
- All release ACh.
- Parasympathetic nerves tend to operate individually, as needed.

ANS Afferents

- Autonomic nerves also carry sensory fibers from organs to CNS
- These play a role in autonomic reflexes as well as in our conscious awareness of some bodily functions
- Localization of autonomic sensations is imprecise (e.g. referred pain phenomena discussed in pain topic)

An Autonomic Dysfunction: Raynaud’s Disease

- Over-reaction of sympathetic nerves to peripheral blood vessels to cold causing intense vasoconstriction, pallor, cyanosis and pain in fingers.
Raynaud's Induced Gangrene

Drug Manipulation of ANS

- Drugs which act like NE or make NE more available will produce sympathetic effects (asthma inhalers, amphetamine, cocaine are some "sympathomimetics").
- Drugs which block NE receptors will decrease sympathetic function (e.g. beta "blockers" to control blood pressure).

CNS-ANS Interaction

- The hypothalamus, brainstem reflex centers, & even frontal lobe centers help to coordinate & control ANS activity.
- Some autonomic reflexes are spinal reflexes & can function independent of the brain.
- Spinal injuries can damage:
  - descending voluntary control pathways (ANS "UMNs")
  - damage the "LMNs" of the ANS, causing loss of reflex responses

Drug Manipulation

- Drugs which act like ACh can be used to stimulate parasympathetic function.
- Drugs which block ACh receptors will decrease parasympathetic function (e.g. "anticholinergics" like atropine).

Autonomic Reflexes

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Reflex Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Direct light &amp; close eye reflex</td>
<td>Light stimulus to retina leads to contraction of pupil &amp; dilatation of iris</td>
</tr>
<tr>
<td>2</td>
<td>Tonic neck reflex</td>
<td>Neck flexion leads to contraction of eye muscles</td>
</tr>
<tr>
<td>3</td>
<td>Postural reflex</td>
<td>Postural change leads to adjustment of body position</td>
</tr>
<tr>
<td>4</td>
<td>Respiratory reflex</td>
<td>Respiration changes in response to external stimuli</td>
</tr>
<tr>
<td>5</td>
<td>Vasomotor reflex</td>
<td>Changes in blood pressure in response to external stimuli</td>
</tr>
<tr>
<td>6</td>
<td>Sweat gland reflex</td>
<td>Sweating occurs in response to external stimuli</td>
</tr>
<tr>
<td>7</td>
<td>Corneal reflex</td>
<td>Stimulation of cornea leads to closure of eye</td>
</tr>
<tr>
<td>8</td>
<td>Tonic leg reflex</td>
<td>Stimulation of leg muscles leads to contraction</td>
</tr>
<tr>
<td>9</td>
<td>Biliocolic reflex</td>
<td>Stimulation of liver leads to contraction of gallbladder</td>
</tr>
</tbody>
</table>

Constant Interaction Between Sympathetic & Parasympathetic to maintain internal balance
Spinal Shock

• Immediately following a spinal injury the cord below injury may “go into shock” and show little or no function for a period of time (1-6 weeks). As the shock wears off, spinal reflex functions (and perhaps some degree of other functions) will return.

Autonomic Dysreflexia After SCI

(med. emergency syndrome after upper cord injury)(after spinal shock wears off)

• Cervical or upper thoracic (T6 or above) spinal injury disrupts normal feedback between sympathetic & parasympathetic nerves.
• Bladder/bowel distension/irritation, skin irritation, uterine contractions, pain or air temperature changes can provoke uninhibited autonomic discharges (sym. below injury, parasymp. above) with dangerous hypertension.
• Signs: intense headache, sweating, hypertension

The Hypothalamus

• Small but highly specialized ventral region of diencephalon containing many nuclei
• Many hypothalamic cells are sensitive to special stimuli (hormones, glucose, sodium, temperature)
• Some hypothalamic cells release hormones rather than transmitters
Functions of Hypothalamus

- Involved in basic motivations (hunger, thirst, sex, keeping warm, sleep and biorhythms) & the related behaviors
- CNS center for autonomic controls
- CNS center for endocrine controls
- Part of limbic system - plays a role in emotional experience & expression and memory consolidation

Pituitary = 2 Glands in 1

- One part is a physical extension of the hypothalamus (neurohypophysis or Posterior Pituitary)
- One part developed from oral ectoderm (adenohypophysis or Anterior Pituitary)

Oxytocin - Paraventricular

ADH/Vasopressin - Supraoptic

The posterior pituitary is really the axon endings of hypothalamic neurons which release these hormones into the bloodstream instead of releasing neurotransmitter.

Oxytocin (from Paraventricular Hypothalamus)

Labor contractions, milk ejection, orgasmic contractions
Released in response to pleasurable touch; associated with bonding/affiliation/love
### Anti-Diuretic Hormone
(aka vasopressin)

- Allows kidney to produce concentrated urine by reabsorbing water.
- Without ADH you will have Diabetes Insipidus (weak, watery urine copiously produced, unable to conserve water so always thirsty)
- No relationship to Diabetes Mellitus

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### Anterior Pituitary

- No hypothalamic neurons extend down to AP
- Instead, hypothalamus regulates function of AP by secreting “releasing” and “inhibiting” hormones into the blood supply to the AP

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### Extremes of Hypothalamic Dysfunction

- Overeating (hyperphagia)—anorexia
- Polydipsia --- adipsia
- Precocious or inappropriate sexual function—absent sexual function
- Gigantism, acromegaly, dwarfism
- Altered autonomic, endocrine, temp regulation, biorhythms, sleep waking
- Mood swings, emotion extremes
Paleocortex Regions

The limbic system also includes the inner most regions of the cortex (immediately surrounding the brainstem and subcortical structures). This inner most cortex (or “paleocortex”) is evolutionarily more ancient than the neocortex we see on the surface of the brain. Some anatomists even consider this old cortex as a separate “lobe” – the limbic lobe – distinct from the overlying neocortex lobes.

Limbic Memory Regions

• Essential for the storage of new memories
  – hippocampus
  – mammillary bodies & medial thalamus
• Emotional aspects of memory
  – Amygdala
• Long-term memories
  out
cortex

http://www.youtube.com/watch?v=CL-0gfpf_6g

• Hippocampal damage – problems storing new declarative memories (semantic & episodic)
• Mammillary bodies & medial thalamus damage
  memory difficulties of Korskoff’s syndrome
• Damage to selective areas of cortex – may lose specific long term memories (like the names for things or the color of things)

• Limbic system regions also involved in emotional experience and expression
• Hypothalamus triggers bodily signs of emotion
• Amygdala particularly critical for recognizing and experiencing fear; also probably involved in aggressive/rage type emotions