

## Criterion 3 biological inquiry and evaluation of data

### Definitions

**Independent variable** – the thing the experimenter deliberately varies.

**Dependent variable** – the thing the experimenter measures.

**Trial experiments** conducted in a confined situation (laboratory/greenhouse) need to precede field investigations.

**A replica** is multiple identical groups within the one experiment.

**A repeat** is doing the experiment again at a future time.

**A follow up experiment** is one which builds on the original experiment in some way.

### Experimental design

#### Formulating a Hypothesis

Your hypothesis should:

1. be feasible (ie: be sensible and based on scientific concepts)
2. be a statement (not a question)
3. be based on observations
4. involve one independent and one dependent variable in a cause-and-effect relationship
5. be testable and measurable in a way that demonstrates cause and effect.

#### Designing an Experiment

State the hypothesis to be tested (unless already stated):

1. State the independent variable and how it is manipulated
2. State the dependent variable and how it is measured.
3. Describe the procedure clearly in a step-by-step fashion which could be easily followed in a laboratory or the field:
  - Indicate **sample sizes**, quantities of materials and time involved

- Indicate how many replicas there are (if needed)
  - Describe which variables are **controlled** and how. Say **why fixed variables are needed**.
  - Include factors relevant for the organism – biotic and abiotic relevant in the environment
  - Identify what is the **control group** in the experiment and **why** is it needed.
4. State how the results are analysed
  5. Indicate any repetitions of the experiment.

#### If required:

6. State what results would support the hypothesis and what results would not support the hypothesis
7. Discuss any foreseeable problems in conducting the experiment:
  - variables difficult to control, sample size issues, ethical issues, animal vs human experimentation/environmental impacts etc.

#### Designing Experiments with Humans

Designing experiments with humans as subjects is not straightforward because there are a number of areas over which the experimenter has no control.

The impact of these unfixed/uncontrolled variables can be reduced by a number of factors including:

- use of placebos
- double-blind experiments/trials

**Ethical aspects** need to be considered.

### Evaluating experiments

**Valid experiment** – Validity refers to whether your results measure what your investigation set out to measure.

**Reliable experiment** – If results of an experiment are consistent across many repetitions, then the experimental results are deemed reliable.

## Criterion 5 – regulation of biological systems

### Enzymes

Proteins which speed up (catalyse) the chemical reactions which occur in organisms. They are “biological catalysts”.

#### Types of enzymes

Enzymes fall into two types of categories:

1. **Intracellular enzymes:** these occur inside cell and catalyse metabolic reactions
2. **Extracellular enzymes:** these occur outside cells and catalyse reactions involved in digestion.

Enzymes are also classified according to the type of substance on which they act.

### Cell respiration

An energy-releasing process which yields ATP molecules.

ATP – Adenosine

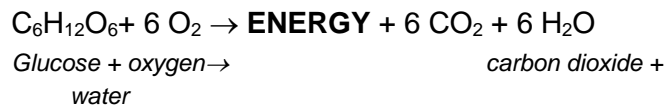
triphosphate

ADP – Adenosine

diphosphate

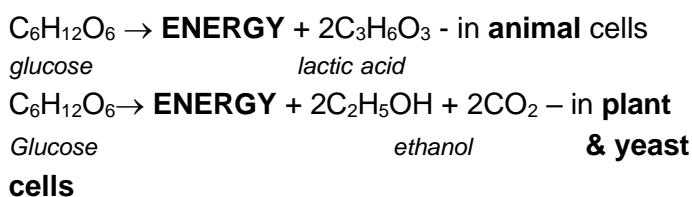
#### a) AEROBIC RESPIRATION

Overall Equation:



#### b) ANAEROBIC RESPIRATION

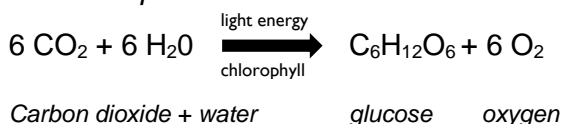
Overall Equation:



### Photosynthesis

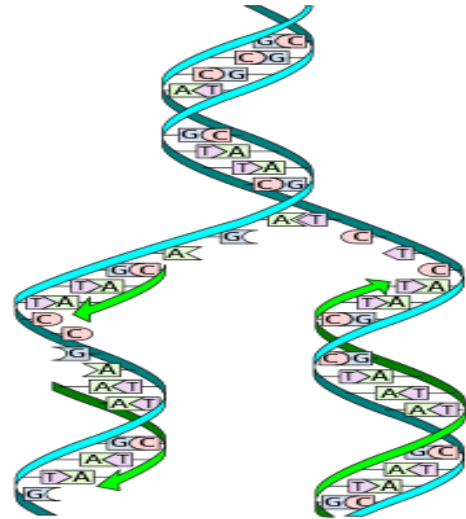
- an energy conversion process
- light energy is converted “chemical” energy.

Overall Equation



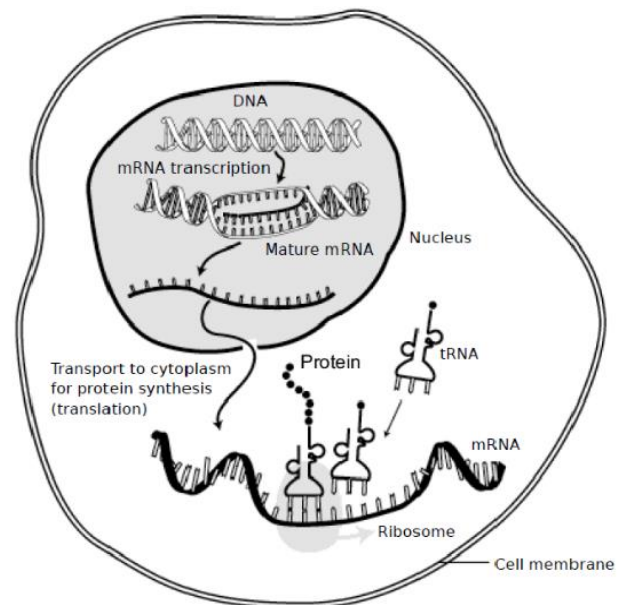
### DNA replication

The process by which DNA makes a copy of itself during cell division.



### Protein synthesis

Process of making proteins in the cell.



### Gene expression

Exons are termed nucleic acid coding sequences, which are present in mRNA. Introns are the non-coding sequences present in the mRNA, which are removed by RNA splicing before translation.

#### Lac operon

The lactose operon (also known as the lac operon) is a set of genes that are specific for uptake and metabolism of lactose and is found in E. coli and other bacteria.

**Mutations** – A change in the sequence of nucleotide bases of the genetic material (**DNA or RNA**).

## Criterion 5 – regulation of biological systems

### Codon Chart

**Codon Chart**

Second Position

		Second Position					
		U	C	A	G		
First Position	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } Ser UCC } UCA } UCG }	UAU } Tyr UAC } UAA } <b>STOP</b> UAG } <b>STOP</b>	UGU } Cys UGC } UGA } <b>STOP</b> UGG } Trp	U C A G	
	C	CUU } Leu CUC } CUA } CUG }	CCU } Pro CCC } CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } Arg CGC } CGA } CGG }	U C A G	Third Position
	A	AUU } Ile AUC } AUA } AUG } Met	ACU } Thr ACC } ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G	
	G	GUU } Val GUC } GUA } GUG }	GCU } Ala GCC } GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } Gly GGC } GGA } GGG }	U C A G	

## Criterion 6 – homeostatic regulation

### Nervous system

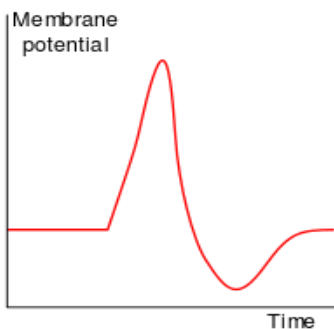
The **nervous system** is a complex network of neurons and cells that carry messages to and from the brain and spinal cord to various parts of the body.

#### Neuron

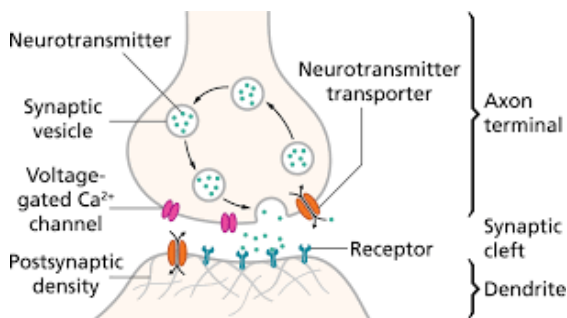
Neurons are electrically excitable cells that transmit signals throughout the body. Neurons employ both electrical and chemical components in the transmission of information. Neurons are connected to other neurons at synapses and connected to effector organs.

#### Action potentials

An action potential is a rapid sequence of changes in the voltage across a membrane. The membrane voltage, or potential, is determined at any time by the relative ratio of ions, extracellular to intracellular, and the permeability of each ion.



### Synapses



### Endocrine system

The endocrine system is a messenger system in an organism comprising feedback loops of hormones that are released by internal glands directly into the

circulatory system and that target and regulate distant organs.

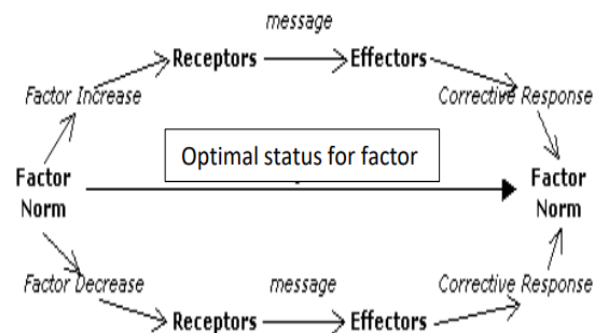
**Gland** – a secretory tissue that produces hormones for release into the blood.

**Hormone** – regulatory substance produced by an endocrine gland and carried by the blood to target cells where they have their effect.

### Homeostasis

Involves a stimulus-response model in which change in external or internal environmental conditions is detected and appropriate responses occur via negative feedback.

#### Homeostasis negative feedback mechanisms



**Negative feedback** – a change which reverses the effect of a particular stimulus to maintain stability.

#### Water balance

- **Osmoregulation** – the active regulation of the osmotic pressure of an organism's body fluids, detected by osmoreceptors, to maintain the homeostasis of the organism's water content.
- **Transpiration in plants**  
The physiological loss of water in the form of water vapour through evaporation from the plant.

#### Glucose regulation

- The process by which the levels of glucose dissolved in blood plasma, are maintained by the body.

#### Thermoregulation

- Thermoregulation is the maintenance of core body temperature in endothermic animals by balancing heat generation with heat loss.

## Criterion 7 – pathogens and immune responses

### Types of pathogens

#### Pathogenic agents

- Prions
- Viruses

#### Pathogenic organisms

- Bacteria
- Fungi
- Protists
- Parasites

### Transmission of diseases

- Direct contact
- Body fluids
- Food
- Water
- Air
- Vectors

### Immune responses

#### Innate Responses

These target pathogens, including through the inflammatory response, which involves the actions of phagocytes.

- **First Line of Defence** - Structural, chemical and biological features can act as barriers to pathogens as a first line of defence.
- **Second Line of Defence**
  - **Phagocytosis** – Phagocytosis is the process by which a cell uses its plasma membrane to engulf a large particle such as a bacteria or virus.
  - **Phagocytic cells** – attracted to site of infection and involve phagocytosis.
  - **Inflammatory response** – Occurs when cells are damaged by physical injury or invading organisms.

#### Adaptive Responses

These lead to the development of humoral immunity through the production of antibodies by B lymphocytes and the provision of cell-mediated immunity by T lymphocytes.

- **Third Line of Defence**

- **Lymphocytes** – specialised white blood cells that respond to specific antigens.
- **Antibodies** – large protein molecules made up of four polypeptide chains arranged in the shape of a Y. Produced in response to and counteracting a specific antigen.
- **Memory cells** - long-lived immune cells capable of recognizing foreign particles to which they were previously exposed.
- **Antigens** – a toxin or other foreign substance which induces an immune response in the body, especially the production of antibodies.

### Types of immunity

	Active	Passive
Natural	Memory cells produced in response to an infection with a pathogen	Antibodies passed from mother to child via placenta or breast milk. No memory cells produced.
Artificial	Memory cells produced in response to a vaccine	Antibodies delivered via a serum. No memory cells produced.

## Criterion 8 – cell division, genetics and evolution

### Cell division

**Cell cycle** – is a series of events that takes place in a cell as it grows and divides.

*There are two types of division:*

**Mitosis** – process of cell division in which daughter cells are identical to parent cells. Process used in growth, repair and replacement of cells.

**Meiosis** – process of gamete (egg and sperm) production in most organisms. Gametes contain half the number of chromosomes as parent cells.

### Reproduction for continuity

**Asexual Reproduction** – production of daughter cells (offspring) which are genetically identical to the parent cell.

**Sexual Reproduction** – involves fertilisation where 2 gametes (sex cells) join to form a zygote.

### Genetics

#### Definitions

**Gene** – a section of DNA that codes for the production of a protein.

**Chromosome** - a threadlike structure of nucleic acids and protein found in the nucleus of most living cells, carrying genetic information in the form of genes.

**Allele** – a particular form of a gene

**Homozygous** – when an individual has 2 copies of the same allele, they are said to be homozygous for that gene.

**Heterozygous** – when an individual has 2 different alleles for a particular gene, they are said to be heterozygous for that gene.

**Monohybrid cross** – a cross between two individuals that differ in only one observed trait.

**Autosome** – chromosomes not associated with the sex chromosomes. There are 22 in humans.

**Sex chromosomes** – X and Y (in humans) - determine the sex of an individual.

### Evolution

Evolution is change in the gene pool of a population over time.

**The mechanisms of evolution** - (mutation, genetic drift, natural selection, non-random mating and gene flow) allow a population, a group of interacting organisms of a single species, to exhibit a change in allele frequency from one generation to the next.

**Species** – is a population of organisms that can potentially interbreed under natural conditions to produce fertile offspring.

**Speciation (Macroevolution)** – begins when gene flow is prevented by isolating mechanisms within a population of a species. Thereafter, the mechanisms of evolution operate independently in each population and lead to irreversible genetic divergence of one from the other.

**Microevolution** – change that occurs within a species due to the mechanisms of evolution. This process leads to a change in allele frequencies within the population – eg: bacterial resistance to antibiotics.