Topics covered: cell/nuclear division, **Mendelian genetics** (majority of questions)

Mitosis

end chromosome number doesn't change.

Explain the importance of mitosis in growth, repair and asexual reproduction

- Repair by replace worn-out cells and make more of these cells eg. RBC replacement in bone marrow
- Asexual reproduction in single-celled organisms eg. bacteria, yeast and hydra
- Growth by allow cells to divide and increase in mass eg. onion root
- In mitosis, cells produced carry the same genes as the parent cell

Explain the need for the production of genetically identical cells

- Dysregulation of checkpoints of cell division can result in uncontrolled cell division, which can result in cancer. Caused by genetics, chemical carcinogens, radiation, loss of immunity which can increase the chances of cancerous growth.

Identify, with the aid of diagrams, the main stages of mitosis (prophase, metaphase, anaphase and telophase)

- you should be able to do this.

Describe with the aid of diagrams, the behaviour of chromosomes during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell membrane and centrioles

1. interphase: Cell synthesizes new molecules and organelles, 2 centrosome with 2 centrioles each, chromosomes duplicate but are loosely packed chromatin
2. prophase: chromatin fibres are more tightly coiled and folded → discrete chromosomes, duplicated chromosome appears as 2 identical sister chromatids joined together with a narrow "waist" at the centromere. Centrosome moves away from each other, microtubules rapidly grows out of them, forming mitotic spindle.
3. metaphase: nuclear envelope broken, centrosome are at both poles, mitotic spindle fully formed, some ends of them attach to kinetochore (narrow waist thing on centromere), others attach to each other. Chromosomes convene on the metaphase plate (imaginary plane equidistant between the 2 poles), centromeres are lined up on metaphase plate. Kinetochores of 2 sister chromatids face opposite poles of spindle.
4. anaphase: 2 centromeres of each chromosome come apart, separating the sister chromatids. Once separated, each sister chromatid is considered a daughter chromosome. Motor proteins powered by ATP in the kinetochore "walk" the daughter chromosomes to the poles. Microtubules attached to the daughter chromosomes shorten, while those attached to each other lengthen. Poles move further apart, elongating the cell.
5. telophase: daughter nuclei appear at 2 poles as nuclear envelopes form around the chromosomes. Chromatin fibres of each chromosome uncoil, mitotic spindle disappears.

Distinguish between nuclear division and cytokinesis with reference to both plant and animal cells.

1. Centrosomes are essential in animal, not in plant. (Plant has no centriole)
2. Cytokinesis in animals occurs through cleavage, cell plate formation in plant cells

Meiosis

Identify, with the aid of diagrams, the main stages of meiosis (4 stages in M1 and 4 in M2)

- come on youve got this travis.

Describe, with the aid of diagrams, the behaviour of chromosomes during meiosis, and the associated behaviour of the nuclear envelope, cell membrane and centrioles

Meiosis I

1. Interphase (duplication of chromosomes)
2. Prophase I (2n pairs)
    a. coiling up
    b. crossing over of chromatids of homologous chromosomes, forming a tetrad
    c. further condensation, nuclear envelope breaks, formation of spindle
3. Metaphase I (n homologous chromosomes/tetrads)
    a. aligned on metaphase plate, sister chromatids still attached by centromere
    b. spindle microtubules attached to one homologous chromosome comes from one pole, microtubule attached to other comes from other pole
4. Anaphase I
    a. sister chromatids making up the chromosome still attached at centromere
    b. migration to poles
    c. only tetrads split up, so only 3 doubled chromosomes (vs mitosis with 6 chromosomes)
5. Telophase I (and cytokinesis)
    a. each pole has haploid chromosome set, although in duplicate form, still have 2 sister chromatids
    b. nuclear envelope forms, cytokinesis, but NO chromosome duplication

Meiosis II

- Same as mitosis except:
    - Begins with n chromosomes
    - Ends with n chromatids

Define the terms haploid and diploid

- Haploid: 1 copy of chromosomes (23, in sex cells before fertilization)
- Diploid: 2 copies of chromosomes (46, in most cells)

Explain the need for a reduction division process prior to fertilisation in sexual reproduction

- Reduction division, also known as meiosis, halves the number of chromosomes in the sex cells. During fertilization, the gametes fuse to restore the diploid number of chromosomes to ensure that there are no mutations in the offspring as a result of excessive chromosomes.

Explain how meiosis and fertilisation can lead to variation

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Similarities and differences

Stage	Mitosis	Meiosis I	Meiosis II
Similarities	• Preceded by one round of DNA replication. • Only in eukaryotic cells. • Use spindle fibres to separate chromatids from each other. • Cytokinesis occurs after or during telophase.		
Difference	Produces 2 daughter cells	Synapsis of homologous chromosomes at chiasma occurs	Produces 4 daughter cells
	Occurs in somatic cells	Occurs in cells in sexual cycle	
	No. of chromosomes remain diploid	Chromosome no. becomes haploid.	
Metaphase	Chromosomes align at the metaphase plate	Tetrads align at the metaphase plane	Chromosomes align at the metaphase plate
Anaphase	Sister chromatids separate	Homologous chromosomes separate	Sister chromatids separate
	Centromeres separate	Centromeres are not separated	Centromeres separate

Mendelian Genetics

gene vs allele
allele is 1, 2 or more forms of a gene

genes that determine the same thing will be around the same area of the DNA
gene is a short segment of dna
you say the gene carries the allele for brown pigment ((of eyes))
Genotype: genetic makeup of organism
Phenotype: external trait manifested ((that word is cool))
BB/Bb/bb: genotype/genetic make-up of trait
B: Dominant allele ((not necessarily the same in every situation - brown fur may be dominant in one case but recessive in another))
b: Recessive allele. Only expresses in absence of dominant allele

homozygous vs heterozygous
if it's BB or bb ((alleles are alike)) then its homozygous
if it's Bb then it's heterozygous condition

Define a gene as a unit of inheritance

- A gene is a unit of inheritance.

Explain the terms allele, dominant, recessive, homozygous, heterozygous, phenotype and genotype.

- Allele: one of 2 or more variations of a gene.
- Dominant: Trait always appears when an individual has an allele for it
- Recessive: Trait appears only when individual has 2 alleles for it
- Genotype: Combination of alleles for any given trait
- Phenotype: Physical/physiological trait that is expressed (eg. brown hair)
- FYI: Carrier - individual is heterozygous for a recessive disease condition

Explain how genotype is linked to phenotype and how genes are inherited from one generation to the next generation via the gametes

Predict the results of simple crosses with expected ratios of 3:1, and 1:1, using the terms homozygous, heterozygous, F_1 generation and F_2 generation.

Using genetic diagrams to solve problems involving monohybrid inheritance, including those involving co-dominance, incomplete dominance and multiple alleles.

- Draw alleles accordingly: R for dominant, r for recessive, X^RX^r for sex-linked alleles.
    - Indicate as X^h - X-chromosome carrying recessive allele for haemophilia
      X^H - X-chromosome carrying dominant allele for normal blood
- Multiple alleles: more than 2 alleles that determine phenotype eg. blood type, hair colour
- Co-dominance: when 2 dominant alleles are equally expressed (eg. AB blood type)
- Incomplete dominance: when no 2 alleles are completely recessed (eg. red flower cross with white flower → pink flower)

Parents
Phenotype: carrier x normal
Genotype: Gg x GG
Gametes: G x g (with circles around them)

Offspring generation

		Carrier male	
	Gametes (random fertilisation)	G	g
Normal female	G	GG	Gg
	G	GG	Gg

Genotype: 1GG:1Gg
Phenotype: 1 normal: 1 carrier

Using a family pedigree chart to solve problems of inheritance of genetically determined traits

Describe the determination of sex in humans - XX and XY in chromosomes.

- sex in humans is very determined.
- (the one that is not autosomal)

Describe the differences between continuous and discontinuous variation and give examples of each.

Continuous	Discontinuous
Deals with a spectrum of phenotypes, ranging from one extremity to another	Deals with a few clear-cut phenotypes
Modified by environmental conditions eg. greater exposure of skin to sunlight will produce a greater skin colour	Not modified by environmental changes
Controlled by many genes	Controlled by a few genes
Genes show additive effects eg. the more “dark” genes you have, the darker you are	Genes do not show additive effect
eg. skin/hair/eye colour, length of little finger	eg. Blood type

Possible essay questions

Why do siblings look different even though they share the same parents?

During synapsis, non-sister chromatids exchange parts in a process called crossing over at the chiama. Because the versions of some genes on a chromosome differ from those on homolog, crossing over rearranges genetic information. As a result, the genetic shuffling produced by crossing over contributes to genetic variability, even if they share the same parents.

Explain how gene recombination occurs.

During Prophase 1 in meiosis, synapsis occurs and chiasmata forms. This results in crossing over of non-sister chromatids of a pair of homologous chromosomes where short segments of chromosomes are exchanged. This leads to gene recombination.

Explain how crossing over occurs.

Crossing over is an exchange of corresponding segments between non-sister chromatids of homologous chromosomes. 2 homologous non-sister chromatids attach to each other at the chiasma, the site of crossing over, during a process called synapsis. The DNA molecules of 2 non-sister chromatids break at the same place and immediately, the 2 broken chromatids join together in a new way.

Compare mitosis and meiosis

[NOTE FOR THESE TYPES OF COMPARE QUESTIONS: Do not write 2 points in the same question or you'll get only 1 mark instead of 2.]
Meiosis produces 4 daughter cells, while mitosis produces 2 daughter cells. In meiosis, synapsis of homologous chromosomes at chiasma occurs, while in mitosis, synapsis does not occur. In mitosis, chromosomes align at the metaphase plate in the metaphase stage while in meiosis, tetrads align at the metaphase plane in the metaphase stage. Meiosis occurs in cells in sexual cycle while mitosis occurs in somatic cells. Meiosis and mitosis are both preceded by one round of DNA replication. Both occur only in eukaryotic cells. Both use spindle fibres to separate chromatids from each other. Both have cytokinesis that occurs after or during telophase.

portion below is in white because apparently it isn't tested
Gene Expression
Process of transcription
At initiation, RNA polymerase binds to the promoter of a gene. DNA double strands separate by breaking the hydrogen bonds. At elongation, the template strand of DNA strand serves as a template for ribonucleotides to base pair. RNA polymerase catalyses phosphoester bond formation between the ribonucleotides to form RNA. RNA is synthesized in a 5' to 3' direction. At termination, the RNA polymerase reaches a sequence of bases in the DNA template called a terminator (hasta la vista, baby.) This sequence signals the end of the gene; at that point, the polymerase molecule detaches from the RNA molecule and the gene

Process of translation
Each amino acid attaches to its proper tRNA (which corresponds to its anticodon) with the help of a specific enzyme and ATP. At initiation, mRNA, tRNA and ribosomes come together. At elongation, in codon recognition, the anticodon of an incoming tRNA molecule, carrying its amino acid, base pairs with the mRNA codon. In peptide bond formation, the ribosome catalyzes formation of the peptide bond, adding one more amino acid to the growing polypeptide chain. In translocation, ribosome moves along the mRNA so codon recognition can start again and tRNA without amino acid could leave the ribosome. At termination, ribosome recognizes a stop codon on mRNA. The polypeptide synthesis is terminated and released.

Compare DNA and RNA

DNA		RNA
1. They share 3 common bases - A, C and G		
2. They have pentose sugar		
Contains thymine (T)	1. Type of base	Contains uracil (U)
No hydroxyl group (H only)	2. Structure of pentose sugar	Hydroxyl group (OH)
Double stranded	3. Number of strands	Single stranded

Important features of genetic code

1. Unambiguous: every codon codes for just 1 amino acid
2. Triplet code: each codon consists of 3 nucleotide bases
3. Each codon starts with 5’ and ends with 3’
4. Degenerate: there are more than 1 codon for a single amino acid → minimises effect of mutation, in case A in Leucine mutates to G, code CUG still codes for Leucine.
5. Universal: works for humans, monkeys, dogs, viruses etc.
6. Most of the amino acids are coded by degenerate codons that differ in the 3rd position of the codon.
7. Non-overlapping, continuous.

Machinery in translation
transfer RNA:

- Serves as an interpreter to bring in specific amino acids in a sequence corresponding to the sequence of codons in mRNA.
- Binds to a specific amino acid at one end
- Binds to the appropriate codon on mRNA by complementary base pairing with anti-codons of tRNA

messenger RNA

- Encodes the amino acid sequence of a polypeptide in the form of a codon
- Serves as a template for translation on ribosomes for anticodon of tRNA to base pair with codon on mRNA

ribosomes

- Positions mRNA and tRNA close together
- Catalyzes peptide bonds formation between two amino acids to form polypeptides.

*** ends before gene engineering