HSC Biology
Core 2 – Blueprint of Life

Focus 3

Chromosomal structure provides the key to inheritance.

Outline the roles of Sutton and Boveri in identifying the importance of chromosomes.

- 1902;
  - 2 scientists credited with discovery of role of chromosome.
    - German scientist; Theodore Boveri.
    - American microbiologist; Walter Sutton.
- Boveri;
  - Worked on sea urchins.
  - Showed chromosomes not all the same.
  - Full complement required for normal development of organism.
- Sutton;
  - Worked on grasshoppers.
    - Showed distinct entities.
  - Even though they duplicate & divide, remain as distinct structure.
  - Pointed out segregation, recombination of genes showed similarities to chromosome behaviour.
  - Associated behaviour of chromosomes with Mendel's work on inheritance of factors.
  - Concluded chromosomes carriers of heredity units.
    - Units also transmitted with chromosomes.
  - Showed;
    - Chromosomes occur as homologous pair.
    - Through meiosis;
      - Chromosomes line up in pairs, each = size & shape.
      - Homologous pairs segregate.
      - Every gamete receives 1 chromosome from each pair.
    - Chromosomes keep individuality throughout cell division.
    - Distribution of members of homologous pair independent of that of

each pair.

- Since heredity factors more numerous than chromosomes;
  - Each chromosome contains many units.
- Sutton also developed hypothesis;
  - Mendel's results explained on assumption genes were part of chromosomes.

- Work became known as Sutton-Boveri chromosome hypothesis.

Describe the chemical nature of chromosomes and genes.

- Chromosomes;
  - 40% DNA
    - Double stranded helical molecule.
    - Made up of sub-units;
      - Nucleotides.
        - Sugar, phosphate, base.
        - Sugar = deoxyribose (ribose lost an O atom).
        - Bases = Adenine, Thymine, Guanine, Cytosine.
  - 60% protein (histone).
  - DNA coiled tightly around protein.
    - DNA approx 2m long.
  - Short lengths of DNA make up genes.
    - Genes have = structure to DNA.

Identify that DNA is a double-stranded molecule twisted into a helix with each strand, comprised of a sugar-phosphate backbone and attached bases, adenine (A), thymine (T), cytosine (C) and guanine (G), connected to a complementary strand by pairing the bases, A-T and G-C.

- DNA;
  - Nucleic acid.
  - Shape of double helix.
    - Each strand of helix consists of 4 different nucleotides made of deoxyribose sugar, PO_4 molecule, N base.
  - Twisted ladder.
    - Sides of ladder made of sugar, phosphate molecules.
    - Bases form rungs, complementary.
      - Only matching bases pair up (A-T, G-C).

Explain the relationship between the structure and behaviour of chromosomes during meiosis and the inheritance of genes.

- Chromosomes;
  - Made of DNA, which forms genes.
- During cell division;
  - Each chromosome replicates itself.
  - New chromosome attached to old at centromere (centre).
  - Initial meiosis division;
    - Homologous chromosomes line up with matching pair, 1 of each pair moves into new cell.
  - Duplicated chromosomes separate, resulting in 4 sex cells that contain ½ number of chromosomes.
- Genes located on chromosomes.
  - Duplicated during 1st stage of meiosis.
  - Randomly assorted depending on which enters haploid cell during 1st & 2nd division.

Explain the role of gamete formation and sexual reproduction in variability of offspring.

- Gamete formation results in;
  - Halving number of chromosomes (haploid)(n).
- Sexual reproduction results in;
  - Combining gametes to create a diploid (2n) organism.
- Processes involved result in variation of offspring.
- Gametes formed through meiosis.
  - 2 stages → variability;
    - Random segregation.
    - Crossing over.
- Sexual reproduction;
  - Each male / female produces 4 sex cells through meiosis.
    - Each has;
      - ½ normal number of chromosomes.
      - Random assortment of genes from parent.
  - Alleles separated.
    - Random assortment of dominant & recessive genes.
  - Resulting embryo genetically different from parents.

Describe the inheritance of sex-linked genes, and genes that exhibit co-dominance and Explain why these do not produce simple Mendelian ratios.

- Codominance;
  - Shown in monohybrid cross when both alleles of homozygous parents expressed in heterozygous offspring.
- Sex genetically determined characteristic.
  - Humans have 46 chromosomes in 23 pairs.
  - 22 pairs + 1 pair of sex chromosomes.
    - Females; both X
    - Males; XY.
- Mendel fortunate;
  - All factors studied had dominant/recessive characteristics.
  - 2 Eg's not showing Mendelian ratio are;
    - Sex linked genes.
    - Co-dominant genes.
- Colour blindness in humans;
  - Sex linked inheritance.
  - Carried on X chromosome.
    - No corresponding gene on Y chromosome.

  ∴ Males need only 1 allele for colour blindness, females need 2.
    - Many more males colour blind than females.

Male: Colour blind. Female: Normal.

	X^N	X^N
X^n	X^NX^n	X^NX^n
Y	X^NY	X^NY

- All offspring have normal vision.
- If female carrier for colour blindness crosses with male, 50% of males will have colour blindness, none of females.

	X^N	X^n
X^N	X^NX^N	X^NX^n
Y	X^NY	X^nY

- Co-dominance gives different result than Mendelian ratio.
  Eg. Human blood types.
  - When male with alleles AA crosses with female alleles BB.
    - Offspring AB (different phenotype, both dominant).

Describe the work of Morgan that led to the identification of sex linkage.

- 1910.
- Thomas Morgan;
  - Worked on fruit fly.
    - Drosophila melangaster.
  - Repeat Mendel's work using an animal.
  - To answer questions about variations in inherited characteristics.
  - He looked at crosses between red-eyed & white-eyed flies.
    - Found results not accounted for by simple monohybrid crosses.
    - Showed genes were sex-linked.
      - Located on X chromosome.

Explain the relationship between homozygous and heterozygous genotypes and the resulting phenotypes in examples of co-dominance.

- Individual has 2 different alleles (heterozygous).
  - Usual case:
    - One will be dominant.
    - Other, not expressed:
      - Recessive.
  - Some cases:
    - Dominance of 2 alleles.
      - Both alleles expressed in phenotype.

Eg. Of Co-Dominance: Human blood type.

- 3 alleles.
  - A & B:
    - Co-dominant.
  - o:
    - Recessive.

Alleles	Blood Type
AA / Ao	A
BB / Bo	B
oo	o
AB	AB

Eg. Of Co-Dominance: Cattle coat colour.

- Have allele for red & white hair.
  - Neither completely dominant.
    - Mixture of both expressed as phenotype.
- Red cattle:
  - RR
- White cattle:
  - WW
- All F_1 have roan coat.

- Mix of red & white.

	R	**R**
W	**RW**	**RW**
W	**RW**	**RW**

- Roan cattle crossed.

	R	**W**
R	**RR**	**RW**
W	**RW**	**WW**

- ½ offspring roan.
- ¼ red.
- ¼ white.

Outline ways in which the environment may affect the expression of a gene in an individual.

- Identical twins:
  - Have identical genotype.
  - Enviro can effect:
    - Height.
    - Weight.
    - Fitness level.
    - Cultural interests.
  - Enviro includes:
    - Diet.
    - Exercise.
    - Experiences.
  - Enviro impacts on the way a genotype is expressed.
  - Twins that have been separated have more apparent differences.

- Height in humans:
  - Determined by interaction of genes & enviro.
  - Modern medicine & nutrient- rich foods increased avg height.
    - Nutrition most influencing.

  Eg. Japanese population in America:
    - Taller than Japanese inhabitants.
      - More nutritious foods.
    - Japanese taller:
      - Intro of foreign foods.

- Soil pH on Hydrangeas:
  - Raising pH (slightly acidic):
    - Blocks out bluing effect of Al.
    - Pink flower.
  - Lower pH (slightly basic):
    - Allows Al in.
    - Blue flower.
  - Strength of colour determined by genetics & plant's heredity.

Process information from secondary sources to Construct a model that demonstrates meiosis and the processes of crossing over, segregation of chromosomes and the production of haploid gametes.

- Process of crossing over;
  - (Swapping of chromatid parts of homologous chromosomes early in meiosis).
  - Chromosomes duplicate.
  - Duplicated chromosomes match in homologous pairs.
  - Crossing over of genetic material. ***(Shown below)***

  - Segregation of duplicated chromosomes.
    - Halving number of chromosomes in each cell.
  - Lining up of duplicated chromosomes across middle of new cells.
  - Separation of chromatids.
  - Formation of gametes.
  - 8 possible combinations.