4. Type I diabetes: how molecular and cell biology research facilitate treatments: Solutions

What is type I diabetes?

Every year, about 90 000 people worldwide, mostly children and young people, are diagnosed with type 1 diabetes – a disease in which the body does not produce the hormone insulin. Type 1 diabetes patients develop an autoimmune response against insulin-producing beta-cells in the pancreas, i.e. their immune system attacks and destroys these cells, and the absence of insulin leads to elevated blood glucose levels. *You can learn more about insulin, its release, actions and regulation in "Insulin signalling" section on the "Regulation of metabolism by cell signalling" resource*.

Symptoms of the disease include increased hunger and thirst, frequent urination and weight loss. If untreated, the disease could lead to kidney failure, cardiovascular disease and eye damage. Research is under way into how this disease might be both cured and prevented, but currently the only treatment is insulin therapy, involving life-long everyday injections of insulin.

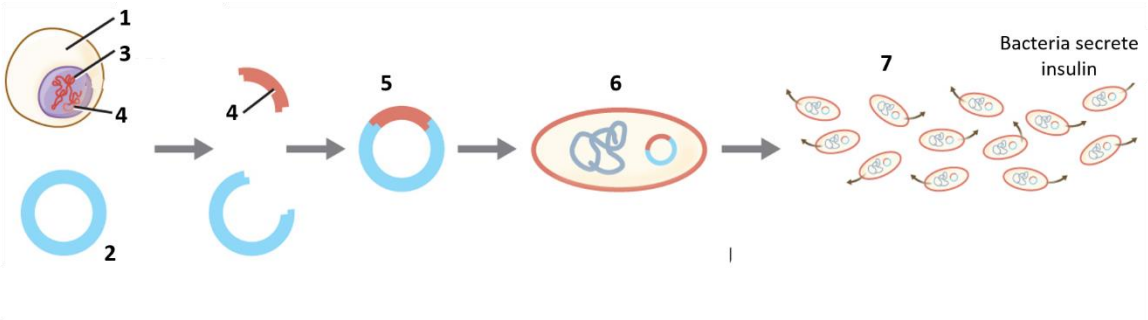
References

Katsarou, A. *et al*. Type 1 diabetes mellitus. *Nature Reviews Disease Primers* **3**, 17016 (2017).
"Diabetes Fact sheet N°312". World Health Organization (WHO). November 2016.

How genetic engineering revolutionised insulin production

So where to get this insulin from? In the first half of 20th century, insulin from cows and pigs was used. However, with advancements of biotechnology and genetic engineering, the following method was developed to produce human insulin on a large-scale, without involving animals. This method involves taking the sequence of the human insulin gene and inserting it into bacteria, allowing the bacteria to produce insulin which we can then collect.

Complete the table by writing the correct number from the diagram next to each label.



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http://cnx.org/contents/e42bd376-624b-4c0f-972f-e0c57998e765@4.2

Number	Label
6	Genetically modified bacterium
3	Human DNA
5	Plasmid, which has insulin gene inserted
1	Human cell
2	Plasmid*
7	The progeny of genetically modified bacteria
4	Insulin gene

*Plasmid is a small circular DNA molecule sometimes present in addition to the chromosomal DNA in a cell

Other treatment options: stem cells

One of the promising alternative treatments for type 1 diabetes that is currently being investigated through clinical research is stem cell therapy. How do you think this might work?

Stem cells are cells that have an ability to differentiate into (i.e. become) many cell types. Stem cells can be grown in the lab.

Stem cells, in particular pluripotent stem cells, have an ability to differentiate into (i.e. become) any cell type. Nowadays there are methods of cell reprogramming: it is possible to take, for example, some skin cells from a patient, turn them back into stem cells in the lab, and then re-differentiate them into another cell type. In theory, that way beta-cells can be produced, and transplanted back to the patient to restore the body's insulin-producing function, effectively curing type 1 diabetes.

The process of de- and re- differentiation is very complex, and unfortunately is not understood well enough in the case of beta-cells for this approach to be used in the clinic just yet. However, major breakthroughs in this area have been made: functional human pancreatic beta-cells have been produced in vitro (in the lab)[1], and pre-clinical studies have shown that such cells could successfully reverse diabetes in mice[2].

References

1. *Pagliuca, F. et al. Generation of Functional Human Pancreatic β Cells In Vitro. Cell 159, 428-439 (2014).*
2. *Rezania, A. et al. Reversal of diabetes with insulin-producing cells derived in vitro from human pluripotent stem cells. Nature Biotechnology 32, 1121-1133 (2014).*