Application of reproduction and genetics 1

Stem cells - Undifferentiated cells that can differentiate into different specialised cells.

Tissue engineering - The cultivation of cells on a framework of synthetic material to form tissue that can be used to repair tissues or organs.

Stem cells

Pleuripotent cells - adult cells that can differentiate into most types of cells.

Totopotent cells - Embryonic cells that can differentiate into all types of cells.

There are ethical issues with using embryonic stem cells such as the opinion that it is the destruction of a potential life. Other stem cell issues include • possible long term and unforeseen effects such as premature aging • It is an expensive and unreliable technology in mammals.

Genomics

The study of structure, function, evolution and mapping of genomes. It could be used to personalise healthcare:

- More accurate diagnosis.
- Better predictions of the effect of drugs.
- Improved design of drugs.
- New and improved treatments for disease.

Human genome project

This was the original project to sequence the whole human genome. Its purpose was to improve knowledge and understanding of genetic disorders and improve their diagnosis and treatment.

The project used **sanger sequencing** that sequenced small sections of DNA and it took a long time.

100K Genome project

A new project to study the genomes of 100,000 people in order to study genome variation in the UK. This uses NGS (Next generation sequencing) which is much faster. It can sequence a whole genome in a few hours.

Primates

Genome projects have sequenced the genomes of chimpanzees and other primates to look at evolutionary relationships and to conserve species.

Mosquito

Sequencing of the genome of the *Anopheles gambiae* mosquito, a vector for the malarial parasite, is allowing scientists to study the cause of insecticide resistance and develop new chemicals to reduce the population.

Malaria - A disease that causes a million deaths per year.

Plasmodium sp

Sequencing the genome of the parasite that causes malaria is allowing scientists to develop more effective drugs to treat the disease.

Advantages and disadvantages of genetic technology

Advantages	Disadvantages
The ability to scan a patient's DNA sample for mutated sequences and to compare the sequence of DNA bases in a patient's gene to a normal version of the gene.	There are ethical issues in terms of ownership of genetic information, potential discrimination, social stigmatisation and misuse of the data.
It may be possible to routinely screen for adult onset disorders such as Alzheimer's disease and some cancers.	
The screening of embryos has been performed to detect the presence of disorders such as cystic fibrosis, Huntington's disease and thalassaemia.	Screening of embryos has led to concerns over choosing alleles to ensure specific characteristics i.e. designer babies.
Only embryos that do not contain the alleles for disease will be implanted.	
The use of genetic screening and the value of genetic counselling to give potential parents the options.	

DNA profiling and PCR - A DNA profile can be read as bands of DNA on an agarose gel. It can be used to compare the DNA from one organism to another. It does this by comparing sections of DNA called **STR's, introns that are highly variable**. To compare DNA, it is necessary to make many copies in a process called **PCR** and then compare them by using **Gel electrophoresis.**

E.g. D7S280 is an example of a STR where 'GATA' bases repeat on human chromosome 7. Different alleles of this locus have from 6 to 15 tandem repeats of this sequence. The more times it repeats, the larger the fragment of DNA will be and different sized fragments move different distances up the gel.

Uses

- Paternity testing.
- Identification of siblings and checking between monozygotic and dizygotic (identical and non-identical) twins at birth.
- Identification of relatives for immigration purposes.
- Forensically ruling out or incriminating suspects in criminal cases.
- To identify closely related organisms for classification purposes.

Advantages	Disadvantages
Non invasive	Privacy and civil liberties issues of taking DNA
Can use on really small samples	Safe storage issues
Can exonerate the falsely accused	Mishandling of DNA evidence may lead to wrongful convictions

Application of reproduction and genetics 1

PCR- Polymerase chain reaction used to amplify small sections of DNA rapidly.

PCR amplifies the STRs by using a primer (single stranded DNA typically 6-25bp in length) which is complimentary to the start of the sequence.

1. Heat the DNA to 95°C to separate the two strands.
2. Cool to 50-60 °C to allow the primers to bind to the DNA strands (annealing).
3. Heat to 70°C allows a thermally stable DNA polymerase to add complimentary nucleotides (extension) by forming the phosphodiester bonds in the sugar-phosphate backbone.
4. Cycle is repeated. After 40 cycles over a billion copies of the target sequence can be produced from just one piece of DNA.

Gel electrophoresis

1. DNA samples are loaded into wells at one end of the gel and a voltage is applied across the gel.
2. DNA is attracted to the positive electrode due to its negative charge on the phosphate group.
3. Smaller fragments find it easier to migrate through the pores in the gel and so travel further than large fragments in the same time.
4. Fragment size can be estimated by running a DNA ladder (which contains fragments of known size) alongside.

Application of reproduction and genetics 2

Genetic engineering - the transfer of a gene from one organism into the DNA of another, forming a transgenic organism.

e.g. Making insulin

1. Identify and obtain the gene.

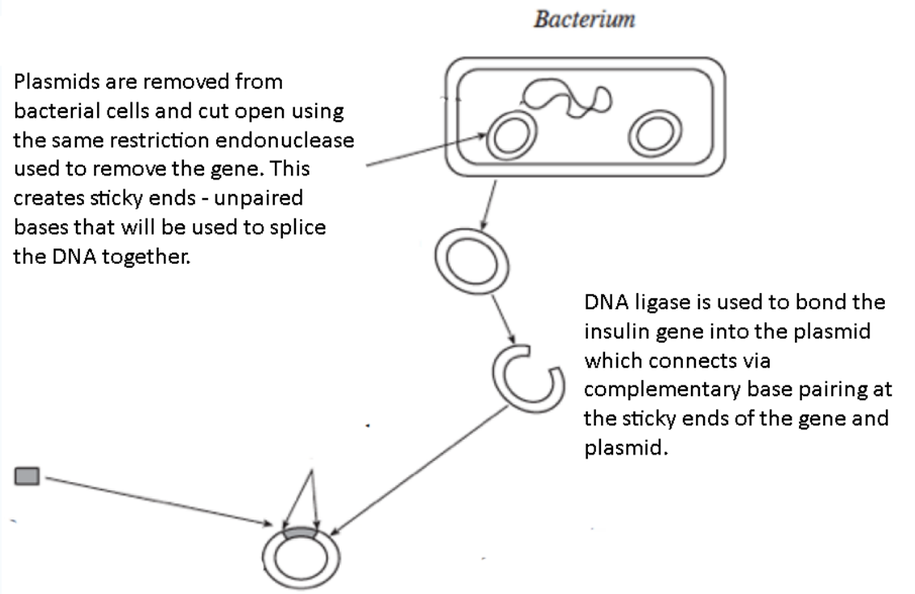
Reverse transcriptase

Collecting mRNA from a cell actively producing insulin will allow this enzyme to form the cDNA from the mRNA. This means there will already be no introns in the mRNA. DNA polymerase can then be used to make double stranded DNA. This avoids having to locate the gene and the problem of restriction enzymes cutting the gene into non-functional fragments.

Restriction endonuclease

Using this enzyme, it is possible to cut the required gene out of the DNA of a cell producing insulin. This gene will contain non-coding introns and bacteria do not contain the enzymes to process the pre-DNA.

2. Insertion of the gene into a vector producing recombinant DNA.



3. Inserting the vector (plasmid) into a host cell (bacteria) and identifying the recombinant organisms.

Special plasmids are used that already contain 2 genes for antibiotic resistance, ampicillin and tetracycline. Insulin is inserted into the plasmid, disrupting the tetracycline resistance gene. This allows a selection of bacteria that have taken up plasmids that have recombined with the insulin gene. The technique used is replica plating.

Concerns

1. Bacteria may pass antibiotic resistant genes onto pathogenic bacteria.
2. Using fragments of DNA could transfer or activate oncogenes.

Genetically modified crops - genetically engineering crops for human consumption either to convey disease resistance or a desired characteristic.

Benefits to GM crops	Concerns of GM crops
Superior keeping qualities	Spreading genetically modified pollen to wild relatives
Higher yield	Unknown effects of eating new protein produced by the crop
Reducing pesticide use	Reductions in biodiversity

Gene therapy

Used to treat genetic disorders by inserting functional DNA sequences into cells to counteract the effect of a defective gene.

Germline therapy

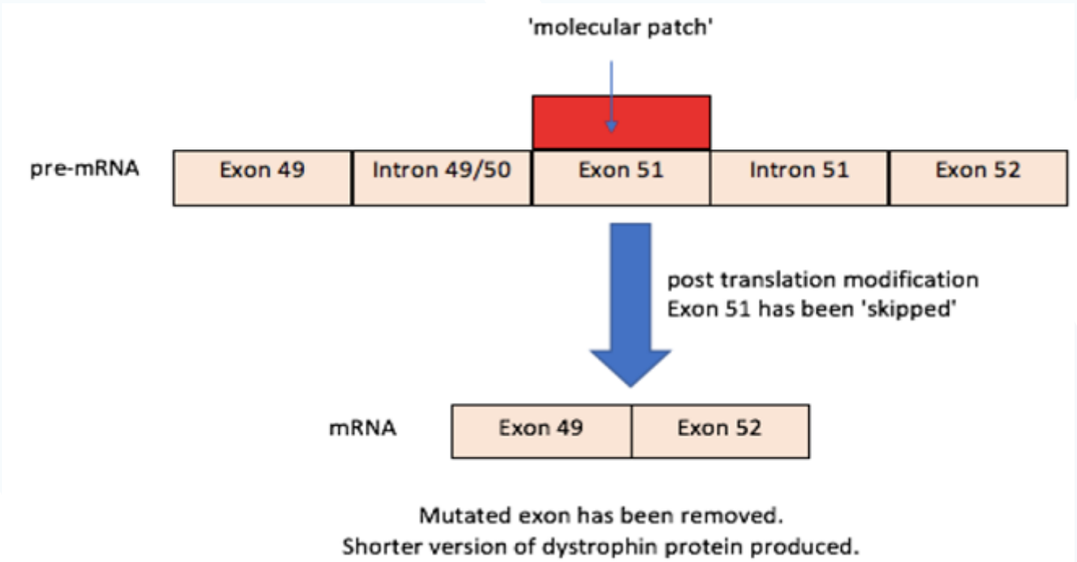
A rare and controversial therapy where genes are replaced in germline cells so that the changes can be inherited.

Somatic cell therapy

Treatment alleviates symptoms but is not permanent and will not be inherited. As treated cells become worn and replaced, the new cells do not contain the new gene and so treatment needs to be repeated.

E.g. Duchenne muscular dystrophy (DMD) • Recessive, sex linked disorder • Mutated dystrophin gene does not produce dystrophin • This causes muscle wastage.

Treatment: A drug called drisapersen treats DMD as shown in the diagram.



1. The drug contains a sequence of bases complementary to the exon with the deletion mutation.
2. The molecular patch allows the mutated exon to be skipped (exon skipping) during translation and a shorter but more functional protein is formed.