Exercise walk-through

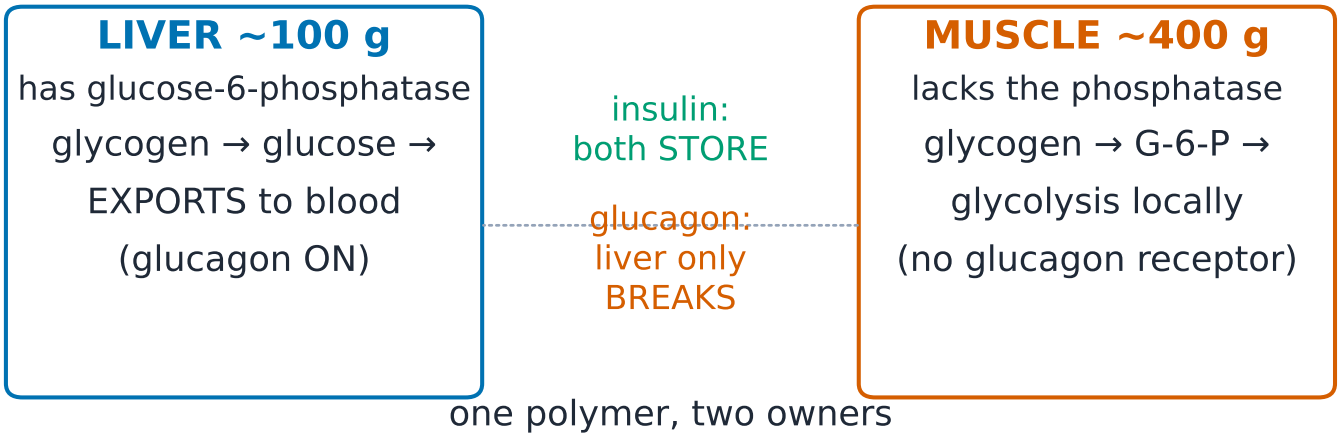
2.5
Glycogen and gluconeogenesis

University Medicine

Two banks, one polymer

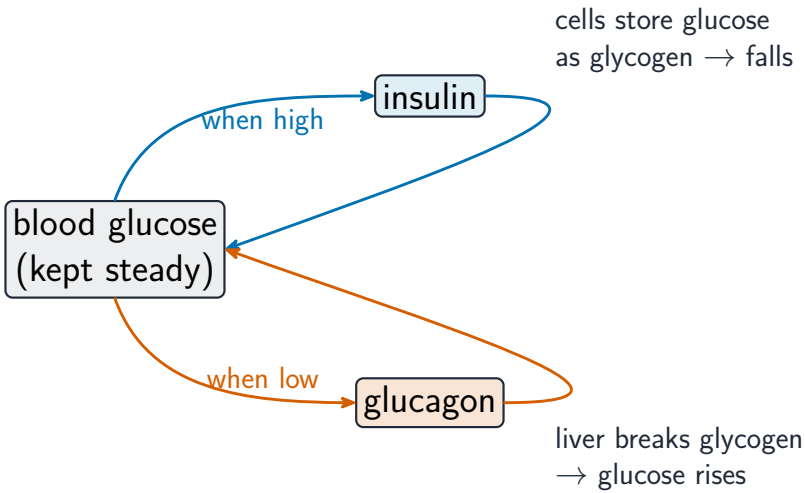
1. **Banks** Liver ~100 g exports glucose (has the phosphatase); muscle ~400 g keeps it (lacks the enzyme).
2. **Switch Insulin**: both store. **Glucagon**: liver only breaks down - muscle has no receptor.
3. **Cost Gluconeogenesis**: 4 ATP + 2 GTP + 2 NADH per glucose (6 high-energy bonds) - storage in reverse costs.

Liver feeds, muscle keeps



> Liver has glucose-6-phosphatase and exports; muscle traps G-6-P for itself - **insulin** stores both, **glucagon** opens only the liver.

Two hormones, one set point



> Negative feedback returns glucose to normal

Exercises 2.1·2.2

2.1 The brain uses 120 g of glucose a day. How long would 100 g of liver glycogen last for the brain alone? [2]

Liver	Brain
100 g glycogen	120 g glucose a day

2.2 Explain why muscle glycogen cannot raise blood glucose. [2]



Exercises 2.1·2.2

2.1 The brain uses 120 g of glucose a day. How long would 100 g of liver glycogen last for the brain alone? [2]



2.1

$100/120 \approx 0.83$ day

about **20** hours

2.2 Explain why muscle glycogen cannot raise blood glucose. [2]



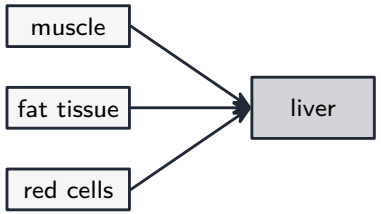
2.2

muscle has no glucose-6-phosphatase

glucose 6-phosphate cannot leave the cell, so it is used by the muscle itself

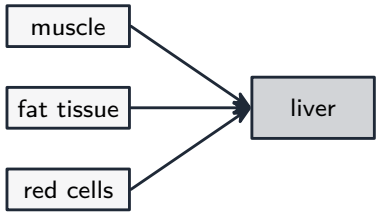
Exercise 2.3

2.3 Name three substrates for gluconeogenesis and give their sources. [3]



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2.3

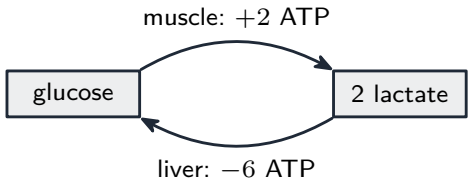
lactate from red cells and working muscle

glycerol from fat breakdown

amino acids (such as alanine) from muscle protein

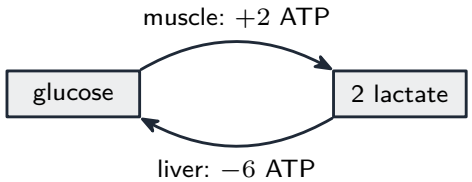
Exercise 2.4

2.4 Find the net ATP cost of turning glucose into lactate and back. Why does the body accept it? [3]



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2.4

$+2 - 6$

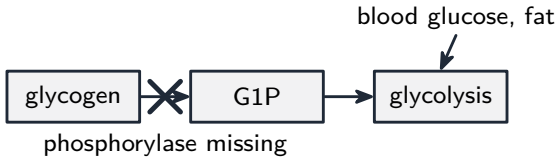
$= \mathbf{-4}$ ATP per round

it keeps blood glucose up for the brain and red cells, using energy from fat in the liver

Exercise 3.1 (a)

3.1 A (fictional) teenager gets painful cramps after a few minutes of hard exercise, but feels better if they slow down and carry on. Muscle **glycogen phosphorylase** is missing.

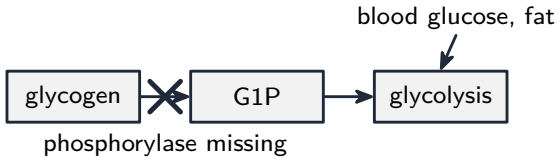
(a) Explain why hard exercise causes cramps. [2]



Exercise 3.1 (a)

3.1 A (fictional) teenager gets painful cramps after a few minutes of hard exercise, but feels better if they slow down and carry on. Muscle **glycogen phosphorylase** is missing.

(a) Explain why hard exercise causes cramps. [2]



(a) the muscle cannot break down its glycogen, its fast fuel, so ATP runs short in hard exercise and the muscle cannot relax properly

Exercise 3.1 (b)

3.1 A (fictional) teenager gets painful cramps after a few minutes of hard exercise, but feels better if they slow down and carry on. Muscle **glycogen phosphorylase** is missing.

(b) Explain why blood lactate does not rise during exercise. [2]

Exercise 3.1 (b)

3.1 A (fictional) teenager gets painful cramps after a few minutes of hard exercise, but feels better if they slow down and carry on. Muscle **glycogen phosphorylase** is missing.

(b) Explain why blood lactate does not rise during exercise. [2]

(b) little glucose from glycogen enters glycolysis, so little pyruvate and lactate are made

Exercise 3.1 (c)

3.1 A (fictional) teenager gets painful cramps after a few minutes of hard exercise, but feels better if they slow down and carry on. Muscle **glycogen phosphorylase** is missing.

(c) Explain the “second wind” after about 10 minutes. [2]

Exercise 3.1 (c)

3.1 A (fictional) teenager gets painful cramps after a few minutes of hard exercise, but feels better if they slow down and carry on. Muscle **glycogen phosphorylase** is missing.

(c) Explain the "second wind" after about 10 minutes. [2]

(c) blood flow rises and brings glucose and fatty acids from outside the muscle; these fuels replace the missing glycogen

Exercise 3.1 (d)

3.1 A (fictional) teenager gets painful cramps after a few minutes of hard exercise, but feels better if they slow down and carry on. Muscle **glycogen phosphorylase** is missing.

(d) Why is fasting blood glucose normal? [1]

Exercise 3.1 (d)

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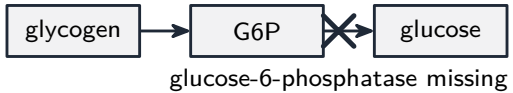
(d) Why is fasting blood glucose normal? [1]

(d) the liver has a different form of the enzyme, which works

Exercise 3.2 (a)

3.2 A (fictional) baby has low blood sugar a few hours after each feed and a large liver. The liver lacks glucose-6-phosphatase.

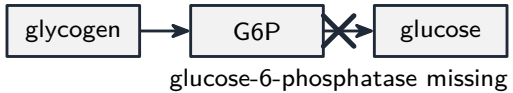
(a) Explain the low blood sugar and the large liver. [3]



Exercise 3.2 (a)

3.2 A (fictional) baby has low blood sugar a few hours after each feed and a large liver. The liver lacks glucose-6-phosphatase.

(a) Explain the low blood sugar and the large liver. [3]



(a) both glycogen breakdown and gluconeogenesis end at glucose 6-phosphate; without the enzyme no free glucose reaches the blood, so sugar falls between feeds; glycogen keeps being made but cannot be used, so the liver fills and enlarges

Exercise 3.2 (b)

3.2 A (fictional) baby has low blood sugar a few hours after each feed and a large liver. The liver lacks glucose-6-phosphatase.

(b) Suggest how feeding can prevent low sugar. [2]

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(b) Suggest how feeding can prevent low sugar. [2]

(b) frequent feeds by day; a slowly digested starch (such as uncooked cornstarch) or a night feed to cover the night

Exercise 3.3 (a)

3.3 A (fictional) adult cannot eat for 3 days before and after surgery. The body uses about 160 g of glucose a day (brain 120 g, others 40 g). About 1.75 g of protein is broken down for each 1 g of glucose made from amino acids.

(a) How long does 100 g of liver glycogen cover the 160 g per day? [1]

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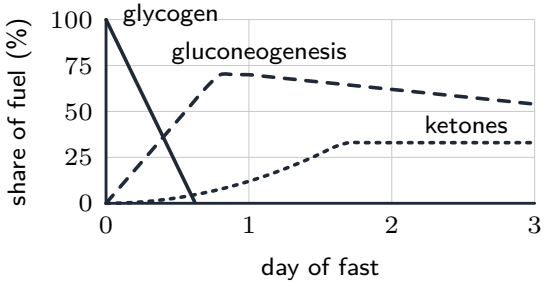
(a) How long does 100 g of liver glycogen cover the 160 g per day? [1]

(a) $100/160 \times 24 = \mathbf{15}$ hours

Exercise 3.3 (b)

3.3 A (fictional) adult cannot eat for 3 days before and after surgery. The body uses about 160 g of glucose a day (brain 120 g, others 40 g). About 1.75 g of protein is broken down for each 1 g of glucose made from amino acids.

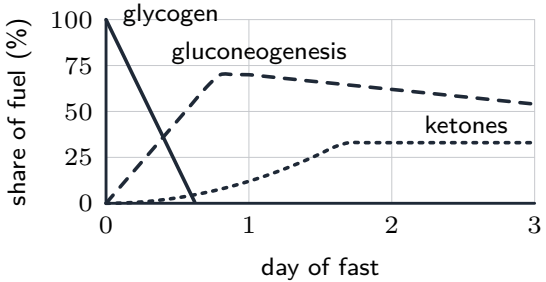
(b) If all the remaining glucose came from protein, how much protein would be lost per day? [2]



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(b) If all the remaining glucose came from protein, how much protein would be lost per day? [2]



(b) $160 \times 1.75 = \mathbf{280}$ g per day

Exercise 3.3 (c)

3.3 A (fictional) adult cannot eat for 3 days before and after surgery. The body uses about 160 g of glucose a day (brain 120 g, others 40 g). About 1.75 g of protein is broken down for each 1 g of glucose made from amino acids.

(c) Explain how ketones reduce this loss. [2]

Exercise 3.3 (c)

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(c) Explain how ketones reduce this loss. [2]

(c) the liver makes ketones from fat, and the brain uses them in place of part of its glucose; by day 3 they cover about a third of brain energy, so less protein is broken down

Exercise 3.3 (d)

3.3 A (fictional) adult cannot eat for 3 days before and after surgery. The body uses about 160 g of glucose a day (brain 120 g, others 40 g). About 1.75 g of protein is broken down for each 1 g of glucose made from amino acids.

(d) Give one way the clinical team can protect the patient. [1]

Exercise 3.3 (d)

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(d) Give one way the clinical team can protect the patient. [1]

(d) give glucose in a drip

Exercise 3.3 (e)

3.3 A (fictional) adult cannot eat for 3 days before and after surgery. The body uses about 160 g of glucose a day (brain 120 g, others 40 g). About 1.75 g of protein is broken down for each 1 g of glucose made from amino acids.

(e) Recommend how fasting should be managed. [2]

Exercise 3.3 (e)

3.3 A (fictional) adult cannot eat for 3 days before and after surgery. The body uses about 160 g of glucose a day (brain 120 g, others 40 g). About 1.75 g of protein is broken down for each 1 g of glucose made from amino acids.

(e) Recommend how fasting should be managed. [2]

(e) keep fasts as short as safely possible, with clear fluids or a carbohydrate drink until shortly before surgery; restart feeding early afterwards, and check blood glucose