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HIGHLIGHTED HANDOUT

PSY610

Neurological Bases of Behavior

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PSY610 Exam Answers

LONG QUESTION 1: **Advanced Technology in Neuroscience**

Lesson 15 (Brain Imaging Techniques)

1) Contrast X-rays

In this method, **a dye or special substance** is injected into part of the brain. This substance blocks X-rays, so the injected area appears differently from the surrounding area.

Use:

It helps detect things like:

- tumor location
- tumor size
- problems in the brain's blood vessels

It gives basic information, but not very detailed brain images.

2) CAT Scan / CT Scan

CAT stands for **Computed Axial Tomography**. In this technique, many X-rays are taken from different angles while the **person lies inside a machine**. A computer combines these images to create a **3D picture** of the brain.

Advantages:

- better than normal X-rays
- gives more detailed images

Limitation:

- it is a **static method**, so it does not show ongoing changes in brain activity

3) MRI

MRI stands for **Magnetic Resonance Imaging**.

In this method:

- the person is placed in a strong magnetic field
- radio waves activate hydrogen atoms in the body
- the machine uses the signals to create detailed images of the brain

Types:

- **Structural MRI:** shows the shape and structure of the brain
- **Functional MRI (fMRI):** shows which parts of the brain are active while a person is doing a task

Example:

If a person is asked to remember a list of words, 

fMRI can show which brain areas are working during memory.

Strength:

It gives very clear, high-resolution images.

4) PET Scan

PET stands for **Positron Emission Tomography**.

This method shows **brain activity**, not just structure. A radioactive substance, such as **radio-labeled glucose**, is **injected** into the body. Active brain areas use more glucose, so they show up more strongly on the scan.

Color pattern:

- red = highest activity
- yellow/orange = medium activity

- blue = lowest activity

PET can also measure **blood flow**, because active brain areas usually need more blood.

Use:

It is useful for studying:

- brain activity
- metabolism
- how much energy different brain areas are using

5) fMRI vs PET

fMRI

- no injection is needed
- shows both structure and function

- has better image resolution

PET

- requires injection of radioactive substances
- shows only function, not structure
- can measure glucose use or blood flow

Important point

Both methods are limited in showing changes across time in a very detailed way.

6) Assays

Assays are chemical tests done on:

- blood
- urine
- cerebrospinal fluid (CSF)

- brain tissue after death

They are used to measure chemicals and metabolites in the body or brain.

Example:

Some studies found high levels of **MHPG** in the urine of people with schizophrenia. This suggested that certain neurotransmitters may be involved in the disorder.

7) Neurophysiological Measures

These methods measure the **electrical activity** of the brain and body.

EEG (Electroencephalography)

EEG records brain waves **using electrodes placed on the scalp.**

It shows:

- ongoing electrical activity in the brain
- different patterns during sleep and wakefulness

Example:

During deep sleep, EEG shows:

- low frequency
- high amplitude waves

EOG (Electro-Oculograph)

EOG measures the electrical activity of the eye muscles.

Use:

It is especially useful in sleep studies, mainly to detect **REM sleep**, when rapid eye movement occurs.

EMG (Electromyograph)

EMG measures the electrical **activity of muscles.**

Use:

In sleep studies, it helps measure muscle tone, especially in the neck muscles, to distinguish between:

- **Non-REM sleep**

- **REM sleep**

Polygraphic Recording

This records several body functions together, such as:

- skin conductance

- blood pressure

- pulse rate

- breathing

It helps show the body's full response in an organized way.

LONG QUESTION 3: Five Evolutionary Theories Lesson 05

Scientists did not always agree on how species came into existence or whether they could change over time. Different thinkers gave different ideas, and gradually these ideas led to modern evolutionary theory.

1) Linnaeus

Linnaeus believed that:

- all animals were created in **one act of creation**
- species were **fixed and unchanging**
- variation within a species could exist

- but each species was still independent and separate in its creation

So, according to Linnaeus, species did not evolve into new species.

2) Comte de Buffon (1707–1788)

Buffon suggested that species could **change over time**. He introduced the idea that one species might become another through **degeneration** or environmental influence.

He emphasized:

- the effect of **environment**
- **migration**
- **environmental variation**
- **struggle for existence**

These ideas later helped Darwin develop his own theory.

3) Lamarck (1744–1829)

Lamarck gave one of the first full theories of evolution in his book *Philosophie Zoologique*.

His main idea was **transmutation**, which means that species are not fixed; they are always changing. He believed:

- living things constantly move toward **higher and more complex forms**
- evolution happens like a **ladder of life**
- dead matter can return to life through regeneration

Lamarck's important ideas:

a. Change, not fixity, of species

Species are not permanent; they can change gradually.

b. Environmental pressure

The environment creates small changes in organisms over time.

c. Use and disuse

- body parts used a lot become stronger and larger
- body parts not used shrink and weaken

For example, if an animal uses a body part regularly, that part develops more.

4) Lysenko

Lysenko supported the idea of **inheritance of acquired characteristics**. He believed that:

- changes acquired during one generation
- could be passed on to the next generation

This idea is similar to Lamarck's view. Later, modern genetics showed that this idea is not generally correct.

5) Darwin (1809–1882)

Charles Darwin gave the most important and accepted theory of evolution. 

He studied many species, especially during his voyage on the **HMS Beagle** and later through careful observations and notes. His work led to the book *Origin of Species*.

Darwin noticed that:

- organisms in a population are **not identical**
- there is **variation** among individuals
- some variations are inherited
- individuals with helpful traits survive better and reproduce more

Darwin's main ideas

a. Variation exists in all populations

No two organisms are exactly the same.

b. Variations are inherited

Useful traits can be passed from parents to offspring.

c. Natural selection

Nature “selects” the organisms that are best adapted to survive.

d. Survival of the fittest

Those with better traits survive, reproduce, and pass those traits on.

Simple difference between Lamarck and Darwin

Lamarck believed organisms change because they **need to adapt** and pass on acquired traits.

Darwin believed organisms already show **variation**, and nature selects the best-suited ones.

PSY610 Important Questions and Answers

1. Induction (Lesson 18)

Induction is the process that signals **change in embryonic cells** and leads to cell **determination** and **differentiation**.

The notochord induces the ectoderm to develop into nervous tissue and directs cells toward specialized functions.

3. Egas Moniz Contributions (Lesson 04)

Psychosurgery refers to surgical procedures performed on the brain to treat severe mental illnesses by changing brain functioning and behavior.

- The first systematic psychosurgery was performed in **1935** by **Egas Moniz** and **Almeida Lima** at the University of Lisbon.
- They developed the **prefrontal lobotomy (leukotomy)**, which involved cutting connections between the **prefrontal cortex** and other parts of the brain.
- The aim was to reduce severe emotional disturbances by decreasing emotional intensity and abnormal thoughts.
- Later, lobotomy was widely criticized because of serious side effects and ethical concerns.
- Today, it is largely replaced by safer treatments such as psychiatric medications, electroconvulsive therapy (ECT), and modern techniques like **Gamma Knife surgery** and **Deep Brain Stimulation (DBS)**.

6. Molar vs Molecular (Lesson 13)

- The **Molar** view focuses on groups of networks, neurons, or neuroanatomical areas

- whereas the Molecular investigation focuses on single units, single cell, single molecule, single impulse and the brain behavior relationships.

In addition to the above there are many areas which form part of neuroscientific study i.e. neurohormonal influences on growth, development and subsequent expression and modulation of behavior, the role of sleep, dreams and how the brain controls these are also important in understanding brain behavior relationships. Behavioral neuroscience studies the brain-behavior relationship from a wide range of perspectives and specializations.

7. How Homo sapiens are Different from Other Organisms (Lesson 05 & 07)

- Upright walking
- Complex language
- Advanced tools
- Abstract thinking
- Larger cerebral cortex
- Developed societies and culture

Homo sapiens has several unique characteristics that distinguish humans from other animals.

First, humans are the only species with **true bipedalism**, meaning they walk upright on two legs. This required major changes in the pelvis,

spine, skull position, and visual system, and it helps humans travel long distances efficiently. Second, humans possess **highly developed language** as an integrated system of speech and communication. Human language is learned, refined, and supported by specialized areas of the cerebral cortex. Third, humans show **specialized social and family roles**, especially in early hunter-gatherer life, where females mainly cared for offspring while males often hunted or gathered food. Fourth, humans have the ability to **domesticate animals** such as camels, horses, cows, dogs, and chickens for survival and support. Fifth, humans live in **highly complex societies** with advanced social organization, culture, and cooperation. In addition, humans are capable of **abstract thinking, art, tool-making, and aesthetics**, as seen in prehistoric cave paintings. Unlike other species, humans can also engage in **warfare and murder without biological survival benefit**. Despite these differences, Homo sapiens still shares basic biological classification with other living organisms

HF Histology and Tracing Techniques (20 Marks)

Histology is the study of brain tissue used to verify the location of lesions, stimulation sites, cells, fibers, and neural connections after experiments. It helps researchers understand the **structure, location, and functional organization of the Central Nervous System (CNS)**. Histological examination is performed after the experiment when the animal is sacrificed and the brain is removed and sectioned.

Steps in Histology

1. Perfusion

The anesthetized animal's circulatory system is washed with **saline solution** through the heart to remove blood and prevent clotting.

2. Fixation

A **fixative (formalin/formaldehyde)** is then perfused through the heart. It preserves brain tissue by preventing degeneration and fixing proteins at the point of death.

3. Hardening the Tissue

The brain is hardened by **freezing** using a freezing microtome. Proper freezing is important because overly hard tissue becomes brittle, while soft tissue cannot be sliced properly.

4. Embedding

The brain is embedded in substances such as **nitrocellulose** to support the tissue and allow very thin sections to be cut.

5. Staining

Stains are applied to make specific cell structures visible under a microscope.

Important Stains

- Nissl Blue Stain

- Stains only **cell bodies** blue.
- Useful for studying neuron distribution.

- Weil Stain

- Stains **myelinated fibers** brown.
- Used to study nerve fiber pathways.

- Golgi-Cox Silver Stain

- Stains only 2–3% of neurons but completely.

- Reveals **cell body, dendrites, axons, and branches.**

- Histofluorescence

- Cells are exposed to formaldehyde gas.
- Different neurotransmitters fluoresce in different colors.
- Used to identify **dopamine and noradrenaline neurons.**

Tracing Techniques

Tracers are chemicals injected into a living animal to trace neural pathways, connections, learning processes, memory, and brain development.

Types of Tracers

1. Anterograde Tracer

- Travels **away from the cell body** toward axons and terminals.

- Used to trace outgoing neural projections.

2. Retrograde Tracer

- Travels **toward the cell body** from synapses.
- Used to identify neuronal connections and inputs.

Major Neuroanatomical Tracing Methods

1. Radio Labeling and Autoradiography

A radioactive substance is injected and later detected through its radiation.

Examples:

- **Radiolabeled Glucose (2-Deoxyglucose, 2-DG):**

- Enters active cells like glucose.
- Shows areas of high brain activity.

- **Radiolabeled Amino Acids and Endorphins:**

- Used to locate neurotransmitter activity and opioid receptor sites.

2. Horse Radish Peroxidase (HRP)

- An enzyme transported through neurons via retrograde transport.
- Traces connections from nerve terminals back to the cell body.
- Useful even for studying single neurons.

3. Histofluorescence

- Developed by **Falck** and **Hillarp** in the 1960s.
- Monoamine neurotransmitters glow under fluorescent light.
- Helps identify neurotransmitter locations and pathways.

4. Immunocytochemistry

- Uses **antigens and antibodies** to identify specific neuroproteins and neurotransmitters.
- Labeled antibodies bind to target molecules and become visible under a microscope.
- Highly useful for locating specific neurotransmitters and receptors.

1. Localization vs. Equipotentiality:

Among the major issues investigated in Behavioral Neurosciences is the localization of functions. Is it one area or a group of areas working together (you need to see or feel or estimate distances when walking), how do they “talk to each other and who listens to whom”? Are functions and neuroanatomical areas localized (specialized) or equipotential (all areas have similar capabilities) or is it a combination of both.

2. Nature vs nurture

This part is very important in psychology. 

Nature

Nature means behavior is influenced by genes and biology.

Nurture

Nurture means the behavior is influenced by environment and experience.

The correct view is that behavior usually comes from both.

Some behaviors are:

- **mostly innate,**
- **some are mostly learned,**
- **and many are a mixture of both.**

For example:

- A fruitfly shows mostly instinctive behavior.
- Human language has a biological basis, but the actual language learned depends on the environment.

So genes do not directly create a behavior fully by themselves. They provide a biological blueprint, and the environment helps shape how that blueprint develops.

Findings have shown that both Nature and nurture play a very important role in development. Till such time it would be appropriate to remember that both have important roles to play in the appearance, development, growth and expression of behaviors. 

3. Molar level vs. Molecular level:

The scope of behaviors studied in the neurosciences vary from microscopic to holistic levels,

Micro- (reductionism as it reduces behavior to its cellular component) **to macro** (holistic and more as a total than sub components). The behaviors studied under the micro level could be that of a cell, or components within a cell, its electrophysiological functioning, its ionic movements etc. Whereas **macro** could be a group of cells, or

neurochemical pathways or behaviors emanating out of neuroanatomical location or even behaviors of a Species.

Genetic variability vs inbreeding

Genetic variability is good because it increases the chances of healthy combinations of genes. **Inbreeding** reduces variation, so harmful recessive traits are more likely to appear.

Sex-linked, sex-influenced, and sex-limited traits

Sex-linked traits are usually carried on the **X chromosome**. Males are more likely to show them because they have only one X chromosome. Examples include **color blindness** and **hemophilia**.

Sex-influenced traits are inherited by both sexes, but one sex shows them more often because hormones affect expression, such as **baldness**.

Sex-limited traits are genes found in both sexes but expressed only in one sex because of hormonal differences, such as **milk production in females**.

One important correction: **Huntington's chorea is not sex-linked**; it is an **autosomal dominant** disorder. Also, **Turner syndrome is a chromosomal condition (XO)**, not a sex-linked trait.

Proteins: there are two kinds of proteins a) structural proteins those which determine

structure of the organism i.e., bones teeth, hair, organs b) enzymes; these modulate the

metabolism of the organism (and other physio-chemical events).

Genes express themselves in two ways:

1. Genotype: set of genes which form the underlying genetic makeup of the individual e.g. hair genes could be for straight or curly, brown or black hair.

2. Phenotypic: These are observable or measurable traits which form the outward expression of genetic basis after interaction with the environment. Behavior in all higher animals is more phenotypical as compared to lower animals.

Table 1: Important Contributors to Neurosciences

Nobel Prizewinner	Year	Contribution
Ivan Pavlov	1904	Digestive systems and their physiology
Camillo Golgi and Ramon Cajal	1906	Histological identification of the structure of Neurons and their connections
Charles Sherrington and Edgar Adrian	1932	Discoveries of neuronal functioning and reflex systems
Walter Hess	1949	Control of brain in behavioral expression
Egas Moniz	1949	Development of the prefrontal lobotomy technique
John Eccles, Alan Hodgkin and Andrew Huxley	1963	Ionic basis of neuronal conduction
Bernard Katz, Von Euler and Julius Axelrod	1970	synaptic transmission
Karl Von Frisch, Konrad Lorenz, and Nikolass Tinbergen	1973	Contribution to studies of animal behavior
Roger Sperry	1981	Brain Hemispheric differences
David Hubel and Torsten Weisel	1981	Information processing within the brain structures of visual system
Rita Levi Montalcini and Stanley Cohen	1986	Discovery of the Nerve growth factor
Erwin Neher and Bert Sakman	1991	Ionic Channels
Alfred Gilman and Martin Rodbell	1994	Discovery of G-protein receptors
Arvid Carlsson, Paul Greengard, and Eric Kandel	2000	Elaboration of Synaptic transmission

Source: From Pinel (2002) p 8.

Mendelian Genetics (Short Note – 5 Marks)

Mendelian Genetics is the study of heredity based on the experiments of Gregor Johann Mendel on pea plants in 1866. He discovered that traits are passed from parents to offspring through hereditary units called **genes**.

Main principles of Mendelian Genetics:

- Traits are inherited through genes passed from parents.

- **Dominant traits** are expressed in offspring, while **recessive traits** remain hidden unless inherited from both parents.
- Experience or environmental influences do not change hereditary units.
- The two forms of a gene are called **alleles**.
- An organism is **homozygous** when both alleles are the same and **heterozygous** when the alleles are different.
- Cell division involves **meiosis** (formation of gametes) and **mitosis** (growth and development after fertilization).

Later, Hugo de Vries introduced the concept of **mutation**, which is a heritable change in genetic material. Mutations may occur in a single gene or in chromosomes.

Do Environment Influences the Affect of Intelligence? (5 Marks)

Yes, the **environment has a significant influence on intelligence**. While genes provide the potential for intellectual development, environmental factors determine how fully that potential is achieved.

Important environmental influences include:

1. **Nutrition** – Proper nutrition is essential for normal  brain growth and development. Malnutrition can reduce intellectual performance.
2. **Education** – Access to learning opportunities helps develop cognitive abilities and problem-solving skills.
3. **Family and Social Environment** – A stimulating and supportive environment promotes intellectual growth.
4. **Experience and Learning** – Interaction with the environment helps develop and strengthen mental abilities.
5. **Health and Early Childhood Care** – Poor health or severe deprivation during childhood can negatively affect brain development and intelligence.

Stages of Development and Influences:

Immediately after embedding (implantation) of the fertilized egg onto the uterine wall Takes place, three germinal cell layers are formed from the increasing number of cells that have been dividing. All three germinal layers are exactly the same. The nervous system develops from one of these layers. These are known as the Ectodermal, the mesodermal and the endodermal cell layers. The **Endodermal** layer eventually forms the internal organs, **Ectodermal** layer forms the Brain cells and the Nervous system, and the **Mesodermal** forms the skeletal muscles

etc. How do these layers become different and develop in different direction would be discussed in the later section.

3) How scientists study genetic behavior

Researchers use:

Twin studies

- **Monozygotic (MZ) twins:** identical twins, share almost 100% of genes
- **Dizygotic (DZ) twins:** fraternal twins, share about 50% of genes

If MZ twins are more similar than DZ twins, genes likely play a strong role.

Adoption studies

These help separate **genetic influence** from **environmental influence**.

- If a child is more like biological parents, genes may matter more.
- If a child is more like adoptive parents, environment may matter more.

4) Schizophrenia and genes

Schizophrenia is a complex disorder and has a strong **genetic component**.

The risk is:

- about **1%** in the general population
- higher if a sibling or parent has it
- much higher in identical twins
- highest when both parents are affected

This does **not** mean genes are the only cause. The environment also matters, but heredity clearly increases vulnerability.

Environmental Influences on Intelligence (3 Marks)

Environmental factors can influence intelligence and IQ scores. A person's IQ score may change over time due to education, nutrition, learning opportunities, and living conditions, although this does not necessarily mean their innate intelligence has increased.

Studies in Israeli **Kibbutz** communities showed that children from different ethnic backgrounds initially had different IQ scores, but after living and learning in the same environment for several years, their scores became similar.

Research on twins also supports environmental influence.

Monozygotic (identical) twins raised together show very high IQ similarity, while those raised separately show slightly lower similarity. Correlations are lower for **dizygotic (fraternal) twins**, siblings, and unrelated individuals, indicating that both heredity and environment contribute to intelligence.

Stages of Development

Aristotle: studied the development of the chick brain and gave the concept of preformation- animals were preformed into the shape they were born. The zygote according to Aristotle is a mini-individual that grows from egg into shape and form of the animal.

Van Baer (1792-1876) Pre Darwinian evolutionary theorist provided evidence against preformation. Since he saw similarities in the various animal embryos he studied, he stated that young stages of higher animals resemble young stages of lower animals. That is to say that all embryos have the same shape and form. He further said that all animals higher up on the evolutionary scale go through the various developmental stages of the animals lower on the evolutionary scale.