Biology: Control of Gene Expression

Mutations

Addition or deletion	Adding an extra nucleotide base or removing one
Substitution	One nucleotide is switched for another.
Inversion	When two breaks occur in one chromosome, sometimes the region between the breaks rotates 180 degrees before re joining with the two end fragments.
Duplication	A sequence of nucleotide bases is duplicated.
Translocation	The movement of a sequence of nucleotide bases from one chromosome to another
Frameshift	Following an insertion or deletion the whole nucleotide sequence moves because the number of nucleotides affected is not divisible by 3

DNA is **degenerate** – more than one triplet codes for the same amino acid – which means a mutation may not always be a problem.

Cancer

benign	A growth that is not **cancer**. It does not invade nearby tissue or spread to other parts of the body. The tumour can negatively affect health.
malignant	A **tumour** that invades surrounding tissues, is usually capable of producing metastases, may recur after attempted removal.
metastasis	Cancer cells detach from the malignant tumour and travel to other areas where more tumours develop.

Correlation

Correlation coefficient
+ve coefficient – both factors increase
-ve coefficient – one factor increases as the other decreases
Causal link – one factor causes the other
Usually more information is needed to be certain of causal link.

Stem Cells

Totipotent	Can differentiate into any type of cell causing cell specialisation by expressing any gene. Have this potential for approx. 4 days in a human embryo.
Pluripotent	Found in mature mammals and can differentiate into nearly all new cell types.
Multipotent	Found in mature mammals and can differentiate into fewer new cell types.
Unipotent	Can differentiate into only one new cell type
Induced pluripotent (iPS)	Derived from skin or blood cells that have been reprogrammed back into an embryonic-like pluripotent state that enables them to be an unlimited source of any type of human cell needed for therapeutic purposes.

Gene Expression

A gene – a section of DNA that can be transcribed into a protein – transcription is controlled by factors

Control by transcription factor e.g. oestrogen	Hormone moves into nucleus from cytoplasm and starts transcription of a gene.
Epigenetic control - where a factor **other than** the nucleotide base sequence of the DNA decides if that gene can be expressed and transcribed or not.	
Epigenetic control : Increased DNA methylation	**Methylation** holds the DNA so tightly on the histone that it cannot be unzipped and read during protein synthesis.
Epigenetic control : decreased acetylation	**Acetylation** of histones controls how easily DNA can be transcribed so decreased acetylation helps transcription
Control by **RNA interference (RNAi)** or **Silencer RNA (siRNA)**	- where the job of mRNA in transcription is inhibited by another molecule - as a result this **STOPS protein synthesis** so the gene is not expressed

Gene Expression and cancer

Tumour suppressor genes	**Tumour suppressor** genes **slow cell division** and cause apoptosis to destroy cells with damaged DNA. **Apoptosis** is pre - programmed cell death, important in cell renewal and development. Mutation in the TS gene will interfere with the rate of the above processes.
Oncogenes	**Proto oncogenes** code for proteins that help regulate cell growth. A mutation in the DNA of the **proto-oncogene** changes it to an **oncogene**, which produces a different protein and interferes with normal cell regulation. Cell growth occurs out of control.
Oncology	The study of Cancer Scientists can use the knowledge about transcription factors, epigenetics and gene expression to prevent, treat and cure cancer

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DNA Technology

Recombinant DNA technology – transferring DNA between species.

1. To **AMPLIFY** the amount of DNA available for use in further study
2. To harvest a protein product when the gene is expressed

Amplification methods:

In vivo

- Put in **host** cells using **vectors**
- Host cells **transformed**
- **Marker genes** detect host cells transformed
- DNA is amplified then useful gene is extracted
- Or host kept alive and product of gene expression is extracted

Eg: Making insulin

In vitro

- **PCR** - Polymerase chain reaction
- **Primers** added
- Series of heating and cooling in the process
- 1000's of fragments of DNA copied
- Total DNA produced = 2^n

  2 = DNA after 1 cycle

  n = number of cycles

Eg: Forensic evidence

Key Enzymes and Vocabulary

DNA helicase	Unzips the DNA helix by breaking the hydrogen bonds between strands
DNA or RNA polymerase	Synthesises the DNA or RNA polymers by joining DNA or RNA molecules
Restriction endonuclease	Cuts DNA into restriction fragments. Cutting at restriction sites. The sites can give 'blunt ends' or 'sticky' (staggered) ends to the restriction fragments.
DNA ligase	Joins together restriction fragments of DNA. Blunt end to blunt end. Sticky end to sticky end.
Reverse transcriptase	Creates cDNA (complementary DNA) by making DNA from mRNA. Reversing the transcription process
Amplify	To make more copies of DNA
Transform	To change the genetic material of one organism by adding DNA/genes from a different organism or different species.
Primer	A **primer** is a short, single-stranded **DNA** fragment used in the polymerase chain reaction (PCR) technique. It binds to the sample DNA fragment and allows the amplification of the DNA to start.
VNTR	Variable number tandem repeat is a repeating sequence of nucleotide bases that are **highly unique** to one individual so the chances of two individuals having the same VNTR's is very low.
Hybridize	When single stranded DNA from 2 different organism **can join** together to make double stranded DNA because the nucleotide base sequence is **complementary**.

Studying DNA

Genetic fingerprinting (also called profiling)	DNA sample or amplified sample is analysed by distance moved by fragment due to it's size using **Gel Electrophoresis**. Looking at the matching of **VNTR's (variable number tandem repeat)** DNA sequences
DNA probe	Short, single stranded DNA fragment that will make a **complementary, hybridization** with DNA being studied
Automated DNA sequencing	**Sanger sequencing**. Method similar principles to Gel electrophoresis but uses colour modified nucleotides called **ddNA** attached to the sample DNA fragments which can be read by a laser and DNA sequence profiled more precisely.

Studying DNA—applications

Forensic evidence – crime scene
Medical diagnosis – finding faulty genes in patients
Animal and plant breeding – breeding better variants
Paternity – identifying unknown father
Cladistics – identifying DNA links between newly discovered and existing or ancient species

Genome -the complete set of genes or genetic material present in a cell or organism

Proteome -the entire complement of proteins that is or can be expressed by a cell, tissue, or organism.