Topic 1: Behavioural neuroscience: Genetics

1. What is behavioural neuroscience:

Behaviour refers to the response of an individual, group or species to a stimuli (trigger) from the environment. Behaviour is not constant across different species or entities due to 2 possible reasons; genetic composition and factors in the environment.

Genetic composition is a nature component that involves the evolution of an entity, often revolving around parental traits such as skin colour, height, intelligence, etc.

On the other hand, environmental factors involve learning and adaptation to experiences and stimuli. As such, it involves how people are feeling (emotion), how culture plays an influence on understanding and learning behaviours, etc.

2. What is a chromosome:

Chromosomes are compounds of genes located in every cell. It is known as the genetic material responsible for the driving of all cell functions. One of the most important cell functions a cell can perform includes the synthesis of protein molecules, which then can be either turned into tissue or transformed into neurotransmitters. Cells can be represented in two different ways:

Single strands is known as a single chromosome, represented as either a less than (<) or greater than sign (>).

Double strands are represented with 2 haploid cells. It is simply a single chromatid that is undergoing duplication (mitosis).

Humans have a total of 46 individual chromosome categories. Since chromosomes are often paired with other similar chromosomes, it is often represented that humans contain 23 pairs of unique chromosomes.

22 chromosomes of which are "human" chromosomes, the 23rd pair is the gender chromosome.

XX pair is female, XY pair is male. Through reasons discussed later, the Y chromatid within a male's gender chromosome decides offspring gender.

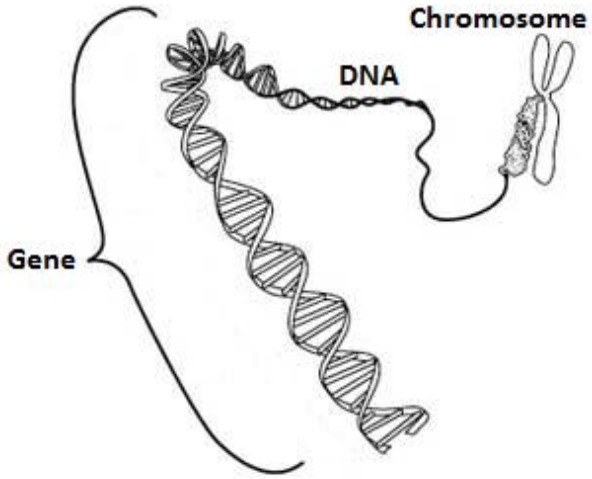
Of all chromosomes, each sister chromatid is from each parent, i.e.

$$XX \rightarrow X_{Dad}+X_{Mum}$$

3. Chromosome composition:

Genes are regions of deoxyribonucleic acid (DNA) passed on from one generation to another. This is called hereditary. Genes are composed of "base pairs"; nucleotides that bind to form a helix of a DNA strand. A gene is a certain region of this DNA strand, that is:

Nucleotides → Genes → DNA → Chromosomes.



Chromosomes are located in the nucleus of cells in animals and plants. The nucleus of the cell contains all genetic information to promote the survival and reproduction of cells. Chromosomes also aid in the production of various proteins, using amino acids obtained from diets during the synthesis process.

Essential amino acids include:

i. Histidine – production starts at later ages
ii. Isoleucine
iii. Leucine
iv. Lysine – comes from beans and meat
v. Methionine
vi. Phenylalanine
vii. Threonine
viii. Tryptophan – comes from turkey and sesame seeds
ix. Valine

4. Protein synthesis:

Deoxyribonucleic acid is composed of 2 nucleotides. When a DNA strand replicates itself, ribonucleic acids copy one strand of the DNA helix. This process is called "transcription".

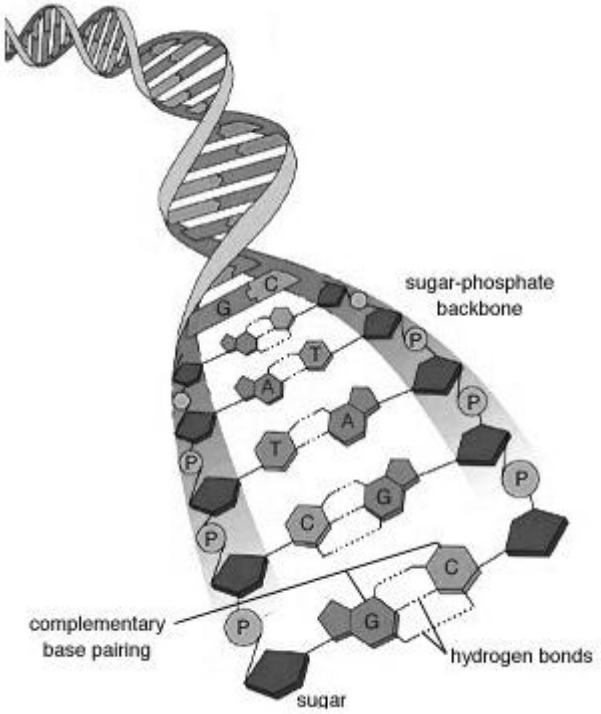
In order for RNA to produce proteins, it determines triplets of of nucleotides to a certain amino acid.

A chain of amino acids (formerly known as a peptide) is then added to another peptide to form a polypeptide. Chains of polypeptides then finally produce a protein molecule.

DNA → RNA → Amino acid → Peptide → Polypeptide → Protein

Through this, outputs of proteins are then responsible for the formation of body structures in the form of tissue, or the decomposition of matter in the form of enzymes. The sequences of nucleotides are the determining factors of the function of the protein molecule.

That is, AAC triplet nucleotides would produce different functioning proteins to proteins produced from ACA triplet nucleotides.



Therefore as a recap, the importance of proteins are high as proteins can readily transform into bodily tissues, enzymes and neurotransmitters. Genetic life cycles of proteins therefore could be depicted below:

$$DNA \xrightarrow{transcription} > RNA \xrightarrow{translation} > Peptides \rightarrow Polypeptides \rightarrow Protein$$

5. Mitosis vs. meiosis:

Chromosomes often undergo splitting and replication to produce new chromosomes. This process is often observed in reproduction. These processes provide advantages to the cell such as genetic diversity as well as versatility of heritable traits.

Mitosis refers to the process of direct replication of haploid cells.
Meiosis refers to the splitting of haploids to pair new diploid cells.
Meiosis comes in two stages;

i. Meiosis stage 1 – splitting of haploid chromosomes
ii. Meiosis stage 2 – splitting to diploid chromosomes

Note meiosis is only possible during sexual reproduction, i.e. to produce the 23rd pair of chromosomes. Any genetic mutation (for the better or worse) is a result from the failure gene reproduction of these processes. Since meiosis is only seen in sexual reproduction, each stage is represented below.

6. Heterozygous vs. homozygous:

If a chromosome pair contains 2 of the same genes it is said to be homozygous, that is if genes are XX. Conversely if a cell contains 2 different chromosomes, it is heterozygous; if cells are XY for example.

Homozygous – 2 of same chromosome

Heterozygous – 2 different chromosomes

Additionally, genes are categorized into recessive and dominant depending on the characteristics of the cell and the nature (if homozygous or heterozygous). A recessive gene could only exhibit its characteristics if there are 2 of the same chromosome (homozygous).

For example, a recessive blue eye gene would only portray blue eyes if both haploid cells were blue eyed (homozygous blue).

Contrastingly if genes are recessive in a heterozygous pair of chromosomes, characteristics of the dominant chromosome are shown. Simply put, cells would exhibit characteristics if there is only one dominant chromosome.

7. Genetic mutations: Peppered moths

During the times of the industrial revolution, soot released from factory procedures resulted in tree's gradually turning darker and black. Peppered moths, of which were generally white, increasingly became preys, leaving moths with darker genetic compositions to reproduce. Eventually the extinction of white genetic compositions lead to the permanent colour mutation of peppered moths. Seeing this, it was speculated that environmental factors can impact on genetic reproduction –and hence mutation- as well as hereditarily factors from ancestral factors. Given that ancestral genes are dormant, scientists questioned if it was possible to "activate" a certain dormant gene. Altering processes such as translation of micro-ribonucleic acid (mRNA) or ribonucleic acid interference genes (RNAI) have been commonly associated with the mediation of gene activity. Natural genetic mutation processes such as epigenetics can also alter the reproduction of genes, allowing environmental factors to alter the translation of DNA sequences that are meant to be translated into proteins.

8. Heritability:

Since behaviour is an output of our genetic makeup as well as the environmental influences that can interfere with genetic reproduction, genes are known to be highly heritable if environment has little effect on traits. That is, environmental factors have little to no influence on traits such as intelligence, eye colour etc. On the contrary if a trait is said to be lowly heritable it is more likely to be a result of environmental factors, such as learned behaviour. Since natural selection proposes that each gene may be kept or eliminated to assist in the survival of a species,

genetic traits passed on through breeding are selectively "kept"; that is, highly heritable traits are most likely to be passed onto offspring. Equally, environmental influences also configure behaviour of humans to aid in survival.

Recap of topic 1:

Biopsychology and learning is the study of how, when and why we behave in certain ways in the environment. It analyses the genetic interaction between behaviour and environment. The brain communicates and translates information to behaviour through chemical reactions underlying the significant nature of chemistry in biopsychology.

Imbalances in chemical compounds cause mental disorders, and by studying these involve the discovery of cures and treatments. Simply put, biopsychology (also known as behavioural neuroscience) is the study of biological mechanisms that mediate behaviour.

Protein synthesis flowchart:

$$\boldsymbol{Nucleotides \rightarrow Genes \rightarrow DNA} \xrightarrow{\boldsymbol{transcription}} \boldsymbol{> RNA} \xrightarrow{\boldsymbol{translation}} \boldsymbol{> Peptides \rightarrow Polypeptides \rightarrow Proteins}$$

Since diet can affect the abundance of amino acids expressed in the chain, where differing sequences of amino acids to form peptides determine the function of that protein molecule. Proteins can either turn into:

i. Tissue
ii. Enzymes
iii. Neurotransmitters

Reproduction of cells:

Cells can be reproduced in two different ways;

i. Mitosis – involves the direct duplication of diploid cells
ii. Meiosis – involves the breaking down to haploid cells before recombining to diploid cells
    – Meiosis comes in two stages:
        i. Meiosis stage 1: splitting of diploids
        ii. Meiosis stage 2: splitting diploids to haploids
    – Meiosis only occurs when sexual reproduction occurs

Since males have an extra genetic component (Y genes), it is the males that determine the sex of the offspring.

Topic 2: The nervous system

1. Appropriate brain conditions:

To discuss how the nervous system works, it is important to highlight how the brain functions. In early years, the brain was expressed as the "big black box", often only depicting how brains communicate to different organs and not the other way around. The brain requires a very specific set of conditions for it to function optimally. These conditions include:

Consistent temperature regulation between 37.2*C-38*C

Consistent power of hydrogen regulation around 7.4pH

Consistent functioning of waste removal of toxins such as carbon dioxide, brain waste, cerebrospinal fluid recycling, etc.

It is important to acknowledge that cells do <u>not</u> operate properly if any of these conditions are abnormal. For example, cells can only operate under specific pH levels. If the levels are too acidic (acidosis), pH causes cells to stop sending messages entirely. On the other hand, if conditions are to basic (alkalosis), pH causes cells to fire uncontrollable messages.

Acidosis leads to termination of firing

Alkalosis leads to uncontrolled firing

Death of cells starts to occur once pH exceeds 6.8-8pH. To prevent this, the body has acid-base homeostatic mechanisms such as:

Respiratory functions to maintain pH through releasing CO_2 to maintain H+ ions

Cardiovascular system functions acting as buffering systems, turning ions in the bloodstream to turn acidic if blood gets too basic, and basic if blood gets too acidic

Kidney's also contribute to pH levels as it alters electrolyte levels, consequently changing H+ ions

These three mechanisms help maintain pH levels for cell optimal performance.

2. The central nervous system and peripheral nervous system:

The nervous system is the system that consists of cerebrum, cerebellum, brainstem and spinal cord. All the nerves outside of this region are considered a separate system; more specifically the peripheral nervous system. While the central nervous system is responsible for most bodily functions including motor output, peripheral nervous systems are commonly associated with both voluntary (somatic nervous system) and involuntary (autonomic nervous system) functions.