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EB Education Revision Guide

How to work with Homeostasis: Part 2
Blood Glucose Regulation

...helping everybody achieve Even Better

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What you need to know about Homeostasis: Part 2

- Blood Glucose Regulation

a) Why your body regulates glucose levels

b) How your body detects changes in glucose levels

c) How your body controls glucose levels

Blood Glucose Regulation

Why?

If your body cannot control the concentration of blood glucose levels it will lead to diabetes.

There are two types of diabetes that you need to know about:

- Type 1 Diabetes
- Type 2 Diabetes

Diabetes

Why?

Type 1 Diabetes:

This is a condition where the pancreas produces little or no insulin. Insulin is a hormone which lowers blood glucose levels.

Insufficient levels of insulin can result in blood glucose levels rising to a level that can cause death.

Insulin therapy is needed to treat this. Insulin is usually taken at mealtimes, ensuring that glucose is removed from the blood quickly once food has been digested to prevent blood glucose levels getting too high. It is usually injected into the fatty tissue under the skin. How much insulin injected depends on diet and how active a person is.

In addition to insulin therapy, the intake of foods rich in simple carbohydrates (sugars) should be limited, and regular exercise should take place to remove excess glucose from the blood.

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Type 1 Diabetes:

The immune system attacks the ß cells in the islets of Langerhans (in the pancreas) so they are unable to produce insulin.

Some people have a genetic predisposition to developing Type 1 diabetes, and it can also be triggered by a viral infection.

After eating, blood glucose levels rise, and remain high – this is called **HYPERGLYCAEMIA**. The kidneys cannot reabsorb all the glucose and some is excreted in urine. If untreated it will result in death.

Most people on insulin therapy have regular injections throughout the day, some will use an insulin pump to deliver insulin continuously. It must be regulated carefully, as too much insulin could lead to hypoglycaemia, too little glucose in the blood.

Diabetes

Why?

Type 2 Diabetes:

This is a condition where the pancreas does not produce enough insulin, or when cells becomes resistant to insulin.

It is associated with lifestyle and usually happens later in life. There is a correlation between obesity and type 2 diabetes. Obese people (BMI > 30) have an increased risk of developing it.

Storing fat around the abdomen also increases the risk.

It can usually be controlled by eating a healthy diet, exercising regularly and losing weight.

Treatment with medication or insulin injections can also be used.

TOP TIP: Remember to check how to calculate BMI and waist-to-hip ratio.

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Type 2 Diabetes:

Cells do not respond properly to insulin, because the insulin receptors on the membranes do not work properly. This means that the cells don't take up enough glucose, leading to a higher than normal blood glucose concentration.

It is becoming increasingly common in the UK, as diets become less healthy, and there are lower levels of physical activity.

It can lead to health problems such as kidney failure and visual impairments.

Health advisors are in place to educate people in the risks and to reduce the incidence of the disease.

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August 2018: KFC and Kellogg's adverts have just been banned for promoting junk food to children

In order to reduce risks it is recommended that people:

a) Take regular exercise

b) Eat a diet low in fat, sugar and salt. It should also include lots of fruit, vegetables and whole grains

c) Lose weight

There are campaigns such as the NHS's "Change4Life" trying to educate people on healthier lifestyle and diets in order to reduce the risk of developing Type 2 Diabetes .

The food industry has been criticised for contributing to the problem. Health advisors have recommended that they:

a) Reduce the advertisement of junk food (especially to children)

b) Use clearer labelling on products, allowing customers to make healthy choices

c) Improve the nutritional value of their products

The food industry is under pressure to change, but also companies need to increase profits. Some companies are using sugar alternatives to sweeten their products, and some are reducing the sugar, fat and salt content in their products.

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Blood Glucose Control

How?

When you eat foods containing carbohydrates, glucose will enter your blood from the small intestines.

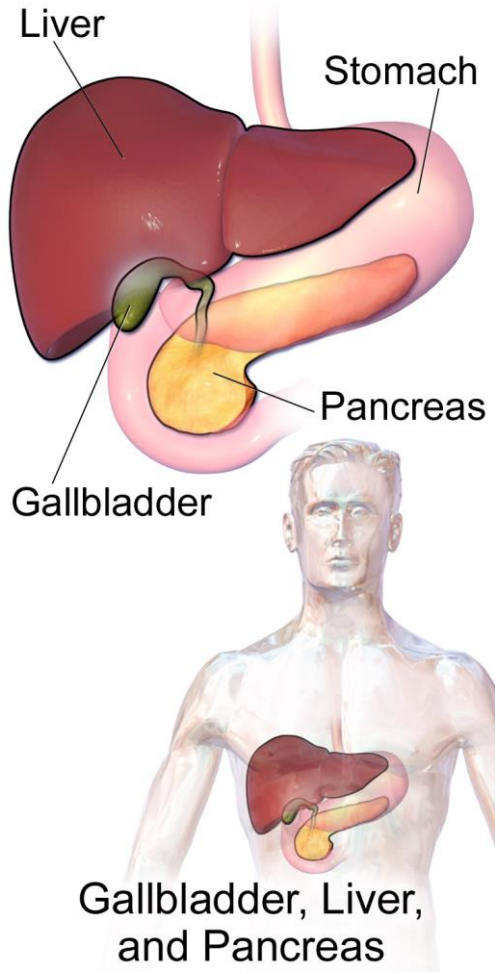
Normal metabolism of cells removes glucose from the blood.

More exercise will remove more glucose, as it is used in respiration to release energy.

Blood glucose levels are monitored by cells in the pancreas.

Excess glucose is stored as **GLYCOGEN** in the liver and in the muscles. Once these stores are full, it is then stored as lipid (fat) in the tissues.

The hormonal system controls the concentration using two hormones, **INSULIN** and **GLUCAGON**



Blood Glucose Control

How does the body respond? Too much glucose

Too much glucose

Insulin is secreted by the pancreas

This causes glucose to move from the blood into liver and muscle cells

It also causes the liver to change glucose into glycogen (which can be stored as it is insoluble)

Blood glucose levels are reduced

How does the body respond? Too little glucose

Too little glucose

Glucagon is secreted by the pancreas

This causes the liver to change glycogen into glucose

It also causes glucose to be released into the blood from the liver

Blood glucose levels are increased

Blood Glucose Control

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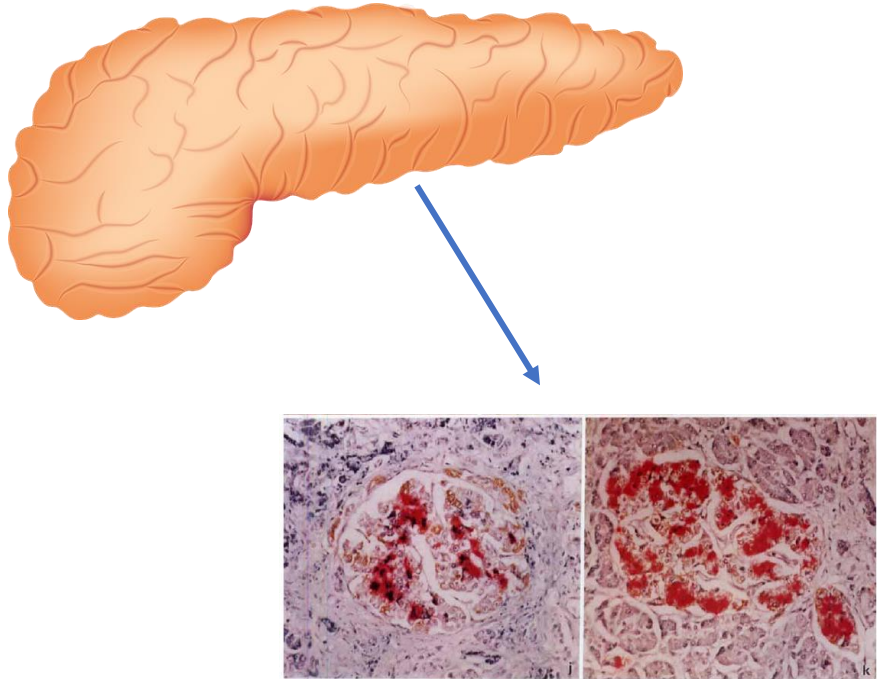
Insulin and glucagon are both secreted by clusters of cells in the pancreas called the islets of Langerhans.

Beta (ß) cells secrete insulin into the blood

Alpha cells (α) secrete glucagon into the blood.

Both these hormones act to ensure blood glucose concentration levels are restored to normal.



Blood Glucose Control

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How does the body respond? Too much glucose

Insulin is secreted by ß cells.

It binds to specific receptors on cell membranes of liver and muscle cells.

It increases the permeability of muscle-cell membranes to glucose. The cells take up more glucose. The number of channel proteins in the cell membranes is increased to do this. Skeletal and cardiac muscle cells contain a channel protein called GLUT4 which transports glucose. Insulin triggers the movement of GLUT4 from vesicles to the membrane. This means glucose can be transported into the cell by FACILITATED DIFFUSION.

It activates enzymes in liver and muscle cells that convert glucose to glycogen. This is called **GLYCOGENESIS**. The cells store the glycogen in their cytoplasm.

It increases the rate of respiration of glucose, especially in muscle cells.

Glucose levels decrease.

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How does the body respond? Too little glucose

Glucagon is secreted by α cells.

It binds to specific receptors on the cell membranes of the liver cells.

It activates enzymes in the liver cells that break down glycogen to glucose. This is called **GLYCOGENOLYSIS**.

It activates enzymes involved in the formation of glucose from glycerol and amino acids. This is called **GLUCONEOGENESIS** (making glucose from non-carbohydrates).

It decreases the rate of respiration of glucose in cells.

When insulin levels are low, GLUT4 is stored in vesicles.

Glucose levels increase.

Blood Glucose Control

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How does the body respond? Too little glucose

Adrenaline, like glucagon, increases blood glucose concentration.

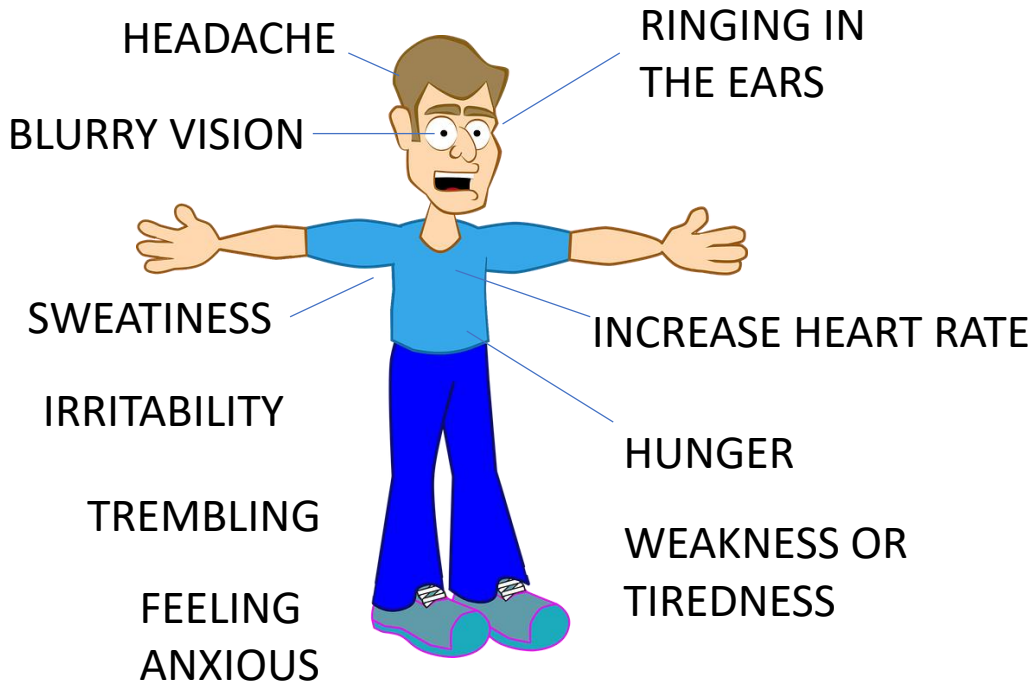
When the concentration of glucose in your blood is low (when you are stressed or exercising), the adrenal glands will secrete adrenaline.
It will bind to receptors in the cell membrane of liver cells and will:

- Activate glycogenolysis
- Inhibit glycogenesis

It also inhibits insulin secretion and activates glucagon secretion.

By increasing the amount of glucose available for muscles to respire, it prepares your body for action.

How does the body respond? Too little glucose



Blood Glucose Control

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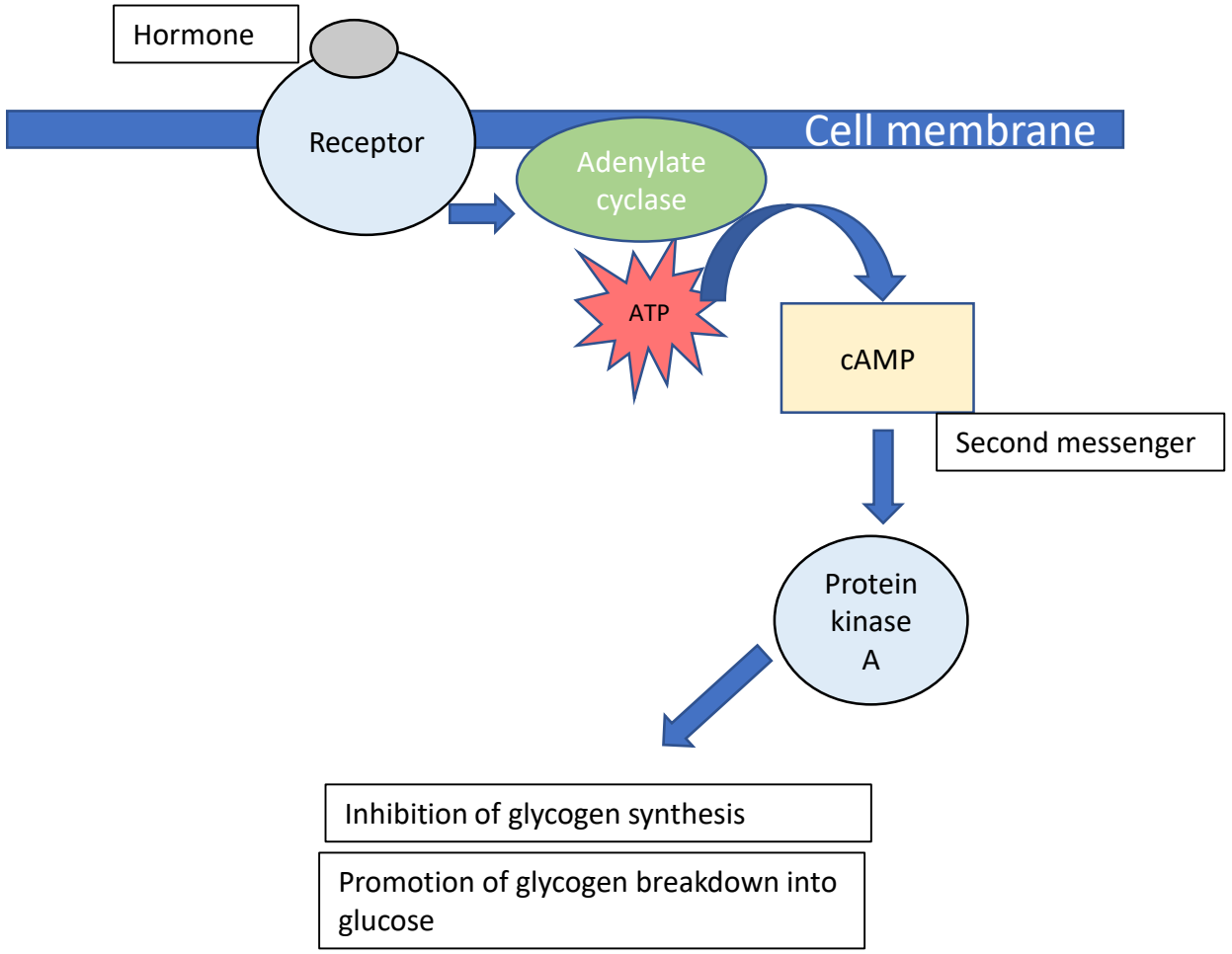
How does the body respond? Too little glucose

Both adrenaline (also known as epinephrine) and glucagon can activate glycogenolysis inside a cell by binding to receptors outside the cell. They need a second messenger to do this.

They bind to their receptors (which are complementary in shape to the hormones), and this activates an enzyme called **ADENYLATE CYCLASE**.
Adenylate cyclase converts ATP into a chemical signal called a second messenger.
The second messenger is called **CYCLIC AMP (cAMP)**
cAMP will activate an enzyme called **PROTEIN KINASE A**.
Protein kinase A causes a chain of reactions (cascade) that break down glycogen into glucose.



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Your turn:

1. The concentration of glucose in the blood is controlled by the human body.

The concentration of glucose in Amy's blood was measured over 7 hours. The table below shows the results.

Time of day	Blood glucose concentration /mg per 100cm^3
6.00	67
7.00	68
8.00	131
9.00	95
10.00	86
11.00	83
12.00	80
13.00	136

a) Describe the trend in blood glucose concentration over the 7 hours.

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b) Explain what could cause the changes in blood glucose concentration over the 7 hours.

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c) Complete the sentence below.

Excess blood glucose is converted into

A Glucagon in the pancreas
B Glycogen in the liver
C Glucagon in the liver
D Glycogen in the pancreas

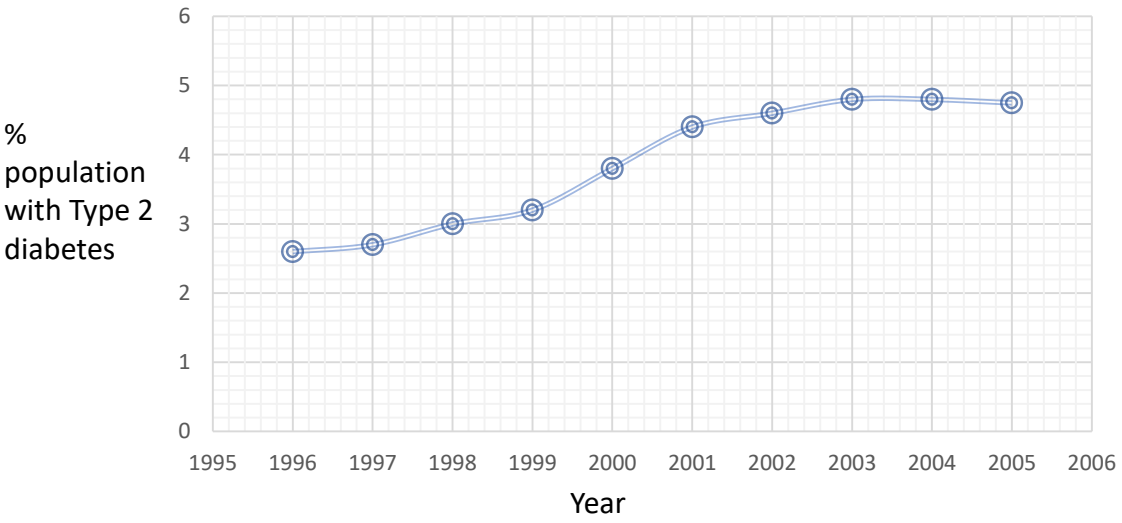
d) A high body mass index (BMI) is a risk factor that may cause Type 2 diabetes. Calculate Amy's BMI if she has a mass of 67.5kg and a height of 1.5 m

$$\text{BMI} = \frac{\text{mass in kg}}{(\text{height in metres})^2}$$

e) Amy develops Type 2 diabetes How can she help control her blood glucose concentration?

Your turn:

2. The percentage of the population with type 2 diabetes has been increasing in the UK



a) Calculate the increase in the number of people with type 2 diabetes between 1996 and 2005, if the population at this time was 60 million.

b) Give two reasons which could have led to the increase in the number of people with type 2 diabetes.

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c) Describe what actions can be taken to control type 2 diabetes without the use of drugs.

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3. Glucose levels need to be regulated in the human body.
Explain, using named hormones, how the body can maintain blood glucose levels. (6)

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Your turn:

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1. Homeostasis involves controlling blood glucose levels in the body.

a) Define homeostasis.

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b) Describe how negative feedback is involved in the control of blood glucose concentration.

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c) Kevin is 58, and has recently been diagnosed with diabetes.
He was advised by the doctor to change his diet, reducing his intake of carbohydrates, especially sugars such as glucose. He was asked to return for a follow up appointment.
The doctor found that changes in his diet had made no impact on his condition. This was not expected.
Kevin required daily hormone injections in order to control his blood sugar levels.

State how Kevin's form of diabetes is similar to Type 1 and Type 2 diabetes, using ONLY information provided above.

i) Type 1 diabetes

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ii) Type 2 diabetes

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Answers:

1. The concentration of glucose in the blood is controlled by the human body.

The concentration of glucose in Amy's blood was measured over 7 hours. The table below shows the results.

Time of day	Blood glucose concentration /mg per 100cm^3
6.00	67
7.00	68
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9.00	95
10.00	86
11.00	83
12.00	80
13.00	136

a) Describe the trend in blood glucose concentration over the 7 hours.

The concentration increases from 6am – 8am. There is a large increase between 7 and 8. It then decreases steadily until 1pm, when there is another large increase.

b) Explain what could cause the changes in blood glucose concentration over the 7 hours.

Increases in glucose concentration are due to eating. Decreases are due to insulin being released and causing glucose to be stored as glycogen. Decreases could also be as a result of exercise.

c) Complete the sentence below.

Excess blood glucose is converted into

A Glucagon in the pancreas
B Glycogen in the liver
C Glucagon in the liver
D Glycogen in the pancreas

d) A high body mass index (BMI) is a risk factor that may cause Type 2 diabetes. Calculate Amy's BMI if she has a mass of 67.5kg and a height of 1.5 m

$$\text{BMI} = \frac{\text{mass in kg}}{(\text{height in metres})^2}$$

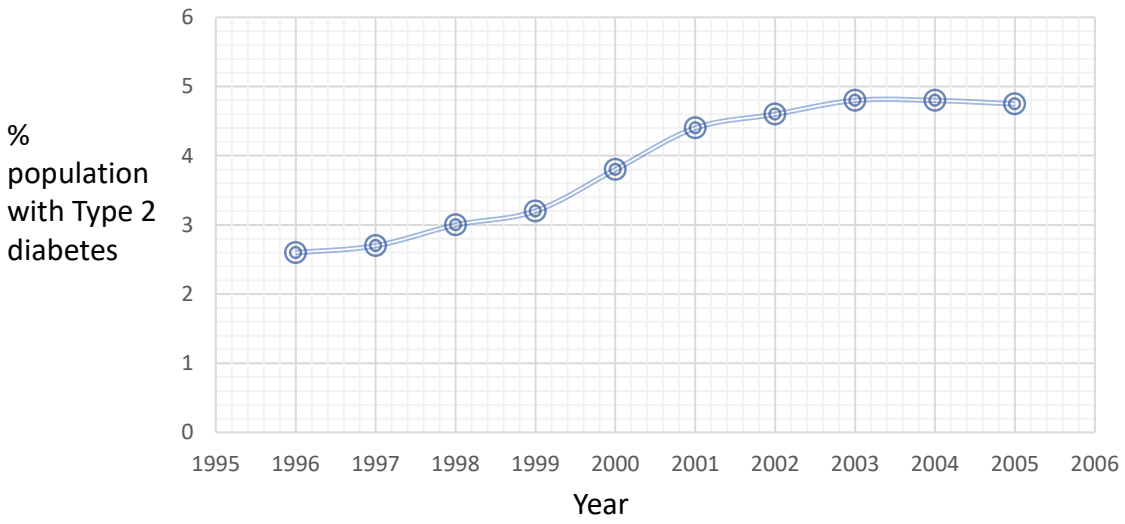
BMI = 67.5/1.5 x 1.5
= 30

e) Amy develops Type 2 diabetes. How can she help control her blood glucose concentration?

- Can exercise to reduce glucose levels
- Can control diet to reduce glucose levels
- Can take medication via injections (insulin)

Answers:

2. The percentage of the population with type 2 diabetes has been increasing in the UK



a) Calculate the increase in the number of people with type 2 diabetes between 1996 and 2005, if the population at this time was 60 million.

4.8% in 2005 2.6% in 1996
4.8 – 2.6 is an increase of 2.2%

2.2% of 60 million
2.2/100 x 60,000,000 = 1320,000

b) Give two reasons which could have led to the increase in the number of people with type 2 diabetes.

There is an increase in
- Number of obese people/high BMI
- Number of people who do not exercise
- Calorie intake of people (too much sugar/carbs/fat)
- Number of people living to an older age

c) Describe what actions can be taken to control type 2 diabetes without the use of drugs.

- Can exercise to reduce glucose levels
- Can control diet to reduce glucose levels
- Can take medication via injections (insulin)

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Answers:

3. Glucose levels need to be regulated in the human body.
Explain, using named hormones, how the body can maintain blood glucose levels. (6)

When blood glucose too high:

- Pancreas secretes insulin
- Insulin causes glucose to move into liver and muscle cells and causes the liver to convert glucose to glycogen and store it
- Glucose levels decrease.

When blood glucose too low:

- Pancreas secretes glucagon
- Glucagon causes the liver to convert glycogen into glucose, and glucose to move into the blood
- Glucose levels increase

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Answers:

Beyond GCSE

1. Homeostasis involves controlling blood glucose levels in the body.

a) Define homeostasis.

Maintaining a stable internal environment within certain limits while the environment is changing

b) Describe how negative feedback is involved in the control of blood glucose concentration.

If glucose levels increase:

- ß cells in the islets of Langerhans release insulin which binds to receptors on cell membranes.
- This increase permeability of membranes by increasing number of channel proteins so uptake of glucose by liver/muscle cells is increased.
- Enzymes activated in the liver to convert glucose to glycogen (glycogenesis).
- There is an increased rate of respiration of glucose, especially in muscle cells.

If glucose levels decrease:

- α cells release glucagon which binds to receptors on cell membranes of liver cells.
- This activates enzymes in liver to break down glycogen to glucose (glycogenolysis).
- Activates enzymes to increase formation of glucose from non carbohydrates (gluconeogenesis).
- Glucose leaves cells by facilitated diffusion.
- There is a decreased rate of respiration in cells.

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Answers:

c) Kevin is 58 and has recently been diagnosed with diabetes.
He was advised by the doctor to change his diet, reducing his intake of carbohydrates, especially sugars such as glucose. He was asked to return for a follow up appointment.
The doctor found that changes in his diet had made no impact on his condition. This was not expected.
Kevin required daily hormone injections in order to control his blood sugar levels.

State how Kevin's form of diabetes is similar to Type 1 and Type 2 diabetes, using ONLY information provided above.

i) Type 1 diabetes

He requires daily insulin injections suggesting that insufficient insulin is being produced, and dietary changes have not had any impact.

ii) Type 2 diabetes

He has developed symptoms in middle age.

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For more help and resources, or to work with us as a tutor, please contact us

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contact@ebeducationservices.co.uk

0161 442 5270

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