**UNIT 3 ATAR HUMAN BIOLOGY**

**Task 5 – How biotechnology is being used to treat endocrine**

**and nervous dysfunction**

**Make research notes on the following:**

1. The causes and symptoms of Parkinson’s disease and Alzheimer’s disease.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Parkinson’s – death of dopamine producing cells, notice after 70% death | 1 |
| Symptoms – **Tremor. Slowed movement (bradykinesia). Rigid muscles. Impaired posture and balance. Loss of automatic movements. Speech changes. Writing changes.** | 1 |
| Alzheimer’s – plaques cause death of neuron/block synaptic gap. Tangles prevent nutrients moving about cell | 1 |
| Symptoms – loss of short term memory can’t retain information, loss recognition of familiar things, can’t reason, do simple tasks | 1 |
|  | **Total 4** |

1. The causes and symptoms of Hypothyroidism and Type I Diabetes.

|  |  |
| --- | --- |
| Description | Marks |
| Hypothyroidism- Hashimoto’s disease, lack of iodine, lack of TSH | 1 |
| Symptoms – lack of energy, intolerance to cold, weight gain, goitre | 1 |
| Type I – autoimmune disease killing Beta cells in pancreas | 1 |
| Symptoms – glucose in urine, tiredness, high blood glucose, thirsty | 1 |
|  | **Total 4** |

The rest of the questions are marked against the grade descriptors on a scale of 1 -3:

**3** - Communicates detailed information and concepts logically and clearly, using appropriate scientific language and conventions. (Accurate coverage of concept using correct terminology).

**2** - Communicates information and concepts clearly, using appropriate scientific language and conventions. (Some gaps).

**1** - Communicates information and concepts, without detail, using some appropriate terminology and conventions. (Right idea but not all details / terminology correct).

1. The process of Gene therapy and Stem cell Replacement therapy.

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| --- | --- |
| Description | Marks |
| Gene therapy | |
| * extract the desired gene/non mutated from DNA * obtain virus/vector/adenovirus that will infect specific cell * remove viral DNA and insert desired gene * infect body with virus * insert gene into target cell * use enzymes to insert gene into cells DNA where it can function * will only work with disease caused by single faulty gene | 1 - 3 |
| Stem Cell replacement therapy |  |
| * obtain an adult stem cell * clean the stem cell and reprogram to desired cell * inject the stem cell into the area where needed * stem cell will divide rapidly replacing damaged cells | 1 - 3 |
|  | **Max 6** |

1. The potential use of gene therapy to treat Alzheimer’s disease with reference to the genes ApoE4 and ApoE2.

|  |  |
| --- | --- |
| Description | Marks |
| * Alzheimers is caused by the death of neurons that have been killed by plaques/tangles * ApoE4 is the gene thought to be responsible. * Person has two ApoE4 genes likely to get Alzheimers, ApoE3 neutral, whilst ApoE2 gives some protection * Person with ApoE2 seems unlikely to get Alzheimers , almost protected * If can replace the ApoE4 gene with the ApoE2 gene then person not likely to get Alzheimers * As will prevent the growth of the plaques and tangles so neurons stay healthy * Treatment will prevent rather than trying to fix once occured | 1 – 3 |
|  | **Max 3** |

1. A comparison of the use of gene therapy and Levodopa to treat Parkinson’s disease.

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| --- | --- |
| Description | Marks |
| * Parkinsons is caused by the death of cells that produce dopamine * The lack of dopamine results in the symptoms of Parkinson’s * Could use gene therapy to insert gene to produce dopamine into the remaining neurons * Then cells would produce dopamine and alleviate some symptoms of the condition * Would mean no injections into the brain, would be produced when needed in a controlled manner * Heightened levels of dopamine do reduce the response after time * Effects would not wear off as natural chemical made by body * Dopamine cannot enter the brain directly so medications used that will enter brain then convert to dopamine (Levodopa) * Will alleviate symptoms but patient can get used to it and effects lessen with time * High doses can cause adverse reactions- involuntary movements, get worse with time * At present even with gene therapy patients still need to take Levodopa but small doses. | 1 - 3 |
|  | **Max 3** |

1. The reasons why stem cell replacement therapy is not being looked at as seriously as gene therapy as treatments for Alzheimer’s and Parkinson’s disease.

|  |  |
| --- | --- |
| Description | Marks |
| * Problems with stem cell therapy - The current, general concerns regarding stem cell-based therapy are as follows: tumorigenicity, immune reaction, contamination while handling, risks from genetic modification, risks of administration modality, unintended migration, unwanted transdifferentiation, infection, and death of the transplant. There are also ethical concerns with regard to certain cell sources. * Gene therapy has less ethical risks. Less chance the cell will go rouge once injected with gene. * Gene could be injected into wrong cell but effects are not as drastic. Less damage to brain during administration/less risk. Less chance of immune reaction as gene is inside cell won’t be detected | 1 - 3 |
|  | **Max 3** |

1. How progenitor cells (stem cells) are being used to treat Type I Diabetes and why the use of technologies such as “Cell in the box”/capsules/tubular chambers are needed to help the treatment be successful.

|  |  |
| --- | --- |
| Description | Marks |
| * Multipotent stem cells are used because worked out a way to program them. Also don’t keep dividing indefinitely * an approach where the implanted cells are reprogrammed into insulin-producing cells /beta cells * However, early attempts at the transplantation of pancreatic cells have largely failed, mostly due to immune reactions against donor cells that cause complications and eventually destroy the implanted cells. * Cells are placed in a capsule so can sense glucose levels and produce insulin but capsule prevent attack from immune system so cells survive. | 1 - 3 |
|  | **Max 3** |

1. How recombinant DNA technology is being used to manufacture thyroxine for the treatment of Hypothyroidism.

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| --- | --- |
| Description | Marks |
| * Gene to make thyroxine is cut from DNA using restriction enzymes * Plasmid is removed from a bacteria and cut using the same restriction enzymes * This create sticky ends on both pieces of DNA * Gene is inserted into the plasmid using DNA Ligase and fastened in place in a process called ligation * The plasmid is then inserted back into the bacteria * Bacteria put in fermenter and left to breed * Bacteria now manufacture the hormone thyroxine * It is collected and purified for use in treating hypothyroidism | 1 - 3 |
|  | **Max 3** |

**Part 2: In-class assessment (one hour) *(90% weighting)***

**Questions:**

1. Describe two symptoms a person would show if they had Parkinson’s and explain why they would occur.

*(3 marks)*

|  |  |
| --- | --- |
| Description | Marks |
| Any two symptoms described – **Tremor, Slowed movement (bradykinesia), Rigid muscles, Impaired posture and balance, Loss of automatic movements, Speech changes, Writing changes.**  Cause by loss of dopamine producingneurons so less impulses resulting in less control | 2  1 |
|  | Total 3 |

2. Addison’s disease (Primary) is brought about by the dysfunction of the adrenal glands; the adrenal cortex does not produce enough cortisol as the persons own immune system has attacked the cells in the cortex causing damage.

1. Explain which treatment, gene therapy or stem cell replacement therapy, would be the most effective to treat a person with Addison’s disease. *(3 marks)*

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Cells of cortex destroyed – so have no cells to insert a gene in | 1 |
| Stem cell replacement therapy would enable a stem cell to be programmed into cortisol producing cell/gene therapy requires a healthy cell to insert the gene into so it can produce cortisol | 1 |
| Inserted and divide rapidly replacing the damaged cells to improve quality of life/ | 1 |
|  | Total 3 |

1. Addison’s disease is currently treated with hormone replacement therapy involving synthetic cortisol. Describe, in detail, the process by which synthetic cortisol would be made. *(6 marks)*

|  |  |
| --- | --- |
| Description | Marks |
| * Gene to make Cortisol is cut from human DNA using restriction enzymes * Plasmid is removed from a bacteria and cut using the same restriction enzymes * This create sticky ends on both pieces of DNA * Gene is inserted into the plasmid using DNA Ligase/ fastened in place in a process called ligation * The plasmid is then inserted back into the bacteria * Bacteria put in fermenter and left to breed * Bacteria now manufacture the hormone cortisol /It is collected and purified for use in treating Addison’s | Max 6 points |
|  | **Total 6** |

1. Explain why a capsule is required to maximise the success of treatment using progenitor cells (kind of stem cells therapy) for Type I diabetes.  *(3 marks)*

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Type 1 caused by own immune system/WBC’s killing the Beta cells | 1 |
| If create new beta cells using stem cell therapy and insert into pancreas they will also be killed | 1 |
| The capsule enables chemicals to flow in and out but stops WBC entering and killing cells | 1 |
|  | **Total 3** |

1. Outline the general procedures that would occur for an Alzheimer’s patient to be treated using gene therapy.

|  |  |
| --- | --- |
| Description | Marks |
| * extract the desired gene for non-mutated/normal amyloid production from DNA * obtain virus/vector/adenovirus that will infect neurons in the brain * remove viral DNA and insert desired gene * infect body with virus which will enter brain * insert gene into target cell /use enzymes to insert gene into cells DNA where it can function | Max 5 points |
|  | **Total 5** |

5. Describe the problems associated with administering dosages of Levodopa to patients suffering from Parkinson’s

|  |  |
| --- | --- |
| Description | Marks |
| Knowing the correct dosage is difficult so could administer too much – lead to excessive dosage causing unnecessary involuntary movements/not enough so not helping problem | Any 3 |
| Patient gets use to the drug so it becomes less effective |
| Side effects from taking the drug cause problems |
| Relies on enzymes converting drug to dopamine inside the brain as dopamine cannot be absorbed directly enzyme may become ineffective/drug may affect other neurons in the body |
|  | **Max 3** |

6. a) Predict what the second necessary feature of these Nanobots is and explain why it is crucial that the

Nanobots have this feature if they are to be used as a long-term treatment for Type 1 Diabetes.  *(3 marks)*

|  |  |
| --- | --- |
| Description | Marks |
| Need to detect levels of glucose | 1 |
| Need to know levels of glucose to know how much insulin to release/respond to changing levels | 1 |
| if not could release insulin when not necessary/use up supplies quickly | 1 |
|  | **Total 3** |

b) Nanobots could also be used to treat Hashimoto’s, an autoimmune disease in which the cells of the thyroid are destroyed.

* 1. Suggest two symptoms a person suffering from Hashimoto’s would experience if they were not medicated. *(2 marks)*

|  |  |
| --- | --- |
| Description | Marks |
| Any two symptoms – weight gain, lack of appetite, lack of energy, intolerance to cold | Max 2 |
|  | **Total 2** |

* 1. Explain how Nanobot technology could be used to treat Hashimoto’s disease.

*(3 marks)*

|  |  |
| --- | --- |
| Description | Marks |
| Hashimotos disease – autoimmune disease where thyroid destroyed | 1 |
| Nanobots could be programmed to detect levels of calcium in the blood/could be programmed to detect levels of energy in the body/detect the bodies temperature | 1 |
| If levels were too high would release calcitonin to enable uptake of calcium from blood into bones/if levels of energy too low then would release Thyroxine to increase metabolism/if the bodies temp is too low the release thyroxine to increase heat production | 1 |
|  | **Total 3** |

Read the following article

1. The following text has been adapted from a 2018 article on Nanowerk.com

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**Nanotechnology based drug delivery systems for nanomedicine**

*September 18th, 2018*

Development of an effective approach for delivering a new drug is as important as inventing a new drug. Even if a developed new drug has excellent therapeutic properties, it shows its potential activity in the body only when it is exactly targeted to specific molecules.

Various nanotechnological approaches for effective drug delivery have been developed and some of them have already been successfully commercialised. Most prominent nano-drug delivery systems that are in market place are cancer/tumour related.

Bioavailability – the problem with conventional drug delivery

The bioavailability of a drug within the body depends on several factors like the size of the drug molecules and solubility. Conventional dosage forms therefore face challenges in reaching the target site at appropriate dose. For example, conventional dosage forms of some of the highly water-soluble drugs cause fluctuations in drug concentration in the body due to high disintegration properties and also result in faster clearance of the drug from the blood stream.

Other drugs are fat soluble and when taken in conventional dosage forms may cause bioavailability problems. Similarly, patients suffering from chronic diseases like diabetes need to take painful insulin injections on a regular basis. Cancer patients regularly have to undergo powerful chemotherapy, which involves quite severe side effects as the anticancer drugs target cancer cells and normal cells equally. Hence, proper platforms to deliver the drugs at targeted sites without losing their effectiveness, while limiting the associated side effects, are highly required.

Many novel technologies for developing effective drug delivery systems have been developed; among these nanotechnology  platforms for achieving targeted drug delivery are gaining prominence these days. Research in this field includes the development of drug nanoparticles, polymeric and inorganic biodegradable nanocarriers for drug delivery, and surface engineering of carrier molecules.

These nanocarriers help in making fat based drugs soluble, protecting fragile drugs from enzymatic degradation, pH conditions, etc., and targeting specific sites with triggered release of drug contents.

Nanobots

Nanobots or nanomotors are advanced sub-micron sized, self-driven, biodegradable nanodevices made of bio-nano components, which carry cargo to the target sites. Basically tiny molecular sized robots that can move through the body’s blood stream and tissues. These robots can carry tiny microchips as well as drugs, hormones, even radioactive material. And, as with robots, they can be programmed.