Ch 6: PNS

1. Intro slide with objectives

2. Communication between CNS & PNS.
   > sensory info from receptors ascends the spinal cord to part of brain where interpreted
   > motor commands descend brain, spinal cord, and exit to PNS

3. Sensory (afferent) division of nervous system = 3 parts
   > Somatic sensory system = receive sensory info from skin, fascia, joints, skeletal muscles
   > Special senses = sensory info for sight, sounds, pressure, temp., taste
   > Visceral sensory system = sensory info from viscera

Motor (efferent) division of nervous system = 2 parts
   > Somatic (voluntary) motor system = control of skeletal muscles through *acetylcholine* (ACh) neurotransmitter
     secreted by somatic motor neuron, binds to *nicotinic cholinergic receptor* on skeletal muscle cells, opens
     Na+ channel to cause contraction.
   > Autonomic (involuntary) motor system = control of cardiac & smooth muscle, and glands.

   **QUEST: What are examples of smooth muscle in body?**
   = bladder, urethra, lining arteries and bronchioles, uterus, lining GI tract.

4. Go over diagram of parasympathetic vs sympathetic autonomic control of body. This will take a lot of time.
   > Parasympathetic = rest & digest. – body functions make sense when resting & digesting
     - Thoracic activities tend to slow down (heart rate & BP decrease, bronchoconstriction)
     - Abdominal activities tend to speed up (GI smooth muscle activity, secretions, and vasodilation of
       arteries to GI.
     - Thoracic & abdominal parasympathetic nerves = **Vagus nerves (you’re calm on vacation at Vagus!)**
   
     - Pelvic activities speed up – good time for urination and defecation.
     - Pelvic parasympathetic nerves = **Sacral nerves (soothing sacral nerves)**

   > Parasympathetic regulation is through ACh binding to muscarinic cholinergic receptors

   > Sympathetic = stress or fight/flight (what body functions make sense when your life is in danger???)
     - Thoracic activities that save your life = increased heart rate, bronchodilation (get in O2!)
     - Abdominal activities shut down – decreased GI peristalsis & secretions, vasoconstriction of arteries to
       GI (blood being diverted away to go to muscles, brain, & heart)
     - Vasodilation of arteries (smooth muscle) to skeletal muscles (can save your life)
     - Thoracic and abdominal sympathetic nerves = **Thoracic nerves (Tense you up)**

     - Pelvic activities slow down – inhibit urination & defecation.
     - Pelvic sympathetic nerves = **Lumbar nerves (Let’s get the hell out of here!)**

   > Sympathetic regulation is through epinephrine (adrenaline) binding to either Beta (β) or alpha (α)
     adrenergic receptors (adrenergic is for adrenaline)

     - **QUEST: How many hearts do you have?** = 1, heart muscle has Beta 1 adrenergic receptors
     - **QUEST: How many lungs do you have?** = 2, bronchiole smooth muscle has Beta 2 adrenergic receptors.
     - Beta 2 adrenergic receptors also on smooth muscle of arteries supplying skeletal muscles.
     - **QUEST: What happens to an apple when you eat it?** = you digest it. α is for apple, and all
       things GI have α adrenergic receptors (GI smooth muscle, glands, & muscle of arteries to GI)
6. This blank flow diagram and a KEY is found on the lecture syllabus for Ch 6.

For autonomic sympathetic regulation of body functions through epinephrine (a.k.a. adrenaline):
>
> **β1 adrenergic receptor** – found on heart muscle to increase heart rate.
> **β2 adrenergic receptor** – found on bronchiole smooth muscle (for bronchodilation) and smooth muscle of arteries (going to skeletal muscles for vasodilation)
> **α adrenergic receptor** – found on GI smooth muscle (to decrease peristalsis), GI glands (decrease secretion), and smooth muscle of arteries going to GI for vasoconstriction

7. Fig 6.12 – review parasympathetic nerves (Vagus) and their effect on HR, bronchioles, GI activity, Sacral nerves & urination & defecation., Thoracic nerves and effect on HR, bronchioles, GI, and Lumbar nerves & urination/defecation

8. Fig 6.10 – review same things again.

9. Fig 6.13 – review same things again for parasympathetic control through ACh & nicotinic cholinergic receptors on skeletal muscles for voluntary movement, and ACh and muscarinic cholinergic receptors on cardiac and smooth muscle for autonomic functions.
10. Table 6.2 – Review sympathetic vs parasympathetic regulation on functions marked by X.

> QUES: What receptors are involved for epinephrine in?
  - increased heart rate? (= β1 adrenergic)
  - Bronchodilatation? (= β2 adrenergic)
  - decreased GI peristalsis & secretion (= α adrenergic)

> QUES: What receptors for ACh are involved with heart rate, bronchioles, GI? = muscarinic cholinergic

<table>
<thead>
<tr>
<th>Organ or Function Affected</th>
<th>Sympathetic Effects</th>
<th>Parasympathetic Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>Increased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>Increased</td>
<td>Slightly decreased</td>
</tr>
<tr>
<td>Urinary bladder</td>
<td>Increased sphincter tone</td>
<td>Decreased sphincter tone (for urinating)</td>
</tr>
<tr>
<td>Intestinal contractions</td>
<td>Decreased</td>
<td>Increased</td>
</tr>
<tr>
<td>Lungs</td>
<td>Dilation of bronchioles</td>
<td>Constriction of bronchioles</td>
</tr>
<tr>
<td>Pupils</td>
<td>Dilation</td>
<td>Constriction</td>
</tr>
<tr>
<td>Sexual function</td>
<td>Ejaculation and orgasm</td>
<td>Erection</td>
</tr>
<tr>
<td>Sweat glands</td>
<td>Sweating</td>
<td>No effect</td>
</tr>
<tr>
<td>Lacrimal glands</td>
<td>No effect</td>
<td>Tearing</td>
</tr>
<tr>
<td>Parotid glands</td>
<td>No effect</td>
<td>Salivation</td>
</tr>
</tbody>
</table>
11. Table 6.3 – review sympathetic effects with epinephrine on following marked X

<table>
<thead>
<tr>
<th>Organ</th>
<th>Adrenergic Effects of Sympathoadrenal System</th>
<th>Adrenergic Receptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye</td>
<td>Contraction of radial fibers of the iris dilates the pupils</td>
<td>$\alpha_1$</td>
</tr>
<tr>
<td>Heart</td>
<td>Increase in heart rate and contraction strength</td>
<td>$\beta_1$, primarily $\beta_1$</td>
</tr>
<tr>
<td>Skin and viscera</td>
<td>Arterioles constrict due to sympathetic nerve activity</td>
<td>$\alpha_1$</td>
</tr>
<tr>
<td>Skeletal muscle</td>
<td>Arterioles dilate due to hormone epinephrine</td>
<td>$\beta_2$</td>
</tr>
<tr>
<td>Lungs</td>
<td>Bronchioles (airways) dilate due to smooth muscle relaxation</td>
<td>$\beta_2$</td>
</tr>
<tr>
<td>Stomach and intestine</td>
<td>Contraction of sphincters slows passage of food</td>
<td>$\alpha_1$, $\alpha_1$</td>
</tr>
<tr>
<td>Liver</td>
<td>Glycogenolysis and secretion of glucose</td>
<td>$\alpha_2$, $\beta_2$</td>
</tr>
</tbody>
</table>

See Clinical App ONLINE: Beta blockers.

B1 agonist = Dobutamine (makes Da heart beat faster!) for heart failure, ↑ BP & cardiac output

B1 & B2 agonist = isoproterenol
↑ BP & cardiac output & bronchodilate

General B-blocker = Propanolol
↓ BP and bronchoconstrict

B1-specific blocker = Atenolol (think it’s been altered or attenuated to be specific)
↓ BP with no bronchiole effect

B2 agonist = Terbutaline & Albuterol bronchodilate for asthmatics

12. – Review slide

13. **Part 2: Junction between CNS (spinal cord) and PNS**
> PNS communicates between the CNS and remainder of the body
> Consists of: 12 pairs cranial nerves
> 31 pairs spinal nerves
> Most (except three of the cranial nerves) carry axons of both sensory and motor neurons
14. **Review of Cranial Nerves:**

What is the mnemonic devices for remember the list of 12 pairs cranial nerves?

Oh Once One Takes The Anatomy Final Very Good Vacations Are Heavenly

What is the mnemonic devices for remember which cranial nerves are sensory (S), motor (M), or both (B)?

Some Say Marry Money But My Brother Says Big Brains Matter Most

***Mistake in textbook table!

<table>
<thead>
<tr>
<th>Nerve Number and Name</th>
<th>Composition</th>
<th>Some Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Olfactory</td>
<td>S</td>
<td>Olfaction (smell)</td>
</tr>
<tr>
<td>II Optic</td>
<td>S</td>
<td>Vision</td>
</tr>
<tr>
<td>III Oculomotor</td>
<td>M</td>
<td>Serves muscles of the eye</td>
</tr>
<tr>
<td>IV Trochlear</td>
<td>M</td>
<td>Serves the superior oblique eye muscle</td>
</tr>
<tr>
<td>V Trigeminal</td>
<td>B</td>
<td>Sensory from face and mouth; motor to muscles of mastication (chewing)</td>
</tr>
<tr>
<td>VI Abducens</td>
<td>M</td>
<td>Serves the lateral rectus eye muscle</td>
</tr>
<tr>
<td>VII Facial</td>
<td>B</td>
<td>Serves the muscles of facial expression, lacrimal glands, and salivary glands</td>
</tr>
<tr>
<td>VIII Vestibulocochlear</td>
<td>S</td>
<td>Equilibrium and hearing</td>
</tr>
<tr>
<td>IX Glossopharyngeal</td>
<td>M</td>
<td>Serves the pharynx (throat) for swallowing, posterior third of tongue, and parotid salivary gland</td>
</tr>
<tr>
<td>X Vagus</td>
<td>B</td>
<td>Sensations from visceral (internal) organs, and parasympathetic motor regulation of visceral organs</td>
</tr>
<tr>
<td>XI Accessory</td>
<td>M</td>
<td>Serves muscles that move head, neck, and shoulders</td>
</tr>
<tr>
<td>XII Hypoglossal</td>
<td>M</td>
<td>Serves muscles of the tongue</td>
</tr>
</tbody>
</table>

15 & 16. **31 Pairs of Spinal Nerves in PNS**
- Sensory tracts (axons) enter spinal cord at dorsal side.
- Motor tracts (axons) exit spinal cord at ventral side.
- Sensory receptors signal enters dorsal spinal cord, ascends to part of brain where interpreted.
- Motor neurons send signal from brain, down spinal cord, exits ventral side.

17 & 18. **31 Spinal Nerve Pairs divided into:**
1. Cervical spinal nerves (C1-C8)
2. Thoracic spinal nerves (T1-T12)
3. Lumbar spinal nerves (L1-L5)
4. Sacral spinal nerves (S1-S5)
5. Coccygeal spinal nerve (Co1)

19. These spinal nerves branch out into dorsal & ventral rami, and form 4 nerve plexuses.

> **Dorsal rami of thoracic spinal nerves for:**
  motor control of erector spinae muscles & sensation of the back.
> Ventral rami of thoracic nerves = intercostal nerves:
   - motor control of intercostal muscles
   - motor control of abdominal muscles.
   - sensory info for skin covering those areas.

   4. Sacral Plexus (L5 – S5)

20. **Cervical Plexus (C1-C4)**
   - motor control of deep neck muscles
   - sensation in neck skin.
   Phrenic nerve of cervical plexus = C3, C4, & C5 has motor control of diaphragm!
   “The primary danger of a ‘broken neck’ is that the phrenic nerve may have been severed above C3, leading to paralysis, cessation of breathing and death ...”

21. **Brachial plexus (C5 – T1)** *(Actual muscles don’t need to be memorized)*
   - motor control of muscles of shoulder/arm
   - sensory perception in skin of those areas.
   1) **Musculocutaneous nerve** – motor control of arm & forearm flexors.
      Ex: biceps brachii, brachialis, coracobrachialis
   2) **Axillary nerve** – motor control of shoulder muscles.
      Ex. deltoide muscle
   3) **Radial nerve** – motor control of extensor muscles of the arm, forearm & hand.
      Ex. triceps brachialis, anconeus, brachioradialis, extensor carpi radialis longus and brevis
   4) **Median nerve** – motor control of flexor muscles in forearm & several muscles in lateral hand.
      Ex. Palmaris longus, flexor carpi radialis, flexor digitorum superficialis
   5) **Ulnar nerve** – motor control of flexor carpi ulnaris muscle & intrinsic hand muscles.

22. **Lumbar plexus (L1 – L4)**
   - motor control of muscles lower abdomen and antero-medial thigh.
   - sensory perception of those areas.
   1) **femoral nerve** - innervates the anterior thigh muscles, lower abdomen, buttocks.
      Ex. Quadriceps femoris (vastus lateralis, vastus medialis, vastus intermedius, and rectus femoris)
   2) **obturator nerve** - innervates medial thigh adductor muscles.
      Ex. Adductor magnus, adductor longus, adductor brevis, gracilis.

23. **Sacral plexus (L4 – S5)**
   - Motor control of posterior thigh (hamstrings) and posterior leg.
   - Sensation in those areas.
   Leads to **sciatic nerve** - largest nerve of the human body!
   Ex. Of hamstrings = biceps femoris, semitendinosus, semimembranosus
   - Sciatic damage leads to inability to extend hip and flex the knee --> “sciatica”.

-Sciatic subdivides in the popliteal region:
  i) **Common fibular nerve** – motor control lateral leg and foot dorsiflexors & everters
     - damage leads to inability to dorsiflex the foot or “footdrop”.
     Ex. Extensor digitorum longus, extensor hallucis longus, fibularis longus & brevis.
  ii) **Tibial nerve** – motor control of posterior leg and foot plantar flexors.
     - damage leads to inability to plantar flex and invert the foot --> “shuffling gait”;
     Ex. Gastrocnemius, soleus, flexor digitorum longus, flexor hallucis longus.