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## Module 3: Neuroscience and Behavior

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### NEURONS

The building blocks of all behaviors and mental processes

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#### Parts of a neuron

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- ▶ Cell Body
- ▶ Semipermeable cell membrane
- ▶ Leakage channels
- ▶ Gated channels
- ▶ Dendrites
- ▶ Axon

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- ▶ Axon hillock
- ▶ Terminal branches
- ▶ Knobs (bouton)
- ▶ Myelin sheath
- ▶ Synaptic gap

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#### Ion: a molecule with an electrical charge (+ or -)

- ▶ Sodium: Na<sup>+</sup>
  
- ▶ Potassium: K<sup>+</sup>
  
- ▶ Calcium: Ca<sup>+</sup>

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#### Resting potential in a neuron

- ▶ When a neuron is not firing, the outside of the semipermeable membrane contains more positive ions than the inside. The resting potential of the inside is negative:  
- 70 millivolts

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#### Graded potentials: nudges from previous neurons

- ▶ When previous neurons fire, they cause the the Na<sup>+</sup> gates in the next neuron to open, allowing Na<sup>+</sup> to rush in through the semipermeable cell membrane.
  
- ▶ This rushing in of positive sodium ions causes the inside of the cell membrane to become slightly less negative: about -60 millivolts.

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#### Graded potentials, continued

- ▶ Graded potentials are usually short-lived: they move a few millimeters down the

dendrite and then they die out, BUT. . .

- 8  One large graded potential or several small graded potentials can change the inside charge to:

-55 millivolts

- 9  -55 millivolts inside the cell membrane is called Threshold Point.

▶ The axon hillock initiates an Action Potential: the actual firing of the neuron.

- 10  What happens during an action potential?

▶ Na<sup>+</sup> gates open again and Na<sup>+</sup> freely enters the neuron.

▶ So much Na<sup>+</sup> enters that the inside of the semipermeable membrane becomes de-polarized—it loses its electrical charge.

▶ Eventually the inside becomes +30 mv: it has reversed its polarity.

- 11  What happens when the inside reaches +30 mv?

▶ The Na<sup>+</sup> gates close

▶ The K<sup>+</sup> gates open and K<sup>+</sup> flows out of the neuron.

▶ The neuron returns to its resting potential of -70 mv.

▶ The sodium/potassium pump pumps Na<sup>+</sup> and K<sup>+</sup> back to their original positions.

- 12  An action potential

▶ Is an "all or nothing" response.

▶ Moves in waves, section by section down the neuron

▶ Can not jump over the 1/1,000,000 inch of the synaptic gap.

- 13  Synaptic Transmission: What happens at the knobs and the synaptic gap????

- 14  When the action potential reaches the knobs. . .

▶ Ca<sup>+</sup> gates open in the knobs and Ca<sup>+</sup> flows in.

- ▶ The presence of  $\text{Ca}^{+}$  in the knobs causes the synaptic vesicles to release their neurotransmitters into the synaptic gap.

15  When neurotransmitters are released into the synaptic gap.

. . .

- ▶ Some fit on receptor sites on the next neuron like keys in a lock, causing a graded potential to begin.
- ▶ Some return to the knob through the reuptake sites and are reused.
- ▶ Some return to the knob through the reuptake sites and are destroyed by enzymes inside the knob.

16  Neural messages can travel  
2 – 200 miles per hour!!

17  Saltatory conduction: from the Latin saltare: to jump

18  The Myelin Sheath

- ▶ Made of white fatty cells called glial cells wrapped around the axon like a jelly roll.
- ▶ Gaps in the myelin sheath are called Nodes of Ranvier. This is where the bare axon is exposed.

19  In a myelinated axon, sodium gates occur only at the Nodes..

20  Since it can only fire at the nodes, the action potential jumps from one node to another, traveling much faster than it would in an unmyelinated axon.

21  Refractory periods

- ▶ Absolute refractory period: The neuron cannot fire again because the  $\text{Na}^{+}$  gates are open and it is in the middle of firing.
- ▶ Relative refractory period: When the  $\text{Na}^{+}$  gates are closed and the  $\text{K}^{+}$  gates are open. The neuron can fire during this period if there is a strong stimulus.

- 22  Neurons fire faster during loud sounds, lights, tastes, pain, etc. because they are firing during the relative refractory period.
- 23  Neurotransmitters
- ▶ Some cause the next neuron to fire while others cause it to stop firing.
- 24  Types of neurotransmitters
- ▶ Dopamine
  - ▶ Serotonin
  - ▶ Norepinephrine
  - ▶ Gamma-aminobutyric acid (GABA)
  - ▶ Acetylcholine
- 25  Parts of the Nervous System
- 26  The Central Nervous System
- ▶ Made up of the brain and spinal cord
  - ▶ Information travels to and from the CNS through
    - Sensory neurons
    - Interneurons
    - Motor neurons
- 27  The spinal cord can control simple reflex responses on its own, saving time in a possible emergency.
- 28  The Peripheral Nervous System
- ▶ All the neurons outside the CNS.
  - ▶ Links the CNS with the rest of the body
- 29  The Peripheral Nervous system has 2 parts:
- ▶ The Autonomic Nervous System: controls the automatic functions of the body such as heartbeat, breathing, digestion.
    - the sympathetic division
    - the parasympathetic division
- 30  The Peripheral Nervous System, Part 2

- ▶ The Somatic Nervous System: Carries information to the CNS about
  - voluntary muscle movement
  - information coming from the senses.