HSC Biology
Core 2 – Blueprint of Life

Focus 4

- *The structure of DNA can be changed and such changes may be reflected in the phenotype of the affected organism.*

Describe the process of DNA replication and Explain its significance.

The Process of DNA Replication;

- DNA;
  - Double stranded molecule.
  - Twisted into helix.
  - Each strand;
    - Sugar – phosphate backbone.
    - Bases attached.
      - **A**denine-**T**ymine.
      - **C**ytosine-**G**uanine.
- A unit made of deoxyribose sugar, phosphate molecule, 1 of 4 nitrogen bases.
  - Each unit: **Nucleotide**.
  - Nitrogen bases form rungs of DNA double helix.
- Along DNA molecule;
  - Sequences of genetic code, made up of bases.
  - Replication of sequences account for replication of genetic code of an organism.
- DNA replication;
  - DNA double helix unwound by an enzyme.
  - DNA unzips, forming 2 single strands.
    - Bonds break between each helix.
    - Forming **Replication Fork**.
  - Binding proteins prevent strands rejoining.
  - Complementary copy of strand constructed.
    - From new sugar-phosphate-base units.
    - Process catalysed by enzyme DNA polymerase.
  - One strand built as a continuous strand.
  - Other built by linking DNA fragments (Okizaki frags) together.
- 2 double stranded molecules chromatids.

The Significance of DNA Replication;

- Genetic info passed from generation to generation**.**
  - During reproduction:
    - Genetic code copied.
    - ½ passes into each cell (gametes).
    - New organism contains ½ genetic info from each parent.
- Identical copy of gene can be made.

Outline, using a simple model, the process by which DNA controls the production of polypeptides.

- Polypeptide synthesis involves nucleotide; RNA.
  - Intermediary between DNA & polypeptide synthesis.
  - Single strand of nucleotide bases.
  - Consists of;
    - Ribose sugar.
    - Thymine replaced by Uracil.
      - Combines with Adenine.
- 2 types RNA involved in polypeptide synthesis;
  - **Messenger RNA (mRNA).**

  - Carries info from DNA in nucleus to ribosomes in cytoplasm.

- **Transfer RNA (tRNA).**
  - Brings A.A.'s to ribosomes to be linked together to build a protein.
  - 20+ types of tRNA.
    - Different type for each A.A.
  - Each contains anticodon which recognises & is complementary to a codon on mRNA

- In the nucleus;
  - DNA molecules unzip.
  - DNA code transcribed into single stranded mRNA molecule.
    - Enzyme RNA polymerase provides required energy.
  - mRNA moves into cytoplasm, attaches to a ribosome.
- In cytoplasm;
  - mRNA translated into A.A.'s.
- At ribosome;
  - mRNA lines up.
    - Forms a template.
  - A group of 3 bases;
    - A **CODON**.
      - Codes for a specific A.A.

- Codes for starting & stopping chain formation.
  - AUG:
    - Starting point for translation.
  - tRNA;
    - Has **ANTICODON**;
      - Non A.A. forming codon.

  on one end & an A.A. on the other end.
- Polypeptide formed when;
  - Each A.A. added from tRNA to a chain following sequence on mRNA.

Explain the relationship between proteins and polypeptides.

- Polypeptide:
  - Made of a chain of 2 or more A.A.'s.
- Protein:
  - Made of one or more polypeptides.

Explain how mutations in DNA may lead to the generation of new alleles.

- Mutation;
  - Change in DNA info on a chromosome.
- Any change to base sequence in DNA results in changes to polypeptides produced.
  - Source of new alleles.
- To produce new alleles;
  - Mutation must occur in sex cells or organism.
  - Passed onto next generation.
- Mutations in body cells;
  - Change organism.
  - Not passed on.
- Changes in DNA sequences occur when;
  - One base replaced by another.

  Eg. A in place of C
    - Causes change in code for A.A.

  - Extra nucleotide added to the 3-base code sequence.
    - Whole sequence of A.A.'s changed.
    - Structure changed.
      - Protein synthesis significantly altered.
    - Chromosome broken / rearranged.
- Types of DNA change:
  - **Deletion**
    - Some of DNA lost from chromosome.
  - **Duplication**
    - Extra copy of a sequence made on a chromosome.
  - **Inversion**
    - DNA sequence breaks, reattached in wrong way.
  - **Translocation**
    - DNA joins to another chromosome.
  - **Amplification**
    - Many extra copies of DNA made on a chromosome.
  - **Positive effect**
    - Changed DNA sequence affects genes next to or near it.

Discuss evidence for the mutagenic nature of radiation.

- Much evidence for mutagenic nature of radiation.
- Enviro factors that increase rate of mutation;
  - X-rays.
  - Radiation from A bombs.
  - U.V. light.
- Mutagen;
  - Natural / man-made agent (phys / chem) which can alter structure / sequence of DNA.
  - Can be;
    - Carcinogens:
      - Cancer causing.
    - Teratogens:
      - Birth defect causing.
- Radiation 1st mutagenic agent known.
  - Effects on genes first noticed in 1920's.
  - When X-rays discovered:
    - Thought to be harmless.
    - Were a great novelty.
    - Able to buy 'home X-ray' machine for entertainment.
  - Most first generation scientists working with radiation died of cancer.
    Eg. Marie Curie & daughter died of leukemia.
- Hans Muller:
  - Received Nobel Prize 1927:
    - Showing genes had ability to mutate when exposed to X-rays.
- Beadle & Tatum:
  - Used X-rays to produce mutations in bread mould to formulate 'One gene, one polypeptide' hypothesis.
- A bombs dropped on Hiroshima & Nagasaki:
  - Increased evidence of mutations from radiation.
  - Large increase of cancer deaths directly after bombs dropped.
- Mutagens may cause death in individual.
  - Unless affect sex-cell, cannot be passed on to offspring.

Explain how an understanding of the source of variation in organisms has provided support for Darwin's theory of

evolution by natural selection.

- One foundation pillar for theory of evolution:
  - Variation occurs among individual members of a species.
  - Selection acts upon variation.
  - Mutation of DNA provides source for variation;
    - Supporting Darwin's theory for evolution.

Describe the concept of punctuated equilibrium in evolution and how it differs from the gradual process proposed by Darwin.

- Darwin's theory of gradual evolution:
  - Evolution over long period of time.
  - Little change in organism.
  - Followed by short period of rapid changes.
- Punctuated equilibrium:
  - Sudden process.
    - Rather than slow, gradual change.
- Evidence derived from fossil records:
  - Mass extinctions.
  - Appearance of new species.

Analyse information from secondary sources to Outline the evidence that led to Beadle and Tatum's 'one gene – one

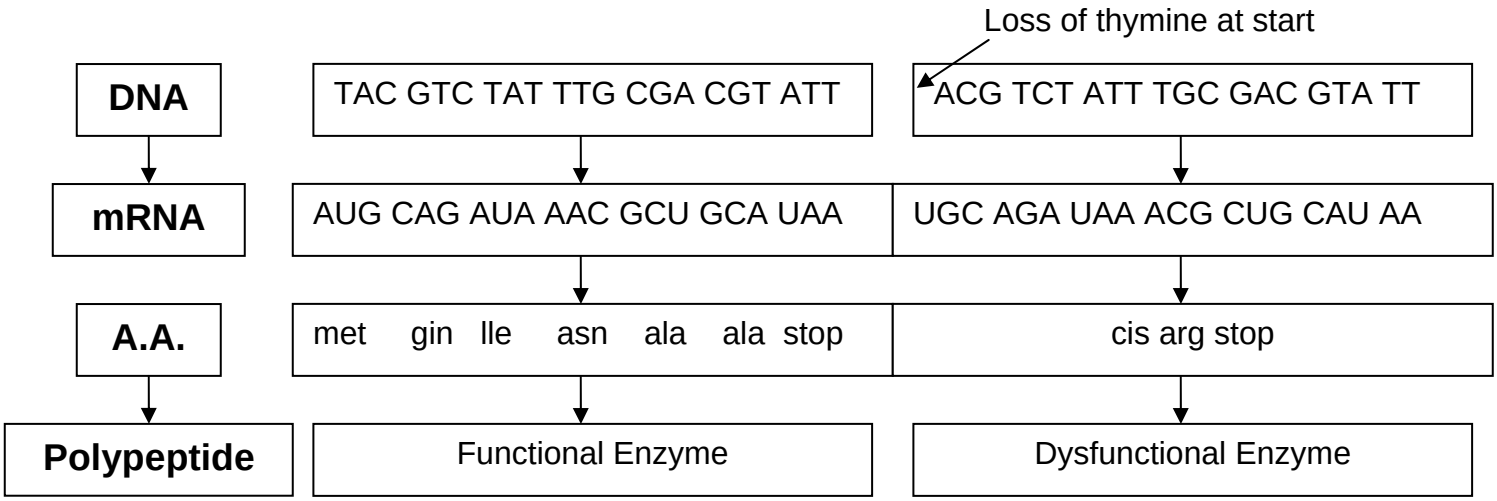
protein' hypothesis and to Explain why this was altered to the 'one gene – one polypeptide' hypothesis.

- Beadle & Tatum:
  - Developed techniques to;
    - Screen.
    - Detect.

  nutritional mutants in pink bread mould (Neurospora crassa).
  - Mutated mould created by x-rays.
  - Each strain lacked ability to produce particular a.a. or vitamin.
  - Showed link between biochemical processes & genes.
  -Suggested 'one gene – one enzyme' hypothesis.
    - Each biochemical reaction controlled by a gene.
    - May be true for some enzymes, not all.
- Altered to '**one gene – one polypeptide**' hypothesis.
  - 1 gene is the portion of DNA specifying single polypeptide chain.
  - Several genes usually required to specify enzyme involved in biochemical process.
    - Even simple pathways.

  Eg. Enzyme tryptophan synthetase consists of 2 structurally different protein chains.
    - Produced by different DNA segments.

Process information to Construct a flow chart that shows that changes in DNA sequences can result in changes in cell activity.



- Cell activity controlled by:
  - Enzymes;
    - Formed from chains of polypeptides.
      - If chain is not in right sequence:
        - Enzyme formed = dysfunctional.
  - Diagram above demonstrates a premature stop.

Process and Analyse information from secondary sources to Explain a modern example of 'natural' selection.

- Insecticide resistance in insect pests.
  - Species laying large numbers of eggs.
  - Reproduce several times in a mating season.
    - Insect species.
- More likely to have offspring with genetic mutation.
  - Can result in genetic mutation for survival.
- Natural pop. of insects;
  - Variety of characteristics.
  - By chance, some insects more resistant to insecticide.
- When insect pop. first sprayed:
  - Most will die.
  - Those with genetic resistance survive.
- Resistant insects reproduce.
  - Pass on genetic characteristics.
  - Some inherit resistance, others don't.
- Proportion of resistant insects increases with each generation.

Process Information from secondary sources to Describe and Analyse the relative importance of the work of:

- **James Watson**
- **Francis Crick**

- **Rosalind Franklin**
- **Maurice Wilkins**

in determining the structure of DNA and the impact of the quality of collaboration and communication on their scientific research.

- Discovery of structure of DNA in 1953:
  - Most significant scientific achievement of 20th Century.
  - Example of how scientists collaborate work, internal conflicts & clashes influence effective communication in scientific research.
- Main scientists responsible for discovery;
  - Rosalind Franklin.
  - Maurice Wilkins.
- Franklin:
  - Contributed development of x-ray crystallography.
    - Method of determining structure of crystals.
    - Based on use of x-rays.
    - Locations of atoms in crystals mapped.
    - Can be used to look at DNA.
  - Used technique;
    - X-ray diffraction.
      - Showed DNA had characteristics of a helix.
  - Suspected all DNA had helix structure.
    - Held back on announcement until sufficient evidence.
  - Worked alone, didn't get on with Wilkins.
- Wilkins:
  - Showed Franklin's work to Watson without her knowledge/consent.
- Watson & Crick:
  - Produced a failed model.
  - Told to stop DNA research.
  - Convinced of 3D structure.
    - DNA could be determined.
    - Way genes passed on could then be determined.
  - Close working relationship.