X-Sheet 9

Nervous System
Animal Responses to the Environment: Nervous System

Terminology & definitions

Homeostasis: processes to maintain a stable, balanced internal environment within the body.

Central Nervous System: is made up of the brain and the spinal cord

Peripheral Nervous System: receives internal and external stimuli, converts the stimuli into impulses and sends impulses to the central nervous system.

Autonomic Nervous system: is made up of the sympathetic and parasympathetic nervous systems that regulate homeostasis. Both systems function antagonistically. The sympathetic nervous system stimulates organs and the parasympathetic nervous system inhibits the same organs.

Double innervation: Each organ in the body is supplied with nerves from both the sympathetic and parasympathetic nervous systems.

Neuron: a single nerve cell.

Nerve: is made up of millions of neurons

Synaptic gap: this is the gap between neurons because neurons do not touch each other.

Neurotransmitters: this is a chemical substance secreted by synaptic vesicles in the presynaptic neuron, to assists in transmitting an impulse across the synaptic gap.

Meninges: membranes that surround the brain. There are three meninges namely: the dura mater, the arachnoid and the pia mater.

Reflex arc: This is the path travelled by the nerve impulse from the receptor to the effector, through the spinal cord.

Reflex action: a rapid automatic response as a result of a stimulus received by a receptor, converted to an impulse that passes through the spinal cord reflex arc to a receptor.

X-planation / Key Concepts / Diagram

All the systems in the body function in a coordinated manner to ensure that homeostasis takes place. The endocrine and the nervous system work together to allow humans and animals to respond to external changes and control internal conditions.

The nervous system: controls the functioning of all the systems in the body allowing humans to react to stimuli from their environment. The central nervous system controls all voluntary movements and internal organs, glands and blood vessels. It responds to information received by the brain and then responds. The nervous system can be divided into three systems that coordinate the functioning of the body namely: the Central nervous system, the Peripheral nervous system and the Autonomic nervous system.

Nervous tissue

Nervous tissue consists of a complex system called neurons or nerve cells that are adapted to conduct and react to all stimuli.

- Sensory neurons: They are unipolar (one pole) and bipolar (two poles). Sensory neurons always conduct impulses from the receptor to the CNS (spinal cord and brain).
- Motor neurons: They are multipolar neurons with many dendrites. Multipolar neurons always carry impulses away from the CNS (spinal cord and brain).
- Connector / inter-neurons: They connect sensory neurons to motor neurons in the spinal cord and the brain.
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The Central Nervous System (CNS)

Brain: protected by the bones of the cranium and is surrounded by three layers of membranes or meninges for protection. The cortex consists of cell bodies and is called the grey matter. The medulla consists of the nerve fibres or axons and is called the white matter.
The spinal cord: protected by the **vertebrae** and **cerebrospinal fluid**. Nerves from the body parts enter the spinal cord as 31 pairs of spinal nerves. The spinal cord is the pathway for all the impulses that are conducted to and from the brain and also processes reflex actions. Sympathetic and parasympathetic nerve impulses are conducted along the spinal cord to all organs.

The reflex arc: is the path travelled by the nerve impulses and is a **rapid automatic response** to a stimulus, received by a sensory organ. The reflex arc will cause a **reflex action** allowing the body to respond very quickly to protect itself and prevent severe injury.
**Effects of drugs on the central nervous system**

Drugs that are legally prescribed by a doctor and are used according to instructions are acceptable, as they used to treat illness and alleviate pain in patients. When drugs are used to *enhance performance* or as a *psychoactive* for non-therapeutic and non-medical effects, it becomes a problem. Drugs that are addictive and harmful are alcohol, amphetamines, barbiturates, cocaine and opium alkaloids. It is a criminal offence to abuse any of these drugs.

Drugs can be classified as stimulants, sedatives and opiate analgesics:

**Common drugs and how the effect the nervous system:**

<table>
<thead>
<tr>
<th>Drug type</th>
<th>Effect on the nervous system:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dagga</strong></td>
<td><em>Also called cannabis</em>, marijuana, ganja, hashish or grass: The effects are psychoactive and physiological and range from a subjective change in perception, increased heart rate, lowered blood pressure, impaired skeletal coordination, lack of concentration and short-term memory loss. Studies have shown that using cannabis increases the probability of using harder drugs.</td>
</tr>
<tr>
<td><strong>Heroin</strong></td>
<td>Heroin is an opiate drug synthesized from morphine, a naturally occurring substance extracted from the seed pod of the Asian opium poppy plant. In the brain, heroin is converted to morphine and binds to opioid receptors important for automatic processes critical for life like...</td>
</tr>
</tbody>
</table>
breathing and blood pressure. Tolerance develops easily and people become addicted. Heroin abuse results in fatal overdoses, spontaneous abortion and infectious diseases, including HIV/AIDS and hepatitis. Addicts may develop collapsed veins, infection of the heart lining and valves, abscesses and liver or kidney disease, pulmonary complications, including various types of pneumonia. In many cases, street heroin contains toxic contaminants and additives that clog blood vessels leading to permanent damage to the lungs, liver, kidneys and brain and eventually leads to death.

**Ecstasy**

Ecstasy is a synthetic drug with amphetamine-like and hallucinogenic properties and is classified as a stimulant. Ecstasy is in tablet form to produce an intensely enhanced sense of self-confidence and energy and users experience a desire to touch others. Other effects include involuntary teeth clenching, a loss of inhibitions, transfixion on sights and sounds, nausea, blurred vision, chills and/or sweating, increased heart rate and blood pressure and seizures. The stimulant effects allows users to dance for extended periods and causes severe dehydration and hyperthermia and dramatic increases in body temperature. This can lead to muscle breakdown and kidney, liver and cardiovascular failure resulting in death. After-effects can include sleep problems, anxiety and depression with repeated use causing damage the cells that produce serotonin, needed for the regulation of mood, appetite, pain, learning and memory.

**Tik**

Tik /Crystal Meth is a very pure form of methamphetamine. It is a powerful and extremely addictive man-made stimulant and use can lead to severe physiological and psychological dependence. The drug’s effects are similar to those of cocaine and causes erratic, violent behaviour. Effects include suppressed appetite, interference with sleeping behaviour, mood swings and unpredictability, tremors and convulsions, increased blood pressure, irregular heart rate. Effects may include homicidal or suicidal thoughts, prolonged anxiety, paranoia and insomnia. Long-term effects include brain damage similar to the effects of Parkinson’s disease or Alzheimer’s disease, coma, stroke and in some cases, death. Chronic users may also develop distinct physical symptoms like excessive weight loss, tooth decay and cracked teeth, psychosis and hallucinations, sores on the body from picking at skin and formication (an abnormal skin sensation that feels like bugs crawling on skin).

#### The Autonomic Nervous System (ANS)

The autonomic nervous system controls many vital activities in the body in order to maintain homeostasis. It consists of nerves, which are connected to the hypothalamus of the central nervous system. This system functions involuntarily and automatically, so it cannot be controlled by the will. It is subdivided into the sympathetic and parasympathetic nervous systems that function antagonistically. The sympathetic
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Nerves stimulate organs to prepare the body for action. The parasympathetic nerves slow the systems down and bring the body back to a state of rest. Each organ in the body is supplied with nerves from both systems and is termed double innervation. The organs are stimulated (sympathetic) or inhibited (parasympathetic) by the autonomic nervous system.

The table shows the ‘opposite’ double innervation functioning of the ANS:

<table>
<thead>
<tr>
<th>Organ</th>
<th>Sympathetic</th>
<th>Parasympathetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupil of the eye</td>
<td>Dilated pupil</td>
<td>Constricted pupil</td>
</tr>
<tr>
<td>Sweat glands</td>
<td>Increased sweat secretion</td>
<td>Decreased sweat secretion</td>
</tr>
<tr>
<td>Heart rate</td>
<td>Increased heartbeat</td>
<td>Decreased heartbeat</td>
</tr>
<tr>
<td>Small intestine</td>
<td>Decreases peristalsis and blood supply</td>
<td>Increases peristalsis and blood supply</td>
</tr>
<tr>
<td>Arteries to skin</td>
<td>Constrict = pale skin colour</td>
<td>Dilate = normal skin colour</td>
</tr>
<tr>
<td>Arteries to muscles</td>
<td>Dilate = to increase blood flow (more nutrients and oxygen means more ATP)</td>
<td>Constrict = to decrease blood flow (less nutrients and oxygen means less ATP)</td>
</tr>
<tr>
<td>Bladder</td>
<td>Contracts (urge to urinate)</td>
<td>Relaxes</td>
</tr>
<tr>
<td>Liver</td>
<td>Glucagon is released to stimulate the release of glucose</td>
<td>Insulin is released to stimulate the storage of glucose</td>
</tr>
</tbody>
</table>

Peripheral Nervous System (PNS)
The peripheral nervous system is made up of sensory cells that respond to stimuli. Sensory cells are called receptors. When the receptors are stimulated, the stimulus is converted into a nerve impulse. The nerve impulse is transmitted along sensory neurons to the CNS.

Types of receptors
- **Exteroreceptors**: They respond to stimuli from outside the body and are found in the skin, nose, tongue, eyes and ears:
  - Photoreceptors are sensitive to light stimuli, for example the eye.
  - Chemoreceptors are sensitive to chemicals as a solution or gas, for example the tongue and nose.
  - Mechanoreceptors are sensitive to changes in pressure such as touch, sound and gravitational stimuli, for example the ear, skin, muscles and tendons.
- **Interoceptors**: They respond to chemical and physical changes inside the body to maintain homeostasis:
  - Chemoreceptors in the aortic arch and carotid arteries are stimulated by incorrect pH levels of the blood.
  - Thermoreceptors are sensitive to heat and cold, for example the skin and hypothalamus.
  - Osmoreceptors are sensitive to changes in osmotic pressure of the blood.
  - Baroreceptors are sensitive to changes in blood pressure. They are located mainly in the aortic arch.
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Diseases and disorders of the nervous system – make sure that you know the causes, symptoms and treatment of any one of the following: Alzheimer’s disease, ADD or depression.

X-ample Questions
Question 1:
(Taken from various DoE Exams Paper 2 exams and modified)

1.1. Identify parts numbered 1 to 5. (5)
1.2. Number 1 is made up of two similar halves. How are these two halves attached to one another? (1)
1.3. What type of tissue is controlled by number 3? (1)
1.4. Name TWO functions of number 4. (2)
1.5. List THREE ways in which the brain is protected. (6)
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Question 2:
(Modified from DoE May/June 2008 HG Paper 2)

Study the following diagram and answer the questions that follow.

![Transverse section of the spinal cord of a human](image)

2.1 Identify parts A, B and C. (3)
2.2 State TWO ways in which the spinal cord is protected. (2)
2.3 Describe what happens in the reflex arc to result in a reflex action. (10)

X-ercise

1. Which of the following structures will enable a dancer to carry out dance movements?
   - 1. Cerebellum
   - 2. Proprioceptors
   - 3. Hypothalamus
   - 4. Cerebral cortex

   A 1 only  
   B 1 and 2  
   C 1, 2 and 3  
   D 1, 2, and 4

2. Which of the following parts of the brain regulates appetite?
   - A Medulla oblongata
   - B Cerebellum
   - C Hypothalamus
   - D Cerebrum

3. The autonomic nervous system controls …
   - A the skeletal muscles.
   - B the senses.
   - C the contraction of involuntary muscles.
   - D reflexes.
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4. Letters X and Y represent neurons that conduct impulses to and from the brain via the spinal cord. Study the diagram and answer the questions that follow.

Using the given key, write down the correct letter (A, B or C in key) of the condition that explains each of the following:
4.1. When the skin of the toe is stimulated, the toe moves and the person knows that it is moving. (1)
4.2. The person can move the toe, but cannot feel the movement. (1)
4.3. The person can feel a pin pricking the toe, but cannot move the toe. (1)

Answers to X-ercise Questions:

1. D
2. C
3. C
4.1. C
4.2. A
4.3. B