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**BIOPSYCHOLOGY**
- The structure and function of sensory, relay and motor neurons. The process of synaptic transmission, including reference to neurotransmitters, excitation and inhibition (lines 1-26)
- The divisions of the nervous system: central and peripheral (somatic and autonomic) (lines 27-57)
- The function of the endocrine system: glands and hormones (lines 58-64)
- The fight or flight response including the role of adrenaline (lines 65-144)

**LOCALISATION OF FUNCTION IN THE BRAIN AND HEMISPHERIC LATERALISATION**
- Motor, somatosensory, visual, auditory and language centres including Broca’s and Wernicke’s areas (lines 145-201)
- Split brain research (lines 202-251)
- Plasticity and functional recovery of the brain after trauma (lines 252-303)

**WAYS OF STUDYING THE BRAIN**
- Scanning techniques, including functional magnetic resonance imaging (fMRI); electroencephalogram (EEGs) and event-related potentials (ERPs); post-mortem examinations (lines 304-362)

**BIOLOGICAL RHYTHMS**
- Circadian, infradian and ultradian and the difference between these rhythms (lines 363-499)
- The effect of endogenous pacemakers and exogenous zeitgebers on the sleep/wake cycle (lines 500-552)
THE PROCESS OF SYNAPTIC TRANSMISSION, INCLUDING REFERENCE TO NEUROTRANSMITTERS, EXCITATION AND INHIBITION.

The nervous system is composed of 100 billion cells called neurons. Although different types of neurons vary in size and function they all operate in the same way – passing on messages via electrical and chemical (neurotransmitter) signals.

Electrical nerve impulses (action potentials) travel from the dendrites along the cell body and the axon to the axon terminals. These action potentials are the basic units of information processing in the nervous system and control all aspects of human behaviour (e.g. perception, memory, emotion, etc.)

Neurons lie adjacent to each other but are not connected. When an electrical signal reaches the axon terminals, molecules of neurotransmitters are released across the synaptic gap/synapse (the gap separating one neuron from another) and then attach to post-synaptic receptors on the adjacent neuron. This will then trigger an electrical impulse in the adjacent cell.
The action of neurotransmitters at synapses can be

- **Excitatory** – make a nerve impulse more likely to be triggered: for example, dopamine or serotonin which produce states of excitement/activity in the nervous system and in our mental state/behaviour.

- **Inhibitory** - make a nerve impulse less likely to be triggered: for example, GABA calms activity in the nervous system and produces states of relaxation (as with anti-anxiety medication such as Valium).

**THE STRUCTURE AND FUNCTION OF SENSORY, RELAY AND MOTOR NEURONS**

- **Sensory neurones** – convey information about sensory stimuli: vision, touch, taste, etc. towards the brain

- **Motor neurones** – convey instructions for physical operations: e.g. release of hormones from glands, muscle movement, digestion, etc.

- **Relay neurons** – connect different parts of the central nervous system (CNS).
The **central nervous system (CNS)** is made up of the **brain** and **spinal cord**.

The **hindbrain** (**pons**, **medulla**, **cerebellum**) is a continuation of the spinal cord carrying on into the bottom of the brain – the brain stem – mainly composed of sensory and motor neurons. The **cerebellum** controls movement and motor coordination.
The forebrain is divided into 2 parts.

- The diencephalon contains the
  - Thalamus: concerned with relaying sensory information from the brainstem to the cortex.
  - Hypothalamus: controls basic functions such as hunger, thirst, sexual behaviour; also controls the pituitary gland.
- The cerebral hemispheres control higher level cognitive and emotional processes
  - The limbic system is involved in learning, memory and emotions
  - The basal ganglia is involved in motor activities and movement
  - The neocortex/cerebral cortex is involved with planning, problem-solving, language, consciousness and personality

The peripheral nervous system (PNS)
The PNS is made up of 31 spinal nerves which radiate out from the spinal cord and can be divided into the

- Somatic Nervous System (SNS) connects the central nervous system with the senses and is composed of
  - sensory pathways which deal with touch, pain, pressure, temperature
  - motor pathways which control bodily movement
- Autonomic Nervous System (ANS). Controls bodily arousal (how ‘excited’ or relaxed we are), body temperature, homeostasis, heart rate and blood pressure. Composed of 2 parts
  - The sympathetic ANS leads to increased arousal: e.g. increase in heart rate and blood pressure, pupil dilation, reduction in digestion and salivation.
  - The parasympathetic ANS leads to decreased arousal.

(See Fight-Flight response below).
**THE FUNCTION OF THE ENDOCRINE SYSTEM: GLANDS AND HORMONES**

Hormones are chemical messengers secreted from structures (glands) in the body which pass through the bloodstream to cause changes in our body or behaviour. The network of glands is called the endocrine system.

<table>
<thead>
<tr>
<th>ENDOCRINE GLAND</th>
<th>MAIN HORMONES</th>
<th>EFFECTS</th>
</tr>
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<tbody>
<tr>
<td>Thyroid</td>
<td>Thyroxine</td>
<td>Regulates metabolic rate and protein synthesis</td>
</tr>
<tr>
<td>Adrenal medulla</td>
<td>Adrenaline and noradrenaline</td>
<td>Fight or flight response: increased heart rate, blood pressure, release of glucose and fats (for energy)</td>
</tr>
<tr>
<td>Adrenal cortex</td>
<td>Corticosteroids</td>
<td>Release of glucose and fats for energy; suppression of the immune system</td>
</tr>
<tr>
<td>Testes</td>
<td>Testosterone</td>
<td>Male sexual characteristics, muscle mass</td>
</tr>
<tr>
<td>Ovaries</td>
<td>Oestrogen</td>
<td>Female sexual characteristics, menstruation, pregnancy</td>
</tr>
<tr>
<td>Pineal</td>
<td>Melatonin</td>
<td>Sleep-wake cycle</td>
</tr>
</tbody>
</table>

The pituitary gland is the master gland and controls release of hormones from many of the glands described above. The pituitary is divided into the anterior and posterior.

<table>
<thead>
<tr>
<th>ANTERIOR PITUITARY (Hormones released)</th>
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<tbody>
<tr>
<td>ACTH</td>
<td>Stimulates release of corticosteroids during flight-flight response</td>
</tr>
<tr>
<td>Prolactin</td>
<td>Stimulates production of milk from mammary glands (breasts)</td>
</tr>
<tr>
<td>Growth Hormone</td>
<td>Cell growth and multiplication</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>POSTERIOR PITUITARY (Hormones released)</th>
<th></th>
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<tbody>
<tr>
<td>Vasopressin</td>
<td>Regulates water balance</td>
</tr>
<tr>
<td>Oxytocin</td>
<td>Uterine contractions during childbirth</td>
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</table>
THE FIGHT OR FLIGHT RESPONSE INCLUDING THE ROLE OF ADRENALINE

Stress is experienced when a person’s perceived environmental, social and/or physical demands exceed their perceived ability to cope. The stress response (otherwise known as the ‘fight or flight’ response) is hard-wired into our brains and represents an evolutionary adaptation designed to increase an organism’s chances of survival in life-threatening situations.

The fight or flight response involves two major systems:

- The **Sympathomedullary Pathway** – deals with **acute** (short-term, immediate) stressors such as personal attack.
- The **Pituitary-Adrenal System** – deals with **chronic** (long-term, on-going) stressors such as a stressful job.
THE BODY’S RESPONSE TO ACUTE (IMMEDIATE) STRESS

THE SYMPATHOMEDULLARY (SAM) PATHWAY

Stressor

Is recognised by the

Hypothalamus

Sends a message to the

Sympathetic branch of the autonomic nervous system (ANS) – state of high physiological arousal.

Neurons send signals to

Adrenal medulla – release of adrenaline and noradrenaline into bloodstream.

Which

Prepares the body for action – to survive life threatening stressors – fight or flight response.

Increased

- heart rate, breathing rate and blood pressure
- oxygen supply to brain and muscles
- salivation reduced, pupil dilation, sweating to cool body, digestion slows
- blood flow diverted from skin surface to heart and brain

Once the stressor has passed or been cope with the parasympathetic branch of the autonomic nervous system is activated which returns the body to a resting state: e.g. heart rate and blood pressure return to normal.
THE BODY’S RESPONSE TO CHRONIC (LONG TERM) STRESSORS

THE HYPOTHALAMIC PITUITARY ADRENAL SYSTEM (HPA AXIS)

Is recognised by the Hypothalamus

Sends a message to The pituitary gland which releases ACTH into the bloodstream.

Which travels to The adrenal cortex which releases corticosteroids into the bloodstream.

Leading to Positive effects – liver releases energy in form of glucose, lowered sensitivity to pain.

However Negative effects – higher blood pressure, lower immune system response (immunosuppression), impaired cognitive performance.
The link between brain structures and their functions (e.g. language, memory, etc.) is referred to as brain localisation. The brain is divided into 2 hemispheres – left and right.

**MOTOR AND SENSORIMOTOR AREAS**

- The motor cortex controls voluntary movements. Both hemispheres have a motor cortex with each side controlling muscles on the opposite side of the body (i.e. left hemisphere controls muscles on right side of body). Different areas of the motor cortex control different parts of the body and these are in the same sequence as in the body (e.g. the part of the cortex controlling the foot is next to the part controlling the leg, etc.)
The sensorimotor cortex registers sensory information from different areas of the body: e.g. pain, temperature, pressure. Both hemispheres have a sensorimotor cortex with each side receiving information from the opposite side of the body.

**VISUAL CENTRES**

- Processing of visual information starts when light enters the eye and strikes photoreceptors on the retina at the back of the eye. Nerve impulses then travel up the optic nerve to the thalamus and are then passed on to the visual cortex in the hindbrain. The right hemisphere’s visual cortex processes visual information received by the left eye and vice-versa. The visual cortex contains different regions to do with colour, shape, movement, etc.

**AUDITORY CENTRES**

- Processing of auditory information (sound) begins in the inner ear’s cochlea where sound waves are converted into nerve impulses which travel along the auditory nerve to the brain stem (which decodes duration and intensity of sound) then to the auditory cortex which recognises the sound and may form an appropriate response to that sound.

**LANGUAGE CENTRES**

- Broca’s Area is generally considered to be the main centre of speech production. The neuroscientist after whom this brain area is named found that patients with speech production problems had lesions (damage) to this area in their left hemisphere but lesions in the right hemisphere did not cause this problem. More recent research indicates Broca’s area is also involved with performing complex cognitive tasks (e.g. solving maths problems).
- Wernicke’s area is also in the left hemisphere and is concerned with speech comprehension. The neuroscientist after whom this brain area is named found that
lesions in this brain area could produce but not understand/comprehend language. Wernicke’s area is divided into the motor region (which controls movements of the mouth, tongue and vocal cords) and the sensory area (where sounds are recognised as language with meaning).

- Broca’s and Wernicke’s areas are connected by a loop which ties together language production and comprehension.

**EVALUATION**

- **Equipotentiality theory** argues that although basic brain functions such as the motor cortex and sensory functions are controlled by localised brain areas, higher cognitive functions (such as problem-solving and decision-making) are not localised. Research has found that damage to brains can result in other areas of the brain taking over control of functions that were previously controlled by the part of the brain that has been damaged. Therefore, the severity of brain damage is determined by the amount of damage to the brain rather than the particular area which has been damaged.

- The way in which brain areas are connected with each other may be as important for normal cognitive function as particular brain sites themselves. Brain sites are interdependent and damage to connections between sites may lead to the brain site not being able to function normally. For example, Dejerine (1892) found that damage to the connection between the visual cortex and Wernicke’s area lead to an inability to read (vision + comprehension).

- Gender differences have been found with women possessing larger Broca’s and Wernicke’s areas than men, presumably as a result of women’s greater use of language.
HEMISPHERIC LATERALISATION & SPLIT-BRAIN RESEARCH

Hemispheric lateralisation concerns the fact that the brain’s 2 hemispheres are not exactly alike and have different specialisms. For example, the left hemisphere is mainly concerned with speech and language and the right with visual-motor tasks. Broca (1861) found that damage to the left hemisphere led to impaired language but damage to the same area on the right hemisphere did not.

The brain’s 2 hemispheres are connected by a bundle of nerve fibres – the corpus callosum – which allows information received by one hemisphere to be transferred to the other hemisphere.

Investigations into the corpus callosum began when doctors severed patients’ corpus callosum in an attempt to prevent violent epileptic seizures. Sperry (‘68) tested such split-brain patients to assess the abilities of separated brain hemispheres.

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