BIOL10005: GENETICS AND THE EVOLUTION OF LIFE LECTURE NOTES

Lecture 1 - Genetics: variation and the genome

WHAT IS GENETICS?
- the variation between and among living things, and how this variation is inherited

GENOTYPE AND PHENOTYPE
- genotype: the genetic constitution of an organism
  - it comes from a parent (**haploid)** or parents (**diploid)**
  - half a genotype comes from each parent
  - there is nothing you can do about your genotype
- phenotype: the morphological, biochemical and behavioural properties of an organism resulting from a specific genotype and its interaction with the environment
  - reliant on what you inherited from your parent + environment
  - i.e. appearance + behaviours (introvert/extrovert)

GENOME
- the total amount of genetic material in a chromosome set
- the genetic material is **DNA**
- **sequencing a genome:** working out the base sequence (ATGC) of the DNA
- humans have 2 genomes: nuclear genome and the mitochondrial genome
- does not tell the function of the sequence
- gene: sequence of DNA that can code for proteins or RNA

HUMAN GENOME
- 1mm space between each nucleotide
- human genome stretches to 3200km

GENOME VARIATION
- variation may be due to environmental factors, genetic factors, or both
- example of environmental factor: drinking alcohol during pregnancy = fatal alcohol syndrome
- example of genetic factor: Huntington disease (gene is on chromosome 4, repeated sequence of CAG)
  - normal range = 35 repeats, 42+ repeats = HD
  - toxic protein in the sequence that degenerates the brain
- example of combination of genetic and environmental factors: epigenetics
  - epigenetic change: change in gene expression without changing the DNA code
  - Glucocorticoid: hormone with a role in regulating responses related to stress
  - methylation

Lecture 2 - Structure and replication of DNA

A VISUAL IMAGE OF VARIATION
- ‘Model Organisms’ - to study genes and their action that are relevant to human life
- human polymorphisms: variations with no differences to viability (i.e attached/unattached earlobes, freckles, tongue rolling); variations with differences to health
- Cystic Fibrosis: 1/25 are carriers, 1/2500 have CF; most common genetic disorder in Australia
  - affects the lungs and digestive system due to a malfunction in the exocrine system, responsible for producing saliva, sweat, tears & mucus
- Ehlers-Dalos Syndrome: collagen defect
- Sex determination
- Albinism: gene that is mutated doesn’t affect the gene in the striping patterns (tigers)
- mutations (changes in DNA) can occur in any organism

VARIATION AT DIFFERENT STAGES OF DEVELOPMENT
- occurs in plants and in animals (juvenile oval leaves, adult long pointy leaves; chicks fluffy feathers, chicken feather)
- variation can be increased/ decreased by human intervention (i.e. selected breeding)
  - selection rather than modifying the genome
- genetic engineering: changing the sequence of human growth hormone in embryonic cells and injecting it into the embryo of another organism
- use a reporter gene (using a construct) against gene of interest to test phenotype
- cancer: accumulated genetic mutation overtime

WHAT IS A GENE?
- fundamental unit of heredity which carries information from one generation to the next
- gene is a segment of DNA

WHAT IS DNA?
- polynucleotide
- nucleotides linked together
- structure of a nucelotide: 3 parts (phosphate, deoxyribose sugar, base)
- AG = purine
- CT = pyrimidine
- two strands are complementary (AT, GC) but antiparallel (5' and 3')
- humans have higher proportion of AT than GC

WHERE ARE GENES FOUND?
- located in chromosomes but also in mitochondria, chloroplasts and plasmids
- position of a gene on a chromosome is a **locus**
- chromosomes: cytosol in prokaryotes, nucleus in eukaryotes
- chromosome consists of DNA and protein
- DNA + protein = chromatin
- chromosomes are only visible during cell division
- nucleosome are wrapped inside the double helix DNA
- nucleosome: basic unit of chromatin

HISTONE MODIFICATION - A WAY OF REGULATING GENE EXPRESSION
- genes are switched on and off so they are not active in all cells at all times
- gene switched on: euchromatin
  - active (open) chromatin
  - unmethylated cytosines
- gene switched off: heterochromatin
  - silent (condensed) chromatin
  - red circles
  - deacetylated histones

CHROMOSOMES
- may consist of one molecule of DNA or two molecules of DNA depending of the cell cycle
- sister chromatid (each strand) in a double stranded DNA

DNA REPLICATION
- occurs in the S stage of the cell cycle
- mutations in genes disrupts the cell cycle regulation
- semi-conservative replication (half of the molecule is saved to be the template for new molecule)
- prokaryotes: circular chromosome with 1 origin of replication
- eukaryotes: linear chromosome with multiple origins of replication that eventually links up, resulting in 2 daughter DNA molecule
- enzymes involved: **helicase** - moves alone the molecule and opens up the strand, **gyrase** - makes nicks in the DNA to relief the tension and joins it back up

- **DNA polymerase III**: needs a short double-stranded region to start DNA replication and need a primer RNA
  - reads DNA 3' to 5' and can only add bases to the 3' OH end of the growing strand
  - forms new strands 5' to 3' on the complementary template with RNA primer at the start of replication
  - makes short sequence: Okazaki fragments
  - beta clamp, a complex of proteins to keep the molecule DNA polymerase in place on the lagging strand
    - increases efficiency of replication
  - RNA primer then removed and replaced with complementary bases (DNA nucleotides) and Okazaki fragments are joined
  - two steps processed by DNA polymerase I
  - ligase can join pieces of DNA