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| --- | --- | --- |
| |  |  | | --- | --- | | |  | | --- | | *Human Perspectives ATAR Units 3 & 4* | | |

Answers: Chapter 8 Technology is used to treat diseases

Questions 8.1

RECALL KNOWLEDGE

**1** Define:

**a** recombinant DNA technology

*Answer:* The procedures used to produce recombinant DNA, involving introducing DNA into a cell from a different type of organism or DNA that has been modified in some way. Also known as genetic engineering.

**b** genetically modified organism

*Answer:* An organism produced by genetic engineering.

**c** transgenic organism

*Answer:* An organism that has had DNA from another species introduced into it artificially.

**d** vector

*Answer:* A bacterial plasmid, viral phage or other such agent used to transfer genetic material from one cell to another.

**e** palindromic

*Answer:* A sequence that reads the same backwards and forwards.

**f** plasmid

*Answer:* In a bacterial cell, small circular strands of DNA distinct form the main bacterial genome; composed of only a few genes and able to replicate independently within cells.

**g** bacteriophage.

*Answer:* A virus that infects bacteria.

**2** Draw a labelled diagram to show the structure of DNA.

*Answer:* Refer to Figure 8.2 on page 200 of the student book.

**3** What base is complementary to:

**a** adenine?

*Answer:* Thymine

**b** cytosine?

*Answer:* Guanine

**c** guanine?

*Answer:* Cytosine

**d** thymine?

*Answer:* Adenine

**4** Describe the function of:

**a** restriction enzymes

*Answer:* Restriction enzymes cut strands of DNA at a specific sequence of nucleotides.

**b** DNA ligase.

*Answer:* DNA ligase is an enzyme capable of combining two small components of single-strand DNA into one single structure.

**5** What vector is used in the production of insulin by recombinant DNA technology?

*Answer:* A plasmid. Circular strands of DNA distinct from the main bacterial genome.

**6** Explain how recombinant DNA technology is used to produce a vaccine for hepatitis B.

*Answer:* The gene for the surface antigen on the virus is isolated and added to the plasmid. The plasmid is introduced into a yeast cell. When the yeast cell divides, the new cells also contain the plasmid with the gene for the antigen. This gene allows the yeast cells to produce the antigen protein, which can be collected and purified.

APPLY KNOWLEDGE

**7** Use a Venn diagram or table to compare and contrast artificial breeding with genetic engineering.

*Answer:*

|  |  |  |
| --- | --- | --- |
| **Characteristic** | **Artificial breeding** | **Genetic engineering** |
| Selection of characteristic | Selecting which male and female organisms to breed | Identifying the organisms with the desired characteristic |
| Isolation of the gene | If desired traits are bred, there is an increased chance of the gene being passed on | DNA is added or removed from the genome |
| Incidence in the next generation | Able to increase or decrease the incidence of certain genes | Able to increase or decrease the incidence of certain genes |
| Efficiency | Low efficiency | High efficiency |

**8** Explain why it is possible for an organism of one species to use a gene from another species to produce a protein.

*Answer:* It is possible if the gene from one species is spliced into the genome of the other species. This is recombinant DNA and the organisms is a genetically modified organism (GMO). The GMO will produce the protein from the introduced gene.

**9** Explain the importance of complementary bases with respect to inserting a fragment of DNA into a vector.

*Answer:* Complimentary bases will allow hydrogen bonds to form between the DNA fragment and the vectors genome. DNA Ligase is then able to join the backbone of each strand. If the bases were not complimentary then the splicing and uptake of the inserted gene would not be successful.

**10** What restriction enzyme is the third one isolated from the d strain of *Haemophilus* *influenzae?*

*Answer:* HindIII

**11** Classify each of the following as blunt ends or sticky ends.

**a** *Answer:* Sticky ends

**b** *Answer:* Blunt ends

**c** *Answer:* Sticky ends

Questions 8.2

RECALL KNOWLEDGE

**1** Define ‘hyperglycaemia’ and explain why a lack of insulin results in this condition.

*Answer:* Hyperglycaemia is a condition where a person has abnormally high blood glucose levels. Insulin normally acts to bring down blood glucose levels, so a lack of insulin will result in higher than normal blood glucose.

**2** What causes type 1 diabetes?

*Answer:* Type 1 diabetes is an autoimmune disease where the person’s immune system destroys beta cells in the Islets of Langerhans in the pancreas.

**3** List the symptoms of hyperthyroidism.

*Answer:* Rapid heartbeat, weight loss, increased appetite, fatigue, sweating, anxiety and protruding eyeballs (Grave’s disease)

**4 a** Is goitre a symptom of hypothyroidism or hyperthyroidism?

*Answer:* Hypothyroidism will result in a goitre.

**b** Explain why goitre occurs.

*Answer:* If there is a lack of iodine in the diet, the thyroid gland becomes enlarged in an effort to increase hormone production.

**5** Explain why iodine supplements are used to treat some forms of hypothyroidism.

*Answer:* Thyroxine molecule contains four iodine molecules, and a tri-iodothyronine molecule contains three iodine molecules. If there is a lack of iodine in the diet, the thyroid gland is unable to make enough hormones, resulting in hypothyroidism.

**6** Explain why levothyroxine is considered the preferred treatment for hypothyroidism.

*Answer:* Levothyroxine is a manufactured form of thyroxine. Previously hypothyroid patients were treated with tablets made from the dried and powdered thyroid glands of animals.

APPLY KNOWLEDGE

**7** Explain why insulin in not an effective treatment for type 2 diabetes.

*Answer:* Type 2 diabetics produce insulin, but their body cells no longer respond to the hormone. Giving more insulin will be ineffective to treat type 2 diabetics.

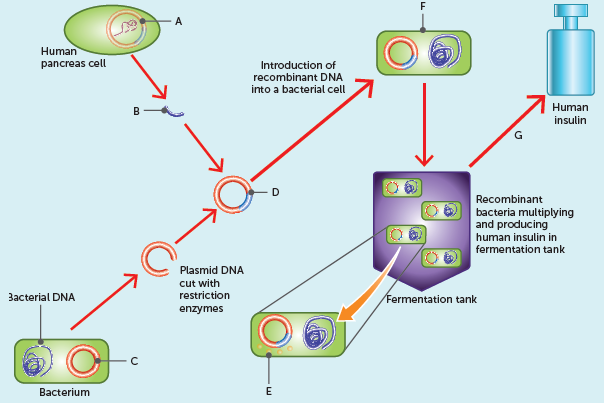
**8** Insulin pumps are programmed to deliver a surge of insulin after meals and a small, steady rate of insulin at other times. Explain why this is preferred over traditional injections.

*Answer:* Insulin pumps can be programmed to change the basal insulin dosage to meet an anticipated increase or decrease in need. This mimics the normal insulin delivery of the pancreas. Insulin can also be delivered while a person is asleep. Traditional injections are needed more regularly.

**9** Suggest why type 2 diabetes is more common in adults.

*Answer:* Type 2 diabetes is also called adult-onset diabetes. Type 2 diabetes is a lifestyle disease and is more common in people who are not physically active and are overweight or obese. Lifestyle habits that contribute to the risk of developing type 2 diabetes include a diet high in fat, sugar and salt and low in fibre, high blood pressure, high cholesterol and smoking.

**10** Label parts A–G on the diagram below to show the steps involved in producing insulin.



*Answer:*

A – Isolate the insulin gene

B – Cut the gene out of the human genome using a restriction enzyme to produce sticky ends

C – Isolate a plasmid from a bacterium

D – Splice the insulin gene into the plasmid and use DNA Ligase to join the ends together

E – The plasmid will produce the insulin hormone

F – Transgenic bacterium / recombinant bacterium

G – Extraction and purification of insulin.

**11** Thyroxine hormone replacement is used to treat hypothyroidism. Explain why some patients with hyperthyroidism may need to receive hormone replacement after initial treatments.

*Answer:* The treatment of hyperthyroidism involves drugs used to block the uptake pf iodine, taking radioactive iodine to kill thyroid cells or surgery to remove some or all of the thyroid gland. All these result in less thyroxine being produced, which poses a risk that the person may develop hypothyroidism and then will need to be treated with synthetic thyroxine.

Questions 8.3

RECALL KNOWLEDGE

**1** Define ‘gene therapy’, and give an example of its possible use.

*Answer:* Gene therapy is the replacement of faulty genes with healthy genes. Research is currently concentrating on single-gene disorders such as cystic fibrosis, Huntington’s disease, muscular dystrophy and sickle-cell anaemia.

**2** List three ways that gene therapy could possibly correct faulty genes.

*Answer:*

* Replacing a mutated gene with a healthy copy
* Fixing or inactivating mutated gens
* Inserting a new gene that will fight the disease
* Making the immune system recognise diseased cells.

**3** Explain the role of a vector in gene therapy.

*Answer:* A vector is used to deliver the desired DNA into a cell. The DNA can be incorporated into the cells’ nucleus and produce the desired protein.

**4** Explain why it is important to diagnose cystic fibrosis at infancy.

*Answer:* Early diagnosis will allow a low-fat, high-carbohydrate and high-protein diet to be established. This will allow CF parents to keep their child as healthy as possible and to delay or prevent serious lifelong health problems related to CF.

**5** Huntington’s disease results in the death of brain cells. Explain how scientists believe gene therapy could work to treat this disease.

*Answer:* Research has indicted that gene therapy could be effective by using a modified virus to deliver a corrective gene into brain cells that boosts a natural shield against the effects of the defective Huntington protein.

**6** What are stem cells, and why are they suitable for cell replacement therapy?

*Answer:* Stem cells are undifferentiated cells that are capable of repetitive mitotic divisions for long periods of time, and given the right conditions, can differentiate into specialised cells. They are suitable for cell replacement therapy as these characteristics make them ideal for producing replacement tissues.

**7** Why is it possible that cell replacement therapy could be used to treat patients with Alzheimer’s or Parkinson’s disease?

*Answer:* Alzheimer’s disease is a progressive disorder that causes brain cells to degenerate and die. This results in a loss of brain volume, memory loss and dementia. Current treatment includes acetylcholine drugs, or drugs that inhibit acetylcholinesterase. Cell replacement therapy could be used to replace the brain cells lost to Alzheimer’s and to produce acetylcholine within the body.

Parkinson’s disease is a progressive, degenerative neurological condition that affects the control of body movements. It is caused by the death of neurons that produce dopamine in the brain. Cell replacement therapy could be used to replace the neurons lost, and to produce the required level of dopamine in the brain.

APPLY KNOWLEDGE

**8** Suggest why gene therapy is more difficult than recombinant DNA technology to develop safely and effectively.

*Answer:* Gene therapy relies on the use of a vector to deliver the replacement gene into the desired cells so that these cells will produce the required protein. Recombinant DNA technology is used to produce vaccine or pharmaceuticals outside of the human body. It is harder to ensure the body cells will uptake the replacement genes. The products produced from recombinant DNA technology is also refined and purified before human use.

**9** Discuss why gene therapy for type 1 diabetes is focused on introducing the gene into alpha cells.

*Answer:* Type 1 diabetes is caused by an autoimmune disease that destroys beta cells in the pancreas. Gene therapy is used to reprogram the alpha cells to produce insulin as alpha cells are not damaged by the autoimmune disease.

**10** Discuss why research into cell replacement therapy has focused on neurological conditions.

*Answer:* The widespread occurrence and debilitating nature of neurological diseases, such as Alzheimer’s and Parkinson’s, makes research into these disorders important and relevant. As demographics change and we move into an ageing society, the prevalence of these conditions is increasing. The central nervous system has a limited capacity of regenerating lost tissue, so transplantation of stem cells is seen as a therapeutic solution to repair the damaged brain.

**11** Tissue engineering utilises a scaffold for the tissues to grow on. Explain why this is necessary, and why it needs to be biodegradable.

*Answer:* The scaffold is required to generate a three-dimensional tissue. The scaffold serves as a template for tissue growth and can allow for diffusion of nutrients and to encourage cells to grow at the same rate and size. They need to be biodegradable so they can be absorbed by the surrounding tissue and not have to be surgically removed.

**12** ‘Gene therapy has suffered from skepticism from both [the] scientific community and [the] pharmaceutical industry. In addition to the risk of insertional mutagenesis/tumorigenesis, the widespread clinical application of gene therapy is hampered due to the inefficient systemic delivery. However, in recent years, new approaches, including stem cell-based gene therapy, have boosted the potential comeback of gene therapy’ (Ye, Z and Mahato, R, ‘Combining Stem Cells and Genes for Effective Therapeutics’, NCBI Online, 2009: <https://www.ncbi.nlm.nih.gov/pmc/articles/> PMC3207237/ [Accessed 30 August 2020].

**a** Suggest how stem cell replacement therapy can be combined with gene therapy.

*Answer:* Gene therapy and cell replacement therapy can be combined by inserting, via a vector, the replacement gene into a pluripotent stem cell. The stem cell can then be specialised and introduced into a human. The cells will multiply via mitosis and produce functional tissue all containing the replaced gene.

**b** Discuss why tumour growth is a possible risk with this technology.

*Answer:* There is a risk of introducing genes that may result in malignant properties in normal cells. The insertion of the gene in the wrong location may cause harmful mutations and could result in cancerous growth.

**c** Suggest a disorder for which this combined therapy may be a viable treatment and explain how it could work.

*Answer:* ADA-SCID (adenosine deaminase deficiency – severe combined immunodeficiency) has been treated with gene therapy and cell therapy combined. ADA gene therapy improves immune function in patients. The treatment for SCID is bone marrow transplant, which provides a new immune system to the patient. Bone marrow contains adult stem cells, which could have the faulty gene edited, and the functional gene inserted. When the bone marrow is then donated, the patient will receive the functional gene to produce the enzyme ADA, plus the ability to repair their damaged immune system from the stem cells.

Chapter 8 Activities

Activity 8.1 Investigating restriction enzymes

Answer the questions below, referring to the relevant parts of this chapter where necessary.

**1** Explain the following terms by describing their role in recombinant DNA technology.

**a** Restriction enzymes

*Answer:* Restriction enzymes cut the DNA at sites that are identified by particular nucleotides. Some restriction enzymes produce a straight cut at the sequence (blunt ends), while others produce a staggered cut (sticky ends).

**b** Recognition sites

*Answer:* The recognition site is the specific sequence of nucleotides in the DNA where the restriction enzyme cuts.

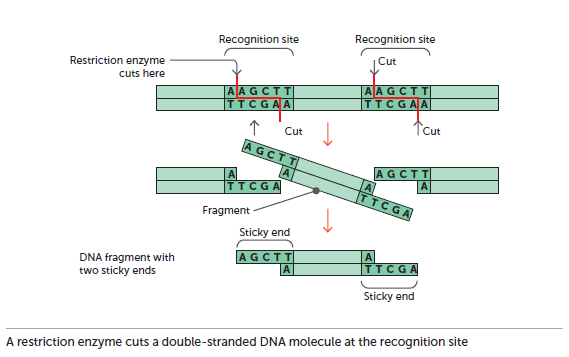
**c** Blunt ends

*Answer:* A blunt end is that produced from a straight cut, which is when the restriction enzyme makes a clean break across the two strands of DNA. A blunt end is when both strands terminate in a base pair.

**d** Sticky ends

*Answer:* A sticky end is that produced from the staggered cut of specific restriction enzymes. Sticky ends, so called because of their ability to combine with sections of DNA that have a complementary ending, are very useful in recombinant DNA technology.

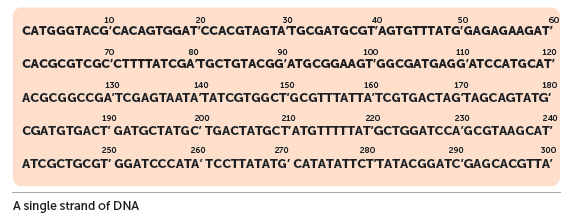
**2** Use Table 8.1 (page 203) to identify the restriction enzyme that is being used in the following figure and the organism from which it was first isolated.



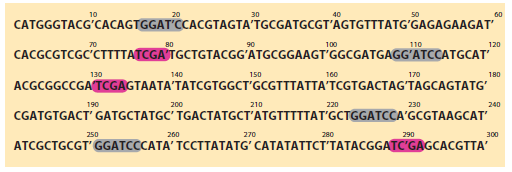
*Answer:* The restriction enzyme is *Hind*III from *Haemophilus influenzae*.

The recognition site is

**3** Imagine that you are a genetic engineer and need to cut the DNA sequence shown on the following page. Using the five restriction enzymes listed in Table 8.1, study the sequence carefully and circle every recognition site that could be cut by each of the enzymes in turn. You may wish to use pens or pencils of four different colours. How many fragments of DNA have you created for each enzyme?



*Answer:*



For enzyme BamHI there will be five fragments produced.

For enzyme TaqI there will be four fragments produced.

**4** A process called ligation is used to reassemble the fragments. Name the enzyme involved in this process.

*Answer:* DNA ligase

**5** Explain why the process of ligation can be viewed as the reverse of the restriction enzyme procedure.

*Answer:* Restriction enzymes cut DNA into fragments and DNA ligase joins DNA fragments.

**6** Use a short summarising statement to explain why the discovery of restriction enzymes and DNA ligase has been so important for the advancement of genetic engineering.

*Answer:* Restriction enzymes and DNA ligase have allowed DNA recombinant technology to develop. By cutting, and then rejoining strands of DNA, genetic engineering has been able to advance. For example, the manufacture of vaccines and insulin has been achieved using recombinant DNA technology. Gene therapy is likely to become possible on an increasing scale.

ACTIVITY 8.2 Investigating bacterial transformation

**Discussion**

**1** Explain what a plasmid is.

*Answer:* Plasmid is a genetic structure, typically circular, located within the cytoplasm of a cell. This structure has the ability to replicate independently of the chromosomes.

**2** Why is the plasmid−bacteria solution placed on ice for 5 minutes?

*Answer:* The cold increases the effectiveness of the heat shock step by increasing the sudden change in temperature. The change in temperature affects the structure of the cell wall, allowing the plasmid to enter.

**3** Which plate forms the control in this experiment? Explain.

*Answer:* The LB − Plasmid plate is the control because it allows us to check that the bacteria has grown as expected without the interference of the plasmid or the ampicillin.

**4** Explain the function of the LB broth. What is the purpose of incubating the cells at room temperature?

*Answer:* The LB broth provides nutrients for the bacterial cells to grow while incubating at room temperature. This recovery period allows the cell walls to be repaired, during which the antibiotic resistance gene begins to be expressed.

**5** Explain how the DNA plasmid is put into bacteria. What is the advantage of being able to do this? Consider what the plasmid DNA allows the bacteria to do.

*Answer:* The cell walls of the bacteria are made unstable by heat shock along with the metal cations of the calcium chloride solution, providing access to the cell by the plasmid.

The advantage of this technique is it allows foreign DNA to be inserted into the bacteria, which can replicate desirable DNA quickly; including an antibiotic-resistant gene allows the transformed cells to be selectively grown on a plate with that antibiotic.

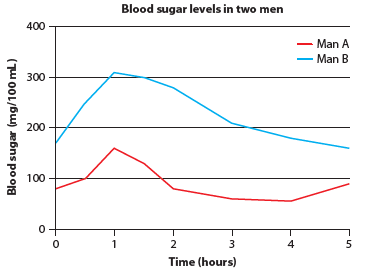
**6** Explain how we are able to identify that the plasmid DNA is in the bacteria.

*Answer:* The glow that can be seen on the petri dish is evidence that the plasmid DNA is in the bacteria, as it is the plasmid DNA that causes the glowing protein to be expressed in the bacteria.

ACTIVITY 8.3 Investigating the regulation of blood sugar

**1** **a** Plot the data for the two men as a graph.

*Answer:*



**b** One of the men had a diseased pancreas. Which man was it? Give reasons to support your answer.

*Answer:* Man B has a diseased pancreas. His blood glucose level before the test was much higher than normal (see Figure 5.16 on page 114), and it took five hours for his blood glucose to return to the pre-test level. This is an indication of low levels of insulin, a hormone that is normally produced by the pancreas.

**c** What is the name of the disease from which the man was suffering?

*Answer:* Diabetes mellitus

**2 a** Which parts of the endocrine system are responsible for releasing each of the hormones listed in the table?

*Answer:*

• Adrenaline – adrenal medulla

• Glucagon – (alpha cells in the islets of Langerhans of the) pancreas

• Cortisol – adrenal cortex

**b** A technician suggested giving the hormones to the dog by adding them to its drinking water. Would this method be effective? Explain.

*Answer:* No, it would not, because the hormones need to circulate through the blood. The hormones would be broken down in digestion before they could be absorbed into the blood.

**c** Compare the effects of these hormones when acting:

**i** singly

*Answer:* The hormones acting alone caused a minor rise in blood sugar levels. The increase ranged from 3 to 30 mg/100 mL of blood.

**ii** together.

*Answer:* The hormones working together result in a marked rise in blood sugar levels. The increase was particularly high when all three hormones were given together.

**d** What do the data indicate about the response of body tissues to the hormone mixtures?

*Answer:* The tissues respond much more to combinations of the hormones than they do to any one hormone. The hormones seem to complement each other’s effect.

**e** In light of your answers to parts **c** and **d**, explain how stress could raise blood glucose levels. What would be the advantage of this response?

*Answer:* Stress causes an increase in levels of cortisol (long term) and adrenaline (short term). The experiment showed that both these hormones reinforce the effect of glucagon. Both cortisol and adrenaline promote glycogenolysis and gluconeogenesis, so that more glucose would be released into the blood. The extra glucose could then be used to provide energy for the body organs to deal with any stressful situation.

**f** Describe at least three major criticisms of the design of the experiment on the dog.

*Answer:* The experiment could be criticised on the following grounds:

• The researchers did not say whether or not the dog had been fed.

• They did not appear to control the volumes of hormones given.

• Only one dog was used (sample size very small) and that dog may have been unusual in some way.

• There was no repetition of the procedure.

• The normal level of blood glucose was not measured before the experiment was begun.

• There was no control so the results could not be compared with a dog that had not been given the hormones.

Activity 8.4 Investigating thyroid hormone

**1** Suggest a hypothesis the scientist may have been testing.

*Answer:* That iodine is absorbed from the blood by the thyroid gland.

**2** Why was the scientist using iodine, rather than some other substance, to investigate the thyroid gland?

*Answer:* Iodine is a part of the thyroxine molecule, the hormone that is secreted by the thyroid.

**3** Why was radioactive iodine used?

*Answer:* Radioactive iodine was being used so that movement of the iodine in the body could be traced.

**4** What do you think the scientist was trying to demonstrate with this experiment?

*Answer:* The scientist was demonstrating the ability of the thyroid to accumulate iodine, or that the iodine used by the thyroid gland to make thyroxine is absorbed from the blood. (Some students may mention the importance of dietary iodine to provide iodine for the blood.)

**5** Using the graph, explain what happened to the iodine in the 40 minutes after it was injected into the arm.

*Answer:* The graph shows that as iodine in the blood declined there was an accompanying increase in iodine in the thyroid. Concentration of iodine in the arm (presumably the muscles) rose a little then fell.

**6** An important part of the investigation was to measure the concentration of iodine in the person’s arm. Why was this necessary?

*Answer:* To compare the original concentration injected with the concentration in the thyroid – that is, as a control. This was necessary to show that any reduction in the level of iodine in the blood was not due to iodine being absorbed by the tissues of the arm.

**7** Would it have made any difference to the investigation if the iodine had been injected into the person’s leg?

*Answer:* It may have taken slightly longer to reach the thyroid, but otherwise it should not have made a difference.

Chapter 8 Review questions

Recall

**1 a** What is recombinant DNA technology?

*Answer:* Recombinant DNA technology, or genetic engineering, uses foreign or altered DNA that is put into the cells of another species of organism and becomes incorporated into the cell’s DNA.

**b** List three possible applications of recombinant DNA technology.

*Answer:* Possible answers include:

* Gene therapy
* Production of pharmaceuticals such as thyroxine
* Production of synthetic hormones including insulin or growth hormone
* Production of vaccines.

**2 a** What are restriction enzymes?

*Answer:* Restriction enzymes cut DNA at particular sequences of nucleotides. They act as chemical scissors. (The name restriction enzymes is used because they restrict the duplication of bacteriophages, viruses that infect bacterial cells.)

**b** How are recognition sites related to restriction enzymes?

*Answer:* Each restriction enzyme has a specific recognition site.

**c** List examples of restriction enzymes.For each, give their bacterial origin.

*Answer*:

**Enzyme Bacterial origin**

*Bam*HI *Bacillus amyloliquefaciens*

*Eco*RI *Escherichia coli*

*Hind*III *Haemophilus influenzae*

*Taq*I *Thermus acquaticus*

**d** Differentiate between ‘sticky’ and ‘blunt’ ends in relation to restriction enzymes.

*Answer:* Blunt ends: When DNA is cut, if both strands of the DNA molecule are cut with a matching base pair, the end is blunt.

Sticky ends: When DNA is cut, the two strands of the DNA molecule are not cut with a matching base pair. This means that the end is uneven or ‘sticky’. There is one base that will ‘stick’ to another piece of DNA with the complementary base.

See also the Figure 8.6 on page 202 of the student book.

**3** What is DNA ligase, and what is it used for?

*Answer:* DNA ligase joins fragments of DNA. It acts as a chemical glue and was originally called ‘DNA-joining enzyme’. It is used to splice genes (groups of nucleotides) into a DNA molecule.

**4 a** What are vectors, and how are they used in recombinant DNA technology?

*Answer:* A vector is the means by which part of a DNA molecule is transferred from the cell of one organism into a cell of another organism. For example, by inserting the gene of interest into a bacterial plasmid or viral phage, which will then act as a vector to transfer the gene to another cell.

**b** List two different types of vectors that are used in this technology.

*Answer:* Bacterial plasmids and viral phages.

**5** Which of the two types of diabetes can frequently be treated by modifying the patient’s behaviour? Explain the nature of the behaviour modification that is necessary for effective treatment.

*Answer:* Type 2 diabetes is a lifestyle disease and can therefore be managed by behaviour modification. (It is more common in people who are not physically active and are overweight or obese.) It is treated by a careful diet, regular physical activity, maintaining a healthy weight, monitoring blood glucose and perhaps medication as the disease develops.

**6 a** What is gene therapy?

*Answer:* Gene therapy is the treatment of genetic disorders by replacing the faulty gene with a gene that works normally.

**b** How is gene therapy likely to advance the treatment of type 1 diabetes, cystic fibrosis and Huntington’s disease?

*Answer:* Cystic fibrosis is caused by a single faulty gene. Using gene therapy, this gene could be replaced with a normal gene before much or any damage occurs. This could alleviate symptoms or even cure the disease. Huntington’s disease is caused by a single gene. This gene could be silenced or shut off with gene therapy. This would alleviate symptoms or cure the patient.

**7 a** Define ‘cell replacement therapy’.

*Answer:* Cell replacement therapy replaces cells of the human body that are damaged, not working properly or are missing.

**b** How could cell replacement therapy aid the treatment of diseases such as Parkinson’s and Alzheimer’s?

*Answer:* Neural crest stem cells, found in the hair follicles of adults, are (in some countries) used to grow new neural tissue that can replace dying tissue.

Embryonic stem cells can also be used to grow new neural tissue that can replace dying tissue.

Transplanted neural tissue could restore functioning of nerves and reduce the symptoms of Alzheimer’s, Parkinson’s and other diseases.

**8** List two diseases that are being prevented with recombinant vaccines.

*Answer:* Hepatitis B and Human Papilloma Virus (HPV).

Explain

**9** Explain, with examples, how a transgenic organism is considered a GMO.

*Answer:* A GMO is a genetically modified organism who has had genetic material added or removed. A transgenic organism is an organism that has genes from a different species transplanted into its genome. For example, Golden Rice is a transgenic organism. It has a gene from maize and from a bacterium found in soil included into its genome so that the rice can produce beta-carotene, needed for humans to produce Vitamin A.

**10** Explain the differences between type 1 and type 2 diabetes.

*Answer:* A person with type 1 diabetes does not produce insulin. In most cases the patient’s cells respond to insulin in the normal way so that the disease can be managed by giving the patient insulin.

Type 2 diabetes (also known as non-insulin dependent or adult onset diabetes) usually develops in people over the age of about 45 years, although increasing numbers of younger people are now being diagnosed. Unlike type 1 diabetes, type 2 patients are able to produce insulin, but their cells do not respond to it.

|  |  |  |
| --- | --- | --- |
|  | **Type 1 diabetes** | **Type 2 diabetes** |
| Onset | Usually in childhood | Usually over age 45, but increasing numbers of younger people affected |
| Cause | Immune system fault causing destruction of beta cells in pancreas so that insulin is not produced | Associated with lack of physical activity and being overweight |
| Treatment | Cells usually respond to insulin normally so insulin can be given to manage the condition | Cells do not respond to insulin, so management involves careful diet with regular physical activity |

**11** Explain how the treatment of type 1 diabetes has been assisted by recombinant DNA technology.

*Answer:* Previously, insulin to supply type 1 diabetics was collected from the pancreases of pigs and cattle. This was a limited source, required purification, and resulted in some people having allergic responses or infections from the insulin. Recombinant DNA technology has allowed insulin to be produced from the human gene by harmless bacteria or yeast in large quantities.

**12** Explain why scaffolds are used in tissue engineering.

*Answer:* Scaffolds are a template that cells are grown on so that they become a three-dimensional tissue. The scaffolds allow for more deliberate tissue growth and can determine shape if a particular organ, for example a human ear, is required to be transplanted. Tissue scaffolds can be used to grow tissue outside the human body for later transplant.

Scaffolds should:

• have pore sizes that allow cell growth

• allow nutrient diffusion to the cells

• be biodegradable

• be able to be absorbed by the tissue

• allow tissue to absorb the scaffold at the same rate as the tissue growth.

**13** Explain the difference between hyperthyroidism and hypothyroidism.

*Answer:* Hyperthyroidism results from too much thyroxine. It occurs when the thyroid gland produces too much hormone. (The most common type of hyperthyroidism is known as Graves’ disease. It is an enlargement of the thyroid caused by an immune system reaction.) Symptoms of hyperthyroidism include weight loss, increased appetite, increased heart rate, fatigue and anxiety.

Hypothyroidism results from too little thyroxine. Causes include deficiency of iodine in the diet, surgery involving removal of all or part of the thyroid, attack on the thyroid by the immune system (Hashimoto’s disease), and problems with the pituitary or hypothalamus. Symptoms include slow heart rate, weight gain, fatigue, intolerance to cold and swelling of the neck.

**14** Explain how a dietary deficiency can cause hypothyroidism.

*Answer:* A thyroxine molecule contains four iodine atoms (hence, T4) and a tri-iodothyronine molecule contains three atoms of iodine (T3). Thus, if there is a deficiency of iodine in the diet, the thyroid gland cannot make enough of the thyroid hormones. If the cause of hypothyroidism is a lack of iodine, it is easily treated by the inclusion of extra iodine in the diet.

**15** Annotate a diagram to explain how biosynthetic insulin is produced.

*Answer:* Refer to Figure 8.15 on page 209 of the student book.

**16** Drugs used to treat thyroid deficiency are produced synthetically. What advantages are there in using synthetic drugs rather than those obtained naturally?

*Answer:* Hormones obtained naturally from the thyroid glands of animals like pigs may contain traces of other hormones. Also they may not contain the correct proportions of T3 and T4. The content of synthetic hormones can be closely regulated.

Apply

**17** Name the third restriction enzyme isolated from *Haemophilus aegyptius*.

*Answer:* HaeIII

**18** The diagram below shows the base sequence for a section of DNA.

G G T C A A G C T T A C T C G G A T C C A G C T G A A T T C

C C A G T T C G A A T G A G C C T A G G T C G A C T T A A G

Use Table 8.1 (page 203) to identify the recognition site for each of the following restriction enzymes, and hence show the cuts that would be made and state whether they produce blunt ends or sticky ends.

*Answer:*

|  |  |  |  |
| --- | --- | --- | --- |
| **Recognition enzyme** | **Recognition site** | **Cuts made shown by highlight** | **Blunt or sticky ends** |
| **a** BamHI | G G A T C C  C C T A G G | G G T C A A G C T T A C T C G G A T C C A G C T G A A T T C  C C A G T T C G A A T G A G C C T A G G T C G A C T T A A G | Sticky ends |
| **b** EcoRI | G A A T T C  C T T A A G | G G T C A A G C T T A C T C G G A T C C A G C T G A A T T C  C C A G T T C G A A T G A G C C T A G G T C G A C T T A A G | Sticky ends |
| **c** HindIII | A A G C T T  T T C G A A | G G T C A A G C T T A C T C G G A T C C A G C T G A A T T C  C C A G T T C G A A T G A G C C T A G G T C G A C T T A A G | Sticky ends |
| **d** PvuII | CAG CTG  GTC GAC | G G T C A A G C T T A C T C G G A T C C A G C T G A A T T C  C C A G T T C G A A T G A G C C T A G G T C G A C T T A A G | Blunt ends |

**19** Compare and contrast synthetic hormones and biosynthetic hormones.

*Answer:*

Compare: Both are hormones, which are used to regulate cell functions and to carry messages around the bloodstream. Both are specific and require receptors in or on the cells to activate particular processes.

Contrast: Synthetic hormones are produced by either recombinant DNA or chemical manufacturing. They mimic natural hormones and are similar but not identical to human hormones. Biosynthetic hormones are produced by other living organisms, bacteria or yeast cells. As the bacteria or yeast contain the gene to produce the hormone, the hormones they produce are more similar, if not identical, to the normal human hormone.

**20** The most commonly used test to see whether thyroid function is adequate is a blood test for thyroid-stimulating hormone (TSH).

**a** How would a blood test for TSH show whether the thyroid is functioning normally?

*Answer:* TSH regulates the release of thyroxine from the thyroid. It is released by the anterior pituitary gland in response to low levels of thyroxine. If thyroxine levels are very low, higher than normal levels of TSH would be expected in the blood. Likewise, if thyroxine levels are higher than normal, TSH levels will be very low. If TSH levels are normal, it probably means that thyroxine secretion is normal.

**b** A test for TSH in the blood can also be used to determine whether a person’s diet has sufficient iodine. How would such a test be able to show whether iodine levels are adequate?

*Answer:* Iodine is needed for production of thyroxine. If iodine levels are low, less thyroxine will be able to be produced by the thyroid gland. This, in turn, would cause TSH levels to increase to try to stimulate the thyroid to produce more thyroxine.

**21** Explain how gene therapy is different from cell therapy.

*Answer:* Gene therapyaims to treat or cure genetic abnormalities by replacing faulty genes with healthy ones. It uses genes as the treatment. Cell therapy uses stem cells to specialise into replacement tissue. The replacement tissue is used to produce products, for example dopamine in Parkinson’s patients, or to replace destroyed tissue, for example knee cartilage.

**22** Imagine that you are a doctor. One of your patients is overweight and complains of feeling constantly hungry and thirsty. You suspect the patient may have type 2 diabetes.

**a** What tests would you do to find out whether the person is suffering from type 2 diabetes?

*Answer:* You could test the patient’s urine to see if glucose is present and, if necessary, test blood sugar concentration.

**b** If type 2 diabetes is positively diagnosed, what treatment would you recommend for the patient?

*Answer:* A change in lifestyle should be recommended. It would incorporate:

• a balanced diet with many serves of fruit and vegetables and fewer serves of fat and sugar

• an exercise regime to be carried out at least three times per week for one hour

• a weight loss program, because obesity causes the insulin receptors to become less sensitive to insulin.

**23** Goitre, enlargement of the thyroid gland, can be associated with both overproduction and under-production of thyroid hormone. Explain how this is possible.

*Answer:* Over-production of thyroid hormone is caused by overactive thyroid cells. This increased cellular activity causes enlargement of the thyroid. Underproduction also results in goitre, because the thyroid enlarges to try to accumulate as much iodine as possible from the blood so that it can synthesise more thyroxine. It is constantly stimulated by TSH to do so.

**24** Graves’ disease is caused by an abnormality of the immune system. The immune system produces an antibody that behaves in the same way as TSH. Explain how this would lead to hyperthyroidism.

*Answer:* If the antibody behaves in the same way as TSH, it would stimulate the thyroid to produce more thyroid hormones leading to hyperthyroidism and the symptoms of Graves’ disease.

Extend

**25** When the Human Genome Project was launched in 1990 it was expected to take until 2005 for complete mapping to be achieved. However, the results of the project were published in 2001, four years ahead of schedule. Find out what enabled the project to advance much faster than originally anticipated.

*Answer:* The project proceeded faster than expected because of:

• international cooperation

• automation of the polymerase chain reaction (allowing rapid sequencing of bases)

• advances in computing technology.

**26** Pregnant women need up to three times more insulin than normal. If the body is unable to produce that much insulin, a condition called gestational diabetes develops. Find out how gestational diabetes could affect the developing foetus.

*Answer:* Babies born to mothers with gestational diabetes have an increased risk of obesity and an increased chance of developing type 2 diabetes later in life.

If untreated, gestational diabetes can cause growth abnormalities and chemical imbalances after the baby is born.

**27** The use of blood products sourced from living donors and human growth hormone from cadavers resulted in products that were devised to improve quality of life, but which also had life-threatening side effects. Using the Internet, find out the types of diseases that were involved with these contaminated products and how they affected the recipients of those products. How has recombinant DNA technology overcome these life-threatening side effects?

*Answer:* The use of blood products from living donors carried the risk of diseases such as hepatitis B and HIV. The use of recombinant DNA to produce blood clotting factors has eliminated this risk.

The main threat from cadaver growth hormone was the transmission of Creutzfeldt-Jakob disease, a form of mad cow disease. By 2003, the numbers of patients treated with cadaver growth hormone who had contracted CJD was so high that use of the hormone from cadavers was stopped. Recombinant DNA technology means that production of human growth hormone is clean. Only the hormone is produced. No other proteins or cell products that could cause negative side effects are made.

**28** Uncontrolled diabetes may result in unconsciousness or diabetic coma. Conduct research to find out:

**a** the three different types of diabetic coma and the cause of each

**b** the relationship between each type of coma and the two types of diabetes

**c** the first aid and treatment for diabetic coma.

*Answer:*

|  |  |  |  |
| --- | --- | --- | --- |
| **Types of diabetic coma** | **Cause of each coma** | **Linked to which type of diabetes** | **First aid and treatment** |
| Diabetic ketoacidosis coma (DKA) | Very high glucose levels, above 17 mmol/L. Results from a build-up of ketones in the blood. May result from missed insulin dose or acute infection. | Usually type 1, but can occur in people with type 2. | Dial 000  Do not give the person anything to drink or eat, put them into the recovery position and follow instructions from the 000 operator.  Intravenous fluids, insulin and administration of potassium. |
| Hyperosmolar coma | Severe dehydration combined with high blood glucose levels. Can be caused by missed insulin dose, infection or illness, or an increased intake of sugary foods. | Type 2 diabetics | Dial 000  Do not give the person anything to drink or eat, put them into the recovery position and follow instructions from the 000 operator.  Intravenous fluids, insulin, potassium and sodium. |
| Hypoglycaemic coma | Low blood glucose levels (below 3.5 mmol/L). Caused by an extra dose of insulin or other diabetes medications, strenuous exercise without eating food to compensate, reduced medication, skipped meal or snack, excessive drinking without eating. | Type 1 diabetics | Dial 000  Do not give the person anything to drink or eat, put them into the recovery position and follow instructions from the 000 operator.  Injection of glucagon to counteract the insulin or intravenous glucose. |

**29** One researcher in the United States stated:

‘Tissue engineering holds out promise of truly healing the heart after congestive heart failure.… Through tissue engineering we could actually restore the function of the heart by replacing large portions of the damaged heart muscle by a bioartificial one.’

This same researcher has been working for a long time on developing the ideal scaffolding to support the injected cells and the architecture of the heart. Use an Internet search engine to find out the type of scaffolding material that is being used in such research and the success that has been achieved to date.

*Answer:* A honeycomb polymer scaffold that stretches like cardiac muscle, passes electrical impulses more in one direction than the other and guides the cultured cells to grow on the scaffold. This is still in the research stages using rat cells. See:

<http://web.mit.edu/newsoffice/2008/heart-1102.html>

<http://www.nature.com/news/tissue-engineering-how-to-build-a-heart-1.13327>

**30** The impact of biotechnology on our daily lives is growing. Much is being said and written about developments in the use of stem cells to aid the treatment of disease. Hold a class debate to canvas both sides of the question: ‘Should the Australian federal government support stem cell research?’ Remember to keep an open mind and to respect the opinions of others.

*Answer*:

**Points for the question**

We have the technology, why not use it?

Advances in medicine could benefit everyone

Potential for cures and treatment of those in pain and suffering

Human nuclei could be inserted into animal eggs, enabling the embryonic cells produced to be used for research into therapies, but not directly for therapeutical use.

**Points against the question**

If embryonic stem cells are used they are taken from embryos, which have the potential to develop into human beings, and are killed in the research

Chances of success are doubtful

Is it really safe?

The risks to women for donating eggs are small but significant

Women are not compensated for the donation of eggs

Research may be driven by profit and scientific advancement, not cures

**31** Population projections by the Australian Bureau of Statistics indicate that by the year 2051 the proportion of the total Australian population that is aged 65 years or more will almost double. Discuss how the impact of this shift in the age structure of the population will affect diseases of ageing such as Parkinson’s and Alzheimer’s, with particular reference to the stress it will create for health systems and resources.

*Answer:* With an increase in ageing population, there would be an increase in the incidence of conditions that occur at this stage of life, such as Parkinson’s and Alzheimer’s. There will be a need for extra care facilities, including doctors, medications and nursing homes with suitably trained carers. This in turn will create problems for the country’s economy because of the cost of providing such facilities.

**32** Recombinant DNA technology has resulted in the manufacture of far more human growth hormone than was available in the past. It is now being used to overcome some of the cosmetic effects of ageing. Find out:

**a** when human growth hormone first became available for use with adults

*Answer:* Human growth hormone (HGH) first was isolated in the late 1950s from cadavers. Recombinant HGH was widely available after 1985.

**b** what evidence there is of beneficial results from anti-ageing use of this hormone

*Answer:* Studies of healthy adults taking HGH may increase muscle mass and reduce body fat, the increased muscle mass does not translate into increased strength. There were no significant changes in ‘bad’ or ‘good’ cholesterol, bone density or fasting blood sugar and insulin levels.

**c** if there are risks involved in the use of the hormone in this way

*Answer:* HGH treatment in healthy adults may cause a high rate of side effects including fluid retention, joint pain, breast enlargement and carpal tunnel syndrome. Increased insulin resistance may lead to Type 2 diabetes and an increased risk of cancer in general and prostate cancer in particular.

**d** if there are other benefits to adults in the use of this hormone.

*Answer:* Adults with a growth human deficiency – not attributed to the normal decline due to ageing – will benefit from an increased exercise capacity, increased bone density, increased muscle mass and a decrease in body fat.