Genetics

DNA characteristics

Adenine binds to Thymine (Uracil in RNA)

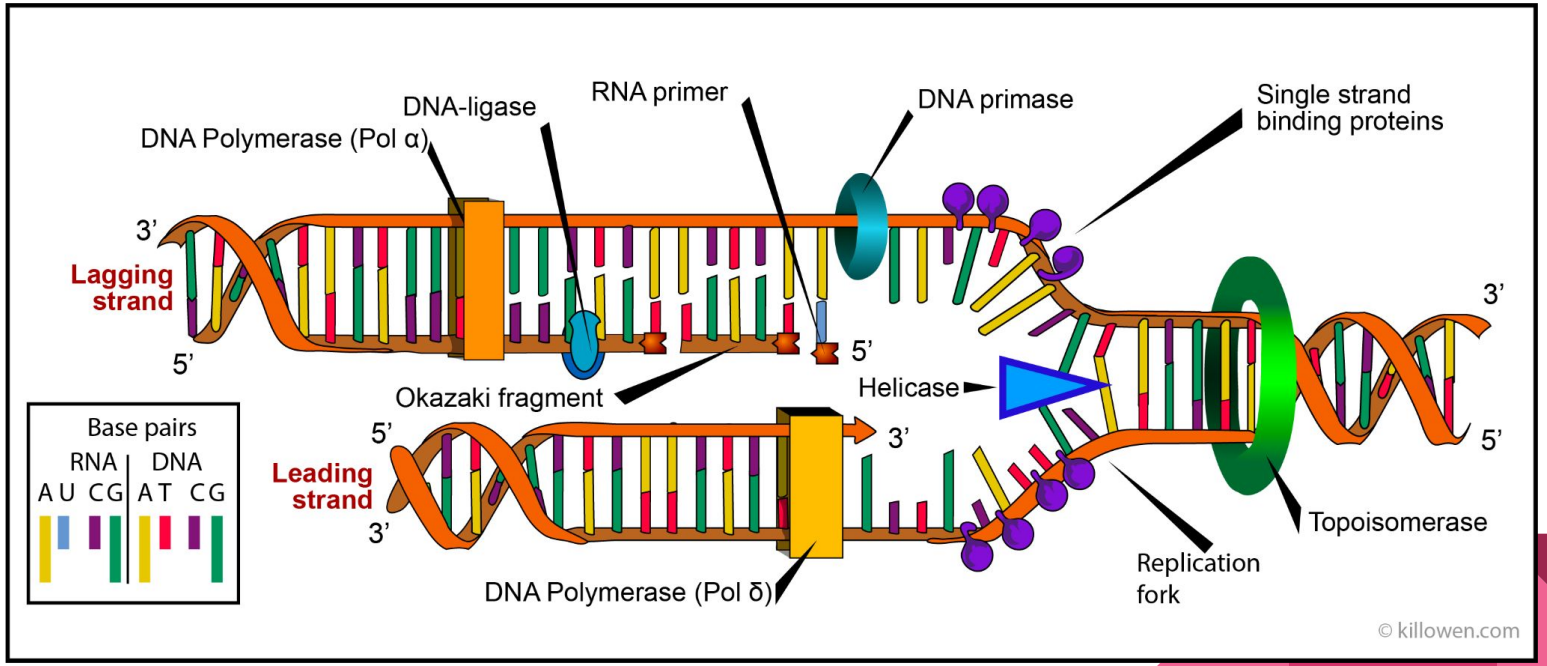
Guanine binds to Cytosine

DNA is **read** from 3’ → 5’

DNA is **synthesised** from 5’ → 3’

Humans have 46 chromosomes 23 pairs of chromosomes, with numbers 1 - 22 called autosomes and the 23rd pair being the sex chromosomes

Learn these enzymes



Enzymes

DNA primase - adds RNA primer to strand

DNA polymerase - binds to primer and adds nucleotides to strand

Topoisomerase - Unwinds supercoiled helix

DNA helicase - Break hydrogen bonds and unzips the strands

DNA ligase - joins okazaki fragments together

Exonuclease - go back and take off RNA primers on the lagging strand

Telomerase - Extends telomere on a chromosome

Leading and lagging strands

- Leading strand

  DNA primase adds an RNA primer to template and DNA polymerase binds to RNA primer and synthesises strand from 5’ → 3’.

- Lagging strand

  DNA primase adds and RNA primer to template in chunks called okazaki fragments which are joined by DNA ligase 3’ → 5’ strand

Telomeres

Telomere - repetitive nucleotide sequence on the end of every chromosome

Function

- Prevent shortening of chromosomes when replicating
- Maintain stability
- Prevent damage at chromosomes

Telomerase - Extends telomere on a chromosome

Older women are more likely to give birth to children with Down's Syndrome because of the chromosomes being shorter, so it is more likely to be damaged

Transcription

DNA is unzipped by DNA helicase so that the gene needed is exposed

RNA polymerase binds to promoter region to add the complementary RNA nucleotides

Pre-mRNA splices off the introns using a spliceosome, allowing the exons to join and leave the nucleus

The mRNA leaves the nucleus towards the ribosomes

Translation

Ribosome as large and small subunit.

Small subunit - Matches tRNA anticodons to mRNA codons

Does this in triplets for each amino acid, with AUG as the start codon

Large subunit - forms peptide binds to the amino acids that enter through a condensation reaction that releases water

This forms the protein that goes to the Golgi apparatus

The protein will be modified post-translation by acetylation, glycosylation, phosphorylation and folding to increase functional diversity for its specialised job

Regulation of gene expression

Process of turning on or off proteins synthesis

Epigenetic modification

Inhibit transcription - Methylation of DNA, such as binding to cytosine

Promote transcription - Histone acetylation by unwinding chromatin from histones

Promote translation - Ubiquitination of histones so that enzymes can bind more easily and begin transcription

Abnormalities in chromosome - numerical

Aneuploidy - Number of 1 pair of chromosomes is off

Polyploidy - Number of set of chromosomes is off

Monosomy - loss of a chromosome

Trisomy - Down’s syndrome - trisomy 21

Triploidy / tetraploidy are fatal in humans

Abnormalities in chromosome - structural

Deletion - DNA section deleted

Duplication - DNA section duplicated

Inversion - DNA section copied wrong way around

Substitution - DNA section moved from 1 chromosome to another

Translocation - 2 DNA sections on different chromosomes swap places

PCR

Used to make copies of a certain region on a DNA sample to be analysed

Denaturing stage - At 94 - 95 degrees the H bonds break to separate the strands

Annealing stage - At 50 - 56 degrees the primers are annealed on the separate strands

Extending stage - At 72 degrees the DNA is extended using a DNA polymerase called Taq polymerase that needs a primer to make DNA

PCR is used in cloning DNA, medical diagnostics and forensic DNA analysis

The polymerase chain reaction has revolutionised many medical tests.

For example, patients with some leukaemias can be monitored following treatment to detect early signs of disease recurrence by using PCR to detect abnormal tumour cells

PCR reaction. You need to design a new test for the sequence shown below.

There are different primer sequences available, which ones would work to produce a PCR product?
The regions that the sequences align to are indicated by the matching highlighted colour
All of the primer sequences are correct (You do NOT need to check the sequences are correct!)

1. 5′TGGGATTGGGGTTTTCCC 3′

2. 5′AGTCTAGAGCCACCGTCC 3′

5′ GATGGGATTGGGGTTTTCCCCTCCCATGTGCTCAAGACTGGCGCTAAAAGTTTTGAGCTTCTCAAAAGTCTAGAGCCACCGTCCAGGGAGCAGGTAGCTCCTGGG 3′
3′ CTACCCTAACCCCAAAAGGGGAGGGTACACGAGTTCTGACCGCGATTTTCAAAACTCGAAGAGTTTTCAGATCTCGGTGGCAGGTCCCTCGTCCATCGACGACCC 5′

3. 3′ACCCTAACCCCAAAAGGG 5′

4. 3′CAGATCTCGGTGGCAGGT 5′

A. 2 - 3
B. 1 - 4
C. 1 - 3
D. 2 - 4

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A. 2 - 3
B. 1 - 4 ✅
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Credit to Mahdiyah Raza - 3rd year

• So basically, DNA is synthesised in a 5' to 3' direction. Primers 1 and 4 will be used to synthesise DNA, so you want them to synthesise along the chain. If you use primer 1 then you will synthesise in a 5' to 3' direction along the length of the chain (to the right on the diagram) and using primer 4 you will synthesise to the left on the diagram.

• Using primer 2 means you only synthesise on the RHS of the yellow highlighted primer and using primer 3 means you only get the LHS of the blue highlighted primer. Therefore primers 1 and 4 will be the suitable options to produce strands for the PCR product.

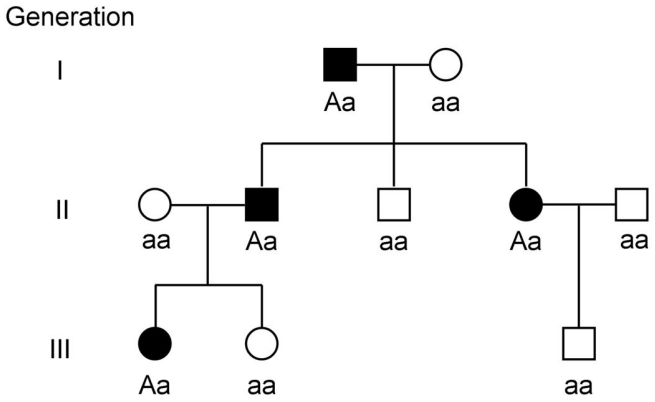
Autosomal dominant

Only need 1 affected gene to have the disease on autosome

Is present in every generation, doesn’t discriminate on gender

Eg - Huntington's disease

- Neurofibromatosis
- Polycystic disease



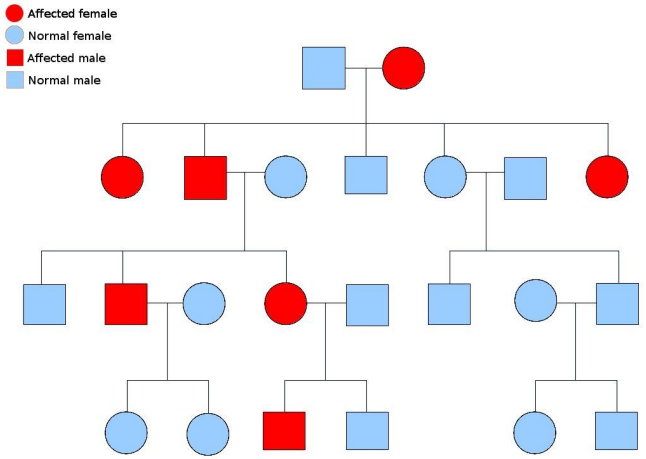
Autosomal recessive

Needs both genes on autosome to be affected

Sometimes skips generation, doesn't discriminate against gender

Eg - Cystic fibrosis

- Sickle cell anaemia
- Tay-Sachs disease
- Friedreich's Ataxia



X - linked recessive

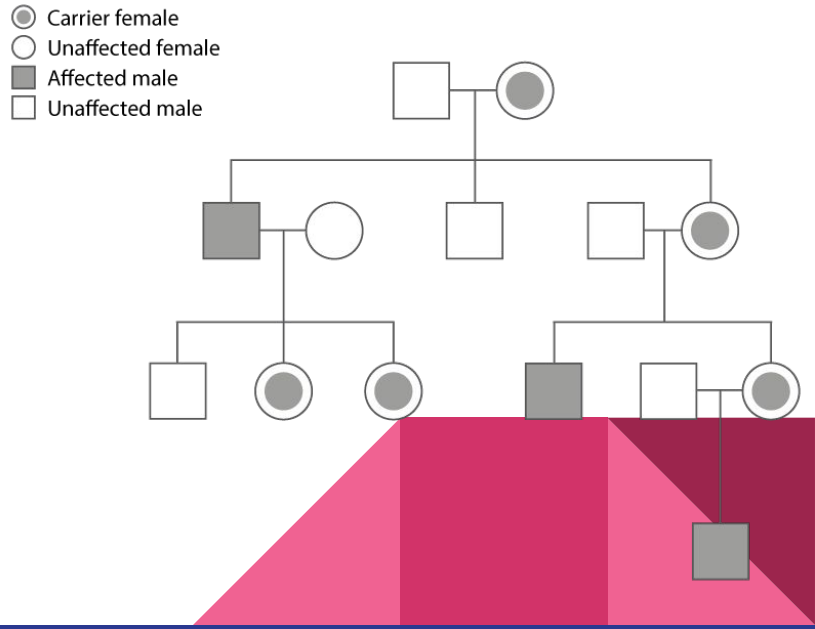
The affected gene is on X chromosome, so can only be passed through the mother

Mostly males affected because they don't have another gene to block it

Carriers may have mild symptoms

Eg - Haemophilia

- Duchenne's muscular dystrophy



X linked dominant

The affected gene is on X chromosome, so a male can’t pass it on to a male

Both males and females can be affected but in men it is more severe because it is only 1 X chromosome

Mitochondrial inheritance

Only passed through mother

Gene in mitochondria is mutated so the mitochondria is damaged

Can occur before fertilisation or in proliferation

Can be passed through a 3 person embryo

Co-dominance

Alleles can be equally expressed so both phenotypes are present

Eg. Blood type

Blood type	Genotype	
A	I^A, I^O I^A, I^A	AO AA
B	I^B, I^O I^B, I^B	BO BB
AB	I^A, I^B	AB
O	$I^O I^O$	OO

Inheritance types

Penetrance - Those with the gene will have the genetic disorder

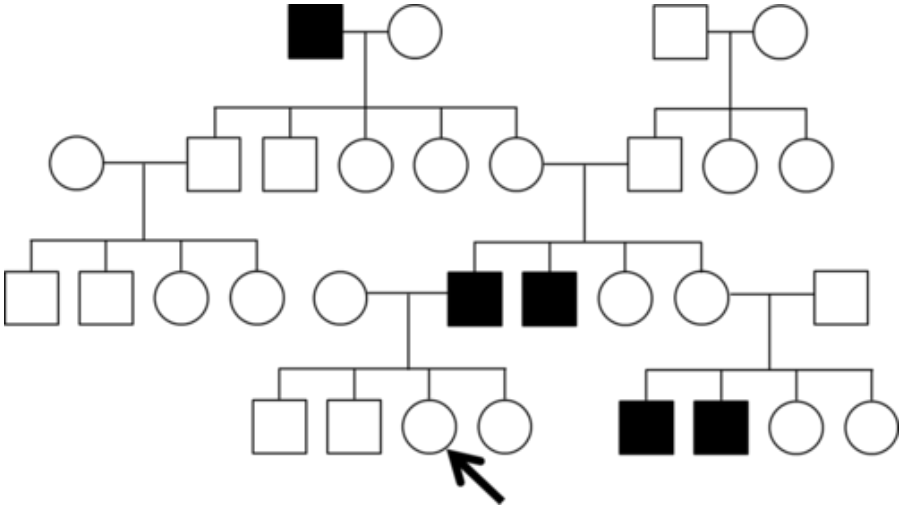
Incomplete penetrance - Those with the gene are more likely to cause a genetic disorder

Lyonization - Females inherit 2 X chromosomes, but one of them is inactivated randomly and permanently, so the genes are overexpressed

Questions

Question 1

What pattern of inheritance best explains this pedigree?



A. Non-Mendelian

B. Autosomal Dominant

C. X-linked Dominant

D. Autosomal Recessive

E. X-linked Recessive

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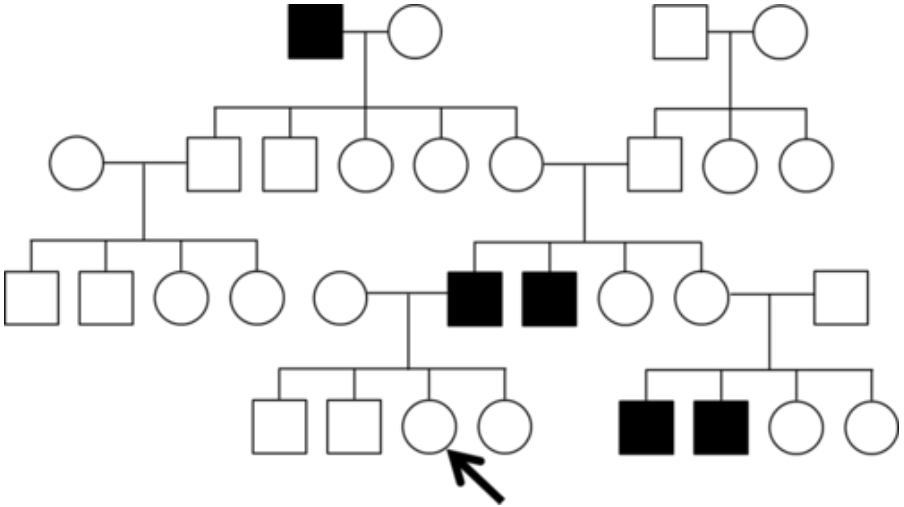

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It skips through generations and only affects the males

Question 2

Which of these enzymes unwinds supercoiled DNA?

A. DNA helicase

B. Telomerase

C. Topoisomerase

D. DNA polymerase

E. Primase

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Question 3

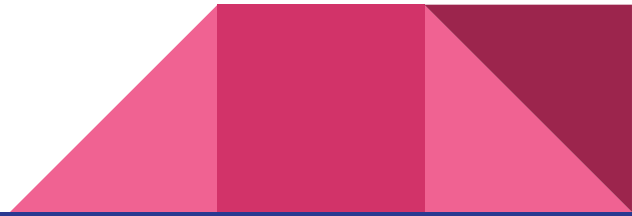
Function of RNA polymerase

A Termination

B Elongation

C Initiation

D All of the above



Answer 3

Function of RNA polymerase

A Termination - telomerase

B Elongation ✅

C Initiation - DNA primase

D All of the above - no enzyme does that

Thank you

Feedback is always appreciated