Case Study #1: Nick

- 56 year old diabetic
- Complains of (symptoms)
  - Burning and prickling sensations in both feet
  - Clumsiness
  - Dizziness when sitting and standing
  - Fatigue
  - “eyes get funny”
- Test results (signs)
  - Biceps tendon and triceps tendon reflexes normal
  - Patellar tendon reflex weak
  - Decreased sensation on bottom of feet
  - Decreased muscle strength in feet
  - Babinski sign
  - Achilles reflex weak
  - Papillary light reflex normal

Which symptoms/signs are relevant to the nervous system?

Classify each of the reflex tests performed as
- Cranial or spinal
- Somatic or autonomic
- Ipsilateral, contralateral, or bilateral

Are his symptoms/signs sensory, motor, or both?

Are his symptoms/signs most likely caused by peripheral nerve damage or a lesion in the central nervous system? Why or why not?

Is the somatic nervous system or autonomic nervous system involved? Why?

...three months later

- Symptoms
  - Lightheadedness and dizziness
  - Vomiting
  - Constipation
  - Loss of consciousness
- Questions
  - Are these symptoms sensory or motor or both
  - Do these symptoms involve the somatic or autonomic nervous system?
  - Which division of the autonomic nervous system is affected and therefore causing the GI problems?
  - How does the autonomic nervous system control blood pressure?

Autonomic Nervous System and Visceral Reflexes
Overview Autonomic NS
Hypothalamus Is Major Control Center

- Input: emotions and visceral sensory information
- Output: to nuclei in brainstem and spinal cord
  - Two Principle motor divisions
    - Sympathetic (thoracolumbar)
    - Parasympathetic (craniosacral)
  - Dual innervation: most internal organs are innervated by both sympathetic and parasympathetic fibers
Physiological Effects of the ANS

- Most body organs receive **dual innervation**
  - Innervation by both sympathetic & parasympathetic
- **Hypothalamus** regulates balance (tone) between sympathetic and parasympathetic activity levels
- Some organs have only sympathetic innervation
  - Sweat glands, adrenal medulla, arrector pili mm & many blood vessels
  - Controlled by regulation (tone) of the sympathetic system

Sympathetic Responses

- Physical or emotional stress
  - Ex: exercise, labor, excitement, fear....
- Alarm reaction = flight or fight response
Sympathetic Responses

- Physical or emotional stress
- Alarm reaction = flight or fight response
  - Dilation of pupils
  - Increase of heart rate, force of contraction & BP
  - Decrease in blood flow to nonessential organs
  - Increase in blood flow to skeletal & cardiac muscle
  - Airways dilate & respiratory rate increases
  - Blood glucose level increase
  - Increased sweat gland activity
- Long lasting due to lingering of NE in synaptic gap and release of norepinephrine by the adrenal gland

Parasympathetic Responses

- Enhance “rest-and-digest” activities
- Mechanisms that help conserve and restore body energy during times of rest
- Normally dominate over sympathetic impulses
- SLUDD type responses and 3 “decreases”
  - Salivation, lacrimation, urination, digestion, defecation
  - Heart rate, diameter airways, diameter pupils

Autonomic or Visceral Reflexes

- Autonomic reflexes occur over autonomic reflex arcs
  - Components of that reflex arc:
    - Sensory receptor
    - Sensory neuron
    - Integrating center
    - Pre & postganglionic motor neurons
    - Visceral effectors
- Subconscious sensations and responses
  - Changes in blood pressure, digestive functions etc
  - Filling & emptying of bladder or defecation

ANATOMY OF AUTONOMIC NERVOUS SYSTEM
The Autonomic Nervous System

- Includes
  - All sensory neurons that transmit impulses from internal (visceral) organs to the CNS
  - All motor neurons that transmit impulses from the CNS to
    - Smooth muscle
    - Cardiac muscles
    - Glands

Sensory Pathways

- **First order neurons**: conduct impulses from somatic receptors into the spinal cord and brain stem
- **Second order neurons**: conduct impulses from the spinal cord and brain stem to the thalamus
- **Third order neurons**: conduct impulses from thalamus to the cerebral cortex
**Autonomic Versus Somatic NS**

**Autonomic Motor Neurons**

- **Preganglionic neuron**
  - Cell body in brain or spinal cord
  - Axon is myelinated type B fiber that extends to autonomic ganglion

- **Postganglionic neuron**
  - Cell body lies outside the CNS in an autonomic ganglion
  - Axon is unmyelinated type C fiber that terminates in a visceral effector

**Divisions of the ANS**

- 2 major divisions
  - Parasympathetic
  - Sympathetic

- Dual innervation
  - One speeds up organ
  - One slows down organ
  - Ex: Heart

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**Autonomic Motor Neurons**

- Motor autonomic pathways consist of 2 neurons
  - Preganglionic neuron
  - Postganglionic neuron

- Principle divisions
  - Sympathetic (thoracolumbar)
  - Parasympathetic (craniosacral)

- Dual innervation: most internal organs are innervated by both sympathetic and parasympathetic fibers
Ganglia & Plexuses

- Cardiac plexus
- Pulmonary plexus
- Celiac (solar) plexus
- Superior mesenteric plexus
- Inferior mesenteric plexus
- Hypogastric plexus
- Renal plexus

Structures of Sympathetic NS

- Preganglionic cell bodies at T1 to L2
- Rami communicantes
  - White ramus = myelinated = preganglionic fibers
  - Gray ramus = unmyelinated = postganglionic fibers
- Postganglionic cell bodies
  - Sympathetic chain (trunk) ganglia along the spinal column
  - prevertebral (collateral) ganglia at a distance from spinal cord
    - Celiac ganglion
    - Superior mesenteric ganglion
    - Inferior mesenteric ganglion
Locations of Autonomic Ganglia

- **Sympathetic Ganglia**
  - *trunk (chain) ganglia* near vertebral bodies (above diaphragm)
  - *prevertebral (collateral) ganglia* near large blood vessel in gut (below diaphragm)
    - celiac
    - superior mesenteric
    - inferior mesenteric

- **Parasympathetic Ganglia**
  - terminal ganglia in wall of organ

Circuitry of Sympathetic NS

- **Divergence** = each preganglionic cell synapses on many postganglionic cells
- Mass activation due to divergence
  - Multiple target organs
  - Fight or flight response explained
- **Adrenal gland**
  - Modified cluster of postganglionic cell bodies that release epinephrine & norepinephrine into blood

Anatomy of Parasympathetic NS

- Preganglionic cell bodies found in
  - 4 cranial nerve nuclei in brainstem (III, VII, IX, X)
  - S2 to S4 spinal cord
- **Postganglionic cell bodies in terminal ganglia**
  - In or near wall of effector organ
**The Autonomic Nervous System**

**Ganglia can act either**

- Automatic relay stations
- Integrating centers
  - Sympathetic ganglia
  - Prevertebral ganglia
  - Terminal ganglia

**ANS Neurotransmitters**

- Classified as either cholinergic or adrenergic neurons based upon the neurotransmitter released

- Adrenergic

- Cholinergic

**Draw and label 4 reflex arcs**

1. Sympathetic NS from baroreceptors in carotid artery to the Heart
2. Sympathetic NS from stretch receptors in bladder to smooth muscle in the Bladder
3. Parasympathetic NS from baroreceptors in carotid artery to the Heart
4. Parasympathetic NS from stretch receptors in bladder to smooth muscle in the Bladder

**Be sure to include:**
- Sensory pathway
- Where does it exit
- Name of the neurons
- Name of the ganglia
- White vs gray rami communicantes
- Dorsal vs ventral rami
- Name of the nerve it travels on
Cholinergic Neurons and Receptors

- Excites or inhibits depending upon receptor type and organ involved
- **Nicotinic** receptors are found on dendrites & cell bodies of autonomic postganglionic neurons and at NMJ
- **Muscarinic** receptors are found on plasma membranes of all parasympathetic effectors

Adrenergic Neurons and Receptors

- Excites or inhibits organs depending on receptors
  - Alpha1 and beta1 receptors produce excitation
  - Alpha2 and beta2 receptors cause inhibition
  - Beta3 receptors (brown fat) increase thermogenesis
- NE lingers at the synapse until enzymatically inactivated by monoamine oxidase (MAO) or catechol-o-methyltransferase (COMT)

1. Why does smoking have the following side effects?
   - Increased blood pressure and heart rate
   - Tremor
2. The heart has B₁ receptors. What happens if you stimulate the sympathetic NS?
3. Which receptors do asthma medications target?
The Autonomic Nervous System

• On your 4 reflex arcs
  1. Sympathetic NS to the **Heart**
  2. Sympathetic NS to the **Bladder**
  3. Parasympathetic NS to the **Heart**
  4. Parasympathetic NS to the **Bladder**

• Be sure to add
  – Neurotransmitters
  – Receptors

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…three months later

• Symptoms
  – Lightheadedness and dizziness
  – Vomiting
  – Constipation
  – Loss of consciousness

• Questions
  – Which motor division of the autonomic nervous system is damaged and therefore causing the GI problems?
  – How does the autonomic nervous system increase blood pressure? — draw and label the reflex arc
Hospital ICU

• Signs
  – Profuse sweating
  – Rapid heart beat and respiratory rate
  – Elevated blood pressure
  – Hoarse
  – Elevated blood sugar

• Tests
  – Slowed pupillary light reflex
  – Limited pain sensation
  – Biceps tendon reflex normal
  – Patellar tendon reflex weak

Hospital ICU

• Questions
  – Which structures that receive autonomic innervation were involved in Nick’s symptoms?
  – After passing out and becoming comatose, Nick was sweating profusely, had a rapid heart rate and respiratory rate, and elevated blood pressure. Which area of the brain interacts with the autonomic nervous system during physical stress to initiate these responses?
    • Which nerve(s) mediated these symptoms?
  – Nick has digestive symptoms indicating reduced gastrointestinal mobility.
    • What autonomic receptors are most likely involved in relaxing the organ walls?

Hospital ICU

• What is the overall cause of Nick’s problem?
  – Why?