BIOTECHNOLOGY EXTENDED ANSWERs:

**Question 1:**

Type 1 diabetes mellitus is an autoimmune disease resulting from the destruction of pancreatic β cells.

Synthetic human insulin was the first golden molecule of the biotech industry and the direct result of recombinant DNA technology. Currently, millions of diabetics worldwide use synthetic insulin to regulate their blood sugar levels. Synthetic insulin is made in both bacteria and yeast.

1. Describe in detail the process by which synthetic insulin is made using yeast, including all biological materials required. You may use detailed annotated diagram. (10 marks)

* *Human genes extracted using restriction enzymes*
* *Both A and B genes required*
* *PCR*
* *Plasmids extracted from yeast cells using the same restriction enzyme*
* *To produce the same sticky ends on DNA*
* *Human genes spliced into plasmid*
* *using DNA ligase.*
* *Forms recombinant DNA*
* *Plasmids taken up (resorbed) into yeast cells again*
* *Forms transgenic orgaisms*
* *Yeast cultured - given all nutrients and amino acids required*
* *Insulin extracted from broth and purified*

1. Outline the advantages to diabetics that production of insulin in this way has provided when compared with the traditional extraction of the hormone from cattle and pig pancreases. (3 marks)

* *Human insulin not bovine insulin so no immune response*
* *No chance of cross species diseases*
* *No contaminants*
* *Ready supply / cheaper production*
* *Religious reasons not to use pigs*

**Question 2:**

The current treatment for patients with type 1 diabetes mellitus of daily insulin injections is associated with profound drawbacks. Despite great improvements in insulin delivery systems seen in the last two decades, it’s still difficult to provide the precise amount of insulin that is required by the patient at any given time. This results in hypo- and hyperglycemic episodes, potentially leading to cell damage in many tissues, ultimately resulting in the development of severe long-term complications. Therefore, treatments which enable the patient to produce their own insulin would seem better long term prospects.

Insulin gene therapy, which has shown great efficacy in correcting hyperglycemia in animal models, holds great promise as an alternative strategy. This refers to the targeted expression of insulin in non-β cells, with hepatocytes (liver cells) emerging as the primary therapeutic target.

Alternatively cell replacement therapy targeting entire β cells or Islets of Langerhan would seem a more complete option.

1. Using the situation outlined above, describe in detail **three** differences between these two therapies. Use examples where appropriate. (9 marks)

|  |  |
| --- | --- |
| *Gene Therapy* | *Cell Replacement Therapy* |
| * *Replaces a single gene- (1)*   *The gene to produce insulin (1)*   * *uses recombinant DNA /vector to carry gene (1)*   *adenovirus, e coli,(1)*   * *Can only treat diseases of singe gene faults (1)*   *Cystic Fibrosis, haemophilia (1)*   * *Patients own cells are used (1)*   *Liver cells modified to secrete insulin*  *(1)*  *OR*   * *Non- pancreatic cells can be used (1)*   *Liver cells modified to secrete insulin*  *(1)* | * *Replaces whole cells or tissues (1)*   *Islets of Langerhans (1)*   * *No alteration of cells (1)*   *whole islets would be transplanted (1)*   * *Can treat diseases of faulty cells (1)*   *Alzheimer’s, Parkinsons(1)*   * *Donor or stem cells (1)*   *Islets removed from donor pancreas (1)*  *OR*   * *Pancreatic cells used (1)*   *B cells or Islets used (1)* |

1. For each therapy, apart from excessive cost, explain two challenges to the success of the procedure. (8 marks)

***Gene Therapy:***

*Delivering the gene to the right place –(1) gene is only required in specific cells / liver cells and the vector must only infect those cells. (1)*

*Gene must be turned on (1) to have the desired effect (1)*

*Avoiding the immune response – (1) produced by the presence of vectors or foreign vector(1)*

*Making sure the new gene doesn’t disrupt the function of other genes(1) and not have desired effect (1)*

*Use of vectors (1) may cause diseases / changes(1)*

***Cell replacement therapy:***

*Rejection of donor tissue – (1) anti rejection drugs must be taken (1)*

*Finding or matching a donor – (1) tissues must match to avoid rejection(1)*

*Use of embryonic stem cells is controversial (1) as the death of an embryo is involved(1)*