Maintaining Dynamic Equilibrium II

Cells, tissues, organs, and organ systems help organisms maintain a biological balance. The nervous system is one of ten systems that has to be properly functioning to help maintain homeostasis. Conditions inside the body have to be kept within certain limits even when the outside environment changes. (*Know Examples!* ) **Homeostasis** is the state of internal balance an organism strives to keep...a “dynamic equilibrium” - keeping a balance within the organism and between the organism and the environment. ( even though the environment is always changing, and trying to change you! )

Unit one will focus on the role the nervous system plays in homeostasis, and structures that are associated with this system, like eyes, ears, and the endocrine (hormonal) system.

The Structure of the Nervous System
The nervous system is a high-speed communication system to and from almost every part of the body, and is subdivided into two major parts: CNS and PNS.

**Central Nervous System (CNS)**
- brain
- spinal cord

*Receives sensory information detected by specialized “receptor cells and organs” around the body. Responds by sending commands in an attempt to maintain homeostasis. (motor control)*

Has **three layers of protection**....

**Bone** - skull protects the brain, and **vertebrae** around spinal cord

**Meninges** - **membranes** that surround the brain and spinal cord
**Cerebrospinal Fluid** - fills spaces, to create a liquid cushion between brain / skull, and spinal cord / vertebrae

**Spinal Cord**

- attaches to base of brain
- connects brain and peripheral nervous system
- spinal nerves branch out through openings between vertebrae (PNS- running between spine and body parts)
The Brain and Homeostasis:

- co-ordinates homeostasis
- processes all information
- only about 2% of body weight
- 15% of blood supply used by the brain
- 20% of O₂ and glucose used by the brain
- about a billion nerve cells

Two halves (or hemispheres)....

These hemispheres are further subdivided into “lobes” as shown here....

The brain tissue is further subdivided based on location and what they do....

Major Brain Parts:
cerebrum, cerebellum, medulla oblongata, thalamus, hypothalamus, midbrain, pons, corpus callosum

there's a lot of diversity in brain size, numbers of connections it contains, processing speed, levels of chemicals it makes, and health.

Glossary of Terms for an Anatomy of the Brain
http://www.ahaf.org/alzheimers/about/understanding/anatomy-of-the-brain.html
Cerebrum

- involved in complex behaviour
- intelligence
- interprets sensory inputs
- memory storage & decisions
- starts movements, speech
- “human consciousness”

Cerebellum

- balance
- muscle coordination
- body kinesthetics
- 50 % of brains nerve cells

Medulla

- controls unconscious functions such as heart rate, breathing, blood pressure, vomiting, swallowing, coughing, hiccupsing
In addition there are some other areas of the brain you should be familiar with:

- **thalamus**
  - sorts sensory information
  - receives sensations of touch, pain, heat, and cold (mild...to cerebrum, strong....to hypothalamus)

- **hypothalamus**
  - autonomic control center
  - controls hunger, body temperature, aggression, behaviour, responds to external threats

- **midbrain**
  - sight and hearing connection

- **pons**
  - bridge between cerebellum and the rest of the CNS, also involved with breathing, along with the medulla

- **corpus callosum**
  - connects the left and right hemispheres
Peripheral Nervous System (PNS)

- all of the nerves that lead into and out of the CNS
- consists of two subdivisions:

  A. **Autonomic Nervous System**
     - not consciously controlled
     - has two divisions that work opposite to each other - the **sympathetic** (responsible for exciting the body during the “fight or flight response”) and **parasympathetic** systems (responsible for bringing the body back to a relaxed state)

     LOOK AT PICTURE ON PAGE 394 !!!!!

  B. **Somatic Nervous System**
     - conscious control
     - made up of sensory nerves and organs
     - includes motor neurons
The Autonomic Nervous System

The two components of the autonomic nervous system work opposite to each other.

<table>
<thead>
<tr>
<th>Sympathetic</th>
<th>Parasympathetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>involved in “fight or flight”</td>
<td>calms body back down again</td>
</tr>
<tr>
<td>dilates bronchioles</td>
<td>constricts bronchioles</td>
</tr>
<tr>
<td>speeds heartbeat</td>
<td>slows heartbeat</td>
</tr>
<tr>
<td>secretes adrenaline</td>
<td></td>
</tr>
<tr>
<td>decreases stomach secretion</td>
<td>increases stomach secretion</td>
</tr>
<tr>
<td>decreases intestinal motility</td>
<td>increases intestinal motility</td>
</tr>
<tr>
<td>retains colon contents</td>
<td>empties colon</td>
</tr>
<tr>
<td>delays bladder emptying</td>
<td>empties bladder</td>
</tr>
</tbody>
</table>
How does the nervous system maintain homeostasis?

The nervous system is responsible for receiving information from internal and external stimuli and the quick response to that information.

There are four requirements for a nervous response:
1. Sensory Receptors
   - these detect the stimulus
   - includes eyes ears skin etc.

2. Impulse Transmission
   - neurons

3. Impulse Interpretation and Analysis
   - brain and spinal cord

4. Effector Response
   - muscles
Neurons

Watch Youtube video:
NEURONS AND NEURO-TRANSMITTERS

The Neuron

• nerve cells make up the CNS and PNS
• numerous neurons held together by connective tissue are called **nerves**
• can survive over 100 years

The neuron has three main parts:

1. **Cell Body** → this has the nucleus, nucleolus, and other organelles (2201)

2. **Dendrites** → primary sites for receiving signals from other neurons. There can be 1 to 1000s!

3. **Axon** → long extension (up to 1m). Impulses are transmitted along its length. The end of the axon has specialized structures (called end brushes or terminals) that release chemicals to the next neuron or to muscle cells.

**IMPULSES ALWAYS TRAVEL FROM THE DENDRITE END TO THE AXON END**
Some neurons also have the following structures:

1. **Schwann Cells**
   - These are cells that surround some axons.
   - They produce layers of a white fatty substance called myelin.
   - Myelin makes the impulse (message) travel faster.
   - Schwann cells also have the ability to repair neurons if the damage is not too severe. This is important because **neurons cannot regenerate**.

**Nodes of Ranvier**
- these are gaps between the Schwann cells
- the impulse travels from one node to the next by jumping at about 120 m/s!
Types of Neurons

Neurons are separated into three classes:

1. **Sensory Neurons**
   These take the information from a sensory receptor (pain, heat, cold, taste, hearing, etc.) and send an impulse to the CNS. Stimulated by chemicals, light, heat, etc.

2. **Interneurons**
   These are the nerve cells that act as a link between sensory and motor neurons and are found only in the brain and spinal cord. They receive and exchange information.

3. **Motor Neurons**
   These transmit impulses from the CNS to the muscle fibres or glands
All of these nerve types react to being excited or inhibited. When excited beyond a “threshold level stimulus”, a series of events occurs that causes an “action potential”. This action potential moves along the length of a neuron to its axon terminal end. The “all or none response”.

Production and Transmission of a Nerve Impulse...

A. Before a stimulus: (ie. Not firing / depolarizing)

Nerve cell not doing anything is said to be “at rest”

outside of the cell membrane is positively charged, due to positively charge ions outside. (sodium ions (Na+) concentrated outside the cell)

- Potassium ions (K+) are concentrated inside (membrane is very permeable to the movement of K+)

- negatively charged particles (anions) like proteins, phosphates, and others outnumber the K+, and will give the interior a negative charge

(At rest.....the “resting potential” is -70mV)
B. The Stimulus:
- Chemicals, light, heat, vibration, electricity, and touch for sensory neurons
- “Neurotransmitters”...chemicals secreted by other neurons....stimulate interneurons and motor neurons
- A stimulus has to be strong enough (above a “threshold stimulus level”) before a neuron will fire...the neuron does or does not fire, there is no weak “in between” impulse. This is called the “all or none response”

C. Firing (“Depolarization”):
- K+ gates in the membrane close, Na+ gates open. Sodium ions flood into the axon from outside
- Neutralizes the negative charge inside (now called an “action potential”) - changing the electric charge of the membrane.
- This electrical change sweeps from dendrites to cell body, along the axon, to the terminals, where neurotransmitters will be released

Youtube animations

D. The aftermath (“Repolarization”):
- depolarization was very quick, now the cell must return to a resting state again
- K gates open, K+ exits, Na+ gates close to prevent more Na+ from entering
- sodium / potassium pumps use energy (ATP) to move Na+ out and K+ back inside
- neuron can’t fire while it is repolarizing (0.001 seconds)...the “refractory period”

Inhibitory vs excitatory stimuli...
Something that slows or prevents this story from happening is called an “inhibitor”......raises the threshold level required to set off a neuron, so they don’t get set off as much.

Ex. ?

Anything that lowers the threshold level strength, causing a neuron to fire more often is called an excitatory stimulus.

The Reflex Response

A simple reflex shows all three types of neurons in action. Example: touching a hot stove.

1. Heat receptors in the hand pick up the stimulus - hot hot hot!

2. The impulse from sensory receptors in the affected body part travels along the interneurons up the arm and to the spinal cord.

3. In the spinal cord the signal is passed on to small interneurons. It interprets the “Hot hot hot!” and sends a signal out along the motor neurons. Reflex responses are carried out without the brain being
4. The motor neuron ends in an effector, or muscle. This triggers the contraction of the arm muscles, which pulls the hand away.

5. Other neurons in the spinal cord send a message to the brain, telling it what happened.

Reflexes are involuntary and can be triggered without input from the brain, just the spinal cord.

Examples of reflex responses:

Knee-jerk Reflex
Achilles Reflex
Babinski Reflex
Pupils Response to Light

Investigation 12.A, page 396 of the text