Chapter 2 Workbook

Your Body in Good Health

Chapter 2 is the chapter the rest of the book leans on. When Chapter 3 shows you what goes wrong in diabetes, and Part 2 turns that into a plan, both assume you can picture how a healthy body handles a meal: taking it apart in the gut, routing it, storing it and drawing on it again later. These pages make sure you can.

They will ask more of you than rereading would, and that is deliberate. Pulling an idea out of your own head, getting it slightly wrong and then putting it right embeds it in memory far better than reading it a second time. The questions start easy and climb. Every answer comes with an explanation, longer where the idea carries more weight later in the book. Take your time, and expect some of it to stretch you.

Contents

		Pages
	How to use these pages	2
1	What food becomes What is in your food and how is it absorbed? · about 10 minutes	3–4
2	Taking protein and fat apart What is in your food and how is it absorbed? · about 12 minutes	5–6
3	Gut plumbing Gut plumbing matters! · about 12 minutes	7–8
4	Fed, fasted and staying in balance The fed and the fasted state · Homeostasis: maintaining internal balance · about 12 minutes	9–10
5	Your lively liver Your lively liver · about 15 minutes	11–12
6	Pancreas, insulin and glucagon Your pragmatic pancreas · Insulin and glucagon keep blood glucose stable · about 12 minutes	13–14
7	Muscle and fat tissue Muscle – the big glucose sponge · Fat tissue – the good, the bad, and the metabolically ugly · about 12 minutes	15–16
8	Join it all up Draws on the whole chapter · about 20 minutes	17–18
✓	Return ticket Spaced review, checklist and a final word	19

BEFORE YOU STA RT

How to use these pages

Read this once.
It takes a minute.

1. Close the book. Answer from memory. Write it down, say it aloud, or think it through fully before you look. Recalling an idea strengthens it far more than rereading it, even when your recall is shaky.
2. Note your confidence. Circle S (sure), U (unsure) or G (guess) beside each question, or just note it in your head.
3. Turn the page to check. Every question page is followed by its answer page, with matching question numbers.
4. Mark yourself. Give each question ✓ ✓ (right), ✓ (partly right) or ✗ (wrong). A question with several parts counts as one, and its answer tells you when to give yourself the mark. The 'brain dump' and the 'look ahead' questions are not marked - they are just there for cognitive processing.
5. Learn most from confident mistakes. Read every explanation, but pay most attention to answers you were sure of and got wrong. Once corrected, those ideas tend to stick best of all.
6. Come back later. A gap before you revisit makes the second attempt harder and the learning stronger. The 'return ticket' at the end shows how.

The five levels

●○○○○	Recall	Bring a fact back from memory.
●●○○○	Understand	Explain meanings or reasons
●●●○○	Connect	Link ideas from different parts of the chapter.
●●●●○	Apply	Use the ideas on a real situation.
●●●●●	Look ahead	Predict what Chapter 3 will say. You are not expected to know these yet, and they are not marked.

Don't skip the easy questions. Fast, confident recall of the basics is what frees your thinking for the harder ones.

On paper or on a screen

On paper: print on A4, double-sided, flipping on the long edge. Each answer page then falls on the back of its questions, so the answers stay out of sight while you work. A pencil is all you need.

On a screen: view one page at a time on a tablet or computer. Think each answer through fully, or say it aloud, before you move on. Nodding along doesn't count. A phone works too, but the pages are A4, so expect to zoom.

Pace: Doing them immediately after and then a day after reading the chapter works wonders for your recall and understanding.

Your progress

Set	Date	Right	Sure but wrong	Redone (date)
Set 1 What food becomes		___ / 7		
Set 2 Taking protein and fat apart		___ / 8		
Set 3 Gut plumbing		___ / 6		
Set 4 Fed, fasted and staying in balance		___ / 7		
Set 5 Your lively liver		___ / 7		
Set 6 Pancreas, insulin and glucagon		___ / 8		
Set 7 Muscle and fat tissue		___ / 8		
Set 8 Join it all up		___ / 3		

The methods here come from the research on learning summarised in Make It Stick (Brown, Roediger and McDaniel, 2014): retrieval practice, spacing, mixing topics, explaining in your own words, and checking your confidence against your results.

1 What food becomes

About 8-10 minutes

Chapter section: What is in your food and how is it absorbed?

Start with a blank mind. The brain dump comes first for a reason: it shows you what you already have before any question prompts you.

1.1 Three-minute brain dump. Close the book. Take a blank sheet of paper or a notebook and write down everything you remember from Chapter 2. Words, short notes, arrows and sketches are all fine. Don't worry about order or neatness. Stop after three minutes. ● ○ ○ ○ ○ RECALL

Prefer not to write? Explain everything you remember aloud instead.

1.2 The chapter sorts what we need from our diet into four kinds of thing. Which list matches it? S U G

● ○ ○ ○ ○ RECALL

- ○ A Protein, carbohydrate, fat and water
- ○ B Food-energy, vitamins, minerals and water
- ○ C Components to build, repair and operate the body; food-energy; vitamins; water
- ○ D Components to build, repair and operate the body; food-energy; fibre; water

1.3 A nutrient is called essential when… ● ○ ○ ○ ○ RECALL S U G

- ○ A your body cannot make it, or not enough of it, so food must supply it
- ○ B your body needs it in larger amounts than other nutrients
- ○ C your body needs it to survive, while non-essential ones are optional
- ○ D it supplies energy as well as raw materials for the body

1.4 The three important monosaccharide (single) sugars in our diet are… ● ○ ○ ○ ○ RECALL S U G

- ○ A glucose, sucrose and fructose
- ○ B glucose, lactose and galactose
- ○ C glucose, maltose and fructose
- ○ D glucose, fructose and galactose

1.5 Table sugar (sucrose) is made of… ● ● ○ ○ ○ UNDERSTAND S U G

- ○ A two glucose molecules bonded together
- ○ B glucose bonded to galactose
- ○ C glucose bonded to fructose
- ○ D a short chain of glucose molecules

1.6 Starch must be broken into sugars before it can be absorbed. Where does most of that breakdown happen? ● ● ○ ○ ○ UNDERSTAND S U G

- ○ A In the mouth, by an enzyme in saliva
- ○ B In the stomach, by acid and enzymes
- ○ C In the intestines, by digestive enzymes
- ○ D In the liver, after the starch is absorbed

1.7 True or false? "Fibre passes through untouched because nothing in your gut can break it down." If false, correct it. ● ● ○ ○ ○ UNDERSTAND S U G

1.8 Using the necklace model, explain why a slice of bread raises your blood glucose even though it barely tastes sweet. ● ● ● ○ ○ CONNECT S U G

Turn the page to check your answers.

1 What food becomes

Mark each question ✓, ½ or ✗

1.1 Not marked. The point is to find out what you can recall before any question gives you clues. Free recall like this is one of the strongest learning techniques we know of, and the gaps you noticed are useful: they show you where to look. Keep your sheet, or jot down a few words about what you managed aloud. You will repeat the brain dump on the Return ticket and can compare.

1.2 D. The chapter sorts by job, not by chemical type. A is the familiar list of nutrients, but it leaves out fibre and mixes up what nutrients are with what they do. Vitamins and minerals (B and C) belong inside the first group: components that build, repair and operate the body.

1.3 A. Essential describes where a nutrient has to come from, not how important it is. C is the tempting reading of the word, but the eleven non-essential amino acids are every bit as necessary; your cells can simply make them from other amino acids.

1.4 D. Glucose, fructose and galactose. Sucrose, lactose and maltose are each a pair of single sugars bonded together (disaccharides).

1.5 C. One glucose bonded to one fructose. A is maltose and B is lactose, the sugar in milk. Keep the fructose half in mind: your liver handles most of it, and Chapter 7 explains why concentrated sugars are cut hard during reversal.

1.6 C. The intestines. Carbohydrate-digesting enzymes work poorly in stomach acid. An enzyme in saliva makes a small start in your mouth, which is why bread chewed for a long time begins to taste faintly sweet, but most of the work happens later. D mixes up digestion and absorption: starch is too large to be absorbed whole, so it never reaches the liver as starch.

1.7 False. You have no enzymes for the bonds that hold fibre together, but the microbes in your gut can break some of them. Fibre keeps those microbes well fed and busy.

1.8 Model answer: Starch is a necklace whose beads are glucose. Locked in long chains, it doesn't taste sweet. Enzymes in your intestines snip the bonds between the beads, the freed glucose is absorbed, and your blood glucose rises. Sweetness is a poor guide: bread, rice and potatoes all end up as glucose. Looking ahead: Chapter 7 calls the rise after a meal 'the spike', and starchy foods drive it as well as sugary ones.

Marked questions right: ____ out of 7 Sure but wrong: ____ (redo these after a day or two)

Several wrong? Try this set again in a day or two, after rereading the section What is in your food and how is it absorbed?

2 Taking protein and fat apart

About 12 minutes
Close the book first

Chapter section: What is in your food and how is it absorbed?

Set 1 took carbohydrate apart. Now protein and fat. Notice the pattern repeating: big molecules in, small ones across the gut wall.

2.1 How many different amino acids make up the protein in your food, and how many of them are essential? ● ○ ○ ○ ○ RECALL S U G

- ○ A 20 kinds; 11 are essential
- ○ B 20 kinds; 9 are essential
- ○ C 50 kinds; 9 are essential
- ○ D 20 kinds; all 20 are essential

2.2 After protein has been digested, what passes from your gut into your blood? ● ● ○ ○ ○ UNDERSTAND S U G

- ○ A whole proteins, unfolded by acid
- ○ B only the nine essential amino acids
- ○ C chains of ten to twenty amino acids
- ○ D single amino acids, cut right down

2.3 Modern protein-quality scores rate a protein on… ● ● ○ ○ ○ UNDERSTAND S U G

- ○ A amino acid balance and absorption
- ○ B protein per typical serving
- ○ C whether all nine are present
- ○ D how fast it is digested

2.4 Priya is vegan and about to start her reversal plan. She already eats a good mix of plant proteins. Which step fits the chapter's advice best? She should… ● ● ● ● ○ APPLY S U G

- ○ A rely on mixing to cover leucine
- ○ B add a protein boost to any meals falling short
- ○ C eat one large protein meal a day
- ○ D choose only high-scoring proteins

2.5 The diagram shows a triglyceride before and after digestion. Name the parts labelled P, Q, R and S. ● ● ○ ○ ○ UNDERSTAND S U G



P _____ Q _____ R _____ S _____

2.6 To help fat digestion, bile… ● ● ○ ○ ○ UNDERSTAND S U G

- ○ A splits chains off the backbone
- ○ B cuts the chains into shorter pieces
- ○ C disperses fat into small droplets
- ○ D carries fat across the gut lining

2.7 A fatty acid has a double bond between two neighbouring carbon atoms. Which statement is correct? ● ● ○ ○ ○ UNDERSTAND S U G

- ○ A It is saturated, because the double bond holds extra hydrogen
- ○ B It is saturated, because every carbon is fully bonded
- ○ C It is unsaturated, because it has lost its glycerol backbone
- ○ D It is unsaturated, because those carbons hold less hydrogen

2.8 Finish the chapter's big idea in your own words: “However different foods look on the plate, once they are absorbed…” ● ● ● ○ ○ CONNECT S U G

_____

_____

_____

Turn the page to check your answers.

2 Taking protein and fat apart

Mark each question ✓, ½ or ✗

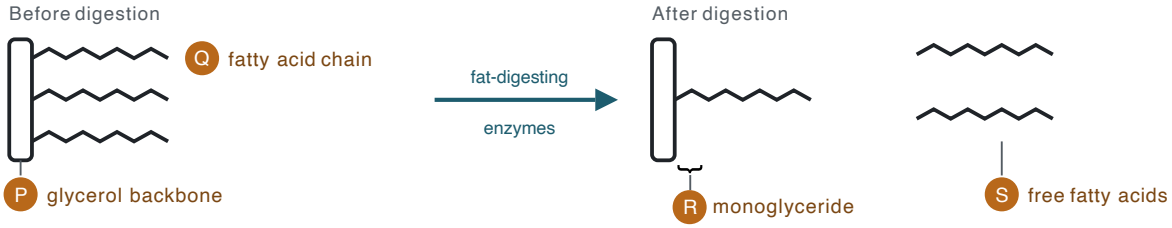
2.1 B. Twenty kinds, of which nine are essential and must come from food. Your cells can make the other eleven from other amino acids.

2.2 D. Stomach acid unfolds proteins and enzymes cut them shorter, and the intestines finish the job. Very short chains of two or three amino acids can enter the cells lining the gut, but are normally broken down to single amino acids inside them, so what reaches your blood is mainly single amino acids. B is wrong because non-essential amino acids are absorbed too.

2.3 A. Balance of essential amino acids and how well they are digested and absorbed. Animal proteins generally score highest, with soy, quinoa, pea protein and mycoprotein not far behind. C describes the older complete-or-incomplete idea that these scores improved on; D is about speed, not quality.

2.4 B. Leucine helps stimulate muscle growth and is lower in plant protein, so a small concentrated boost, such as a soy protein shake or a high-protein soy yoghurt, helps almost every meal reach enough. A is the trap: mixing plant proteins covers the gaps in essential amino acids, but plant sources still tend to run lower in leucine, so vegans should aim a little higher. Chapter 7 (Layer 2) explains why holding on to muscle is a priority.

2.5



Enzymes usually break off two of the three chains, sometimes all three, which leaves glycerol on its own. The fatty acid chains themselves aren't broken apart.

2.6 C. Bile works like washing-up liquid on a greasy pan: it breaks fat into small droplets, so the enzymes have far more surface to work on. That is a physical job. The chemical splitting in A is done by the enzymes, and bile and enzymes work alongside each other rather than one after the other. B is wrong twice: the chains stay intact.

2.7 D. Saturated means holding all the hydrogen it can. A double bond leaves both carbons with one less bond for hydrogen, so the fat is unsaturated. The omega number tells you where the first double bond sits, counting from the omega end of the chain: omega-3 has it at carbon 3.

2.8 Model answer: …they all become the same small, predictable set: sugars, amino acids, fatty acids, glycerol, vitamins, minerals and water. Looking ahead: this underpins a key idea in Chapter 3, that surplus energy from any food can end up stored as fat.

Marked questions right: ____ out of 8 Sure but wrong: ____ (redo these after a day or two)

Several wrong? Try this set again in a day or two, after rereading the section What is in your food and how is it absorbed?

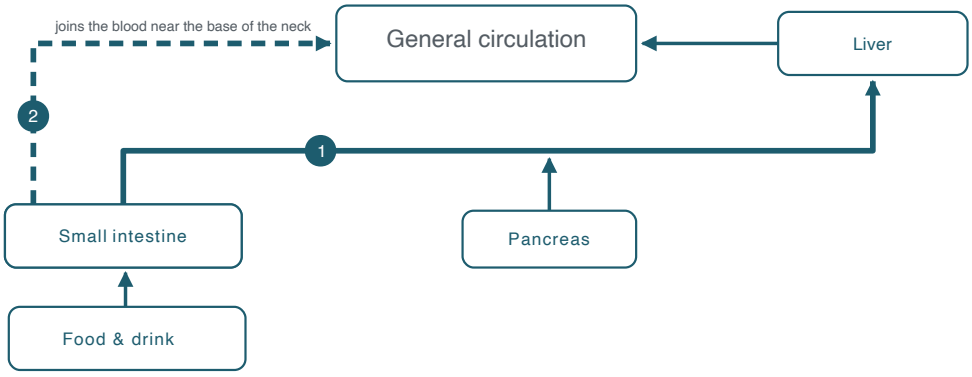
3 Gut plumbing

About 12 minutes
Close the book first

Chapter section: Gut plumbing matters!

The route map for everything you eat. If you can sketch it from memory, much of Chapter 3 will make sense the first time you read it.

3.1 Two routes. The diagram simplifies figure 2.4. Trace each route with your pencil or finger, then answer. ● ● ● ○ ○ CONNECT S U G



a. Which route carries most absorbed sugars and amino acids? Which carries most long-chain fat?

b. What is the blood vessel on route 1 called? What fluid carries fat along route 2?

c. What does the pancreas add to the blood on route 1?

d. Fat on route 2 misses the liver at first. Can it reach the liver later? How?

3.2 Most fat takes the lymph route. Which of these goes to the liver directly through the portal vein instead? ● ● ○ ○ ○ UNDERSTAND S U G

- ○ A Most long-chain fatty acids
- ○ B Short- and medium-chain fatty acids
- ○ C Fat-soluble vitamins
- ○ D All fats, once bile has dispersed them

3.3 The pancreas releases its hormones into blood heading for the liver. This is useful because… S U G

● ● ○ ○ ○ UNDERSTAND

- ○ A the liver gets the signals early
- ○ B the liver stores them for later
- ○ C the muscles get them first
- ○ D they can't enter general circulation

3.4 The chapter says the first pass through the liver is one of the main regulators of blood glucose after meals. In two or three sentences, explain how the liver's position makes this possible. S U G

● ● ● ○ ○ CONNECT

3.5 In diabetes this liver buffering is impaired. Name the two things the chapter says go wrong in the liver after a meal. ● ● ● ○ ○ CONNECT S U G

3.6 Jean eats buttered toast, eggs and bacon. Soon afterwards, which organ is the first to handle most of the absorbed glucose and amino acids, while seeing little of the fat at first? ● ● ● ● ○ APPLY S U G

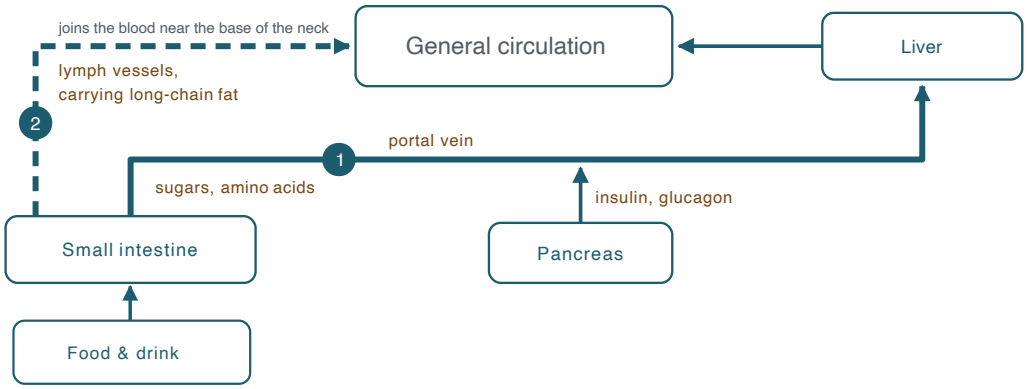
- ○ A Muscle
- ○ B Subcutaneous fat
- ○ C Heart
- ○ D Liver

Turn the page to check your answers.

3 Gut plumbing

Mark each question ✓, ½ or ✗

3.1



a Route 1 carries most sugars and amino acids; route 2 carries most long-chain fat. b The portal vein; lymph, which travels in lymph vessels. c Hormone signals, mainly insulin and glucagon. d Yes. Once fat joins the general circulation it travels round the whole body, and the liver is one of the organs that blood reaches. Mark: give yourself the mark for at least three of the four parts.

3.2 B. Short- and medium-chain fatty acids dissolve well enough in water to go straight into the blood with the sugars and amino acids. Fat-soluble vitamins (C) travel with the fat, by lymph. Bile (D) helps digestion but doesn't change the route.

3.3 A. Through the portal vein, the liver gets the hormone signals early, along with most incoming nutrients. It sees most incoming nutrients and the hormone signals about them before the rest of the body does, so it can adjust how it handles glucose early. C has it backwards: the hormones reach the muscles shortly afterwards, through the general circulation.

3.4 Model answer: Blood draining from the gut goes to the liver before it reaches the rest of the body, carrying most absorbed nutrients and hormone signals from the pancreas. Guided by insulin, the liver can take up a large share of the incoming glucose and turn down its own glucose release. That damps the rise in blood glucose after a meal, like a shock absorber.

3.5 The liver takes up and stores less of the incoming glucose, and insulin is less able to switch off the liver's own glucose output. Hours later, the same fault shows up as extra glucose released into the blood. Looking ahead: Chapter 7 calls that background level the floor.

3.6 D. Glucose and amino acids travel the portal route to the liver first. Most of the fat takes the lymph route and enters the general circulation, which passes through the heart, so the liver sees little of it at first.

> FROM ANDREW
>
> *If you can sketch these two routes from memory, a lot of what follows becomes easier. The liver's place at the end of the portal vein comes up again in Chapter 3, and again in Chapter 7 when we look at what sets your blood glucose between meals.*

Marked questions right: ____ out of 6 Sure but wrong: ____ (redo these after a day or two)

Several wrong? Try this set again in a day or two, after rereading the section Gut plumbing matters!

4 Fed, fasted and staying in balance

About 12 minutes
Close the book first

Chapter sections: The fed and the fasted state · Homeostasis: maintaining internal balance

Moving between using a meal and drawing on stores, and the feedback that keeps glucose in range.

4.1 The move from the fed state to the fasted state happens… ● ○ ○ ○ ○ RECALL S U G

- ○ A at a set time, about 12 hours on
- ○ B once glucose drops below range
- ○ C gradually, from storing to using stores
- ○ D when you fall asleep

4.2 True or false? "The fasted state is unhealthy, and the less time you spend in it, the better." If false, correct it. ● ● ○ ○ ○ UNDERSTAND S U G

4.3 Match each part of the shopping analogy to what it stands for. Write the number in the box. S U G

● ● ○ ○ ○ UNDERSTAND

In the kitchen	In your body
□ Going shopping	1. Fat stored where it shouldn't be
□ Food left out on the countertop	2. Releasing stored nutrients in the fasted state
□ Food packed into the cupboards	3. Eating a meal
□ Dipping into the cupboards	4. Energy stores such as glycogen and fat
□ Food ending up in places it shouldn't be	5. Nutrients circulating after a meal

4.4 The chapter lists four fixes for over-full cupboards and says all four are viable in diabetes. For each, write what it could mean in real life. ● ● ● ● ○ APPLY S U G

Shop less often	
Buy less each time	
Extend the cupboard space	
Use the food up faster	

4.5 Homeostasis works by negative feedback. A change in the body triggers… ● ○ ○ ○ ○ RECALL S U G

- ○ A a response that is harmful to the body
- ○ B a response that amplifies the change
- ○ C a response only in an emergency
- ○ D a response that reverses the change

4.6 Complete the control-loop table. ● ● ● ○ ○ CONNECT S U G

	Sensor	Control centre	Target	Effectors
Temperature	Temperature sensors	Brain		Sweating, shivering
Blood glucose				

4.7 The body holds blood glucose within a range, rather than as low as possible, because… S U G

● ● ○ ○ ○ UNDERSTAND

- ○ A too little glucose harms the body too
- ○ B low glucose triggers insulin release
- ○ C the liver only stores at high levels
- ○ D muscle needs high levels to absorb any

4.8 A control loop only works if each part responds properly. Pick one part of the glucose loop and predict what would happen to blood glucose if it started responding weakly. ● ● ● ● ● LOOK AHEAD S U G

Turn the page to check your answers.

4 Fed, fasted and staying in balance

Mark each question ✓, ½ or ✗

4.1 C. There is no single moment. Over the hours after a meal, as incoming nutrients are used and stored, the body leans more and more on its stores. B is the tempting one, but in the fasted state blood glucose stays in its healthy range; keeping it there is the liver's job between meals.

4.2 False. Both states are normal and healthy, and your body moves between them every day. Drawing on stores between meals and overnight is how a healthy metabolism runs.

4.3 Shopping 3 · Countertop 5 · Cupboards 4 · Dipping in 2 · Wrong places 1 You will meet that last one as ectopic fat in Set 7, and the over-full kitchen returns in Chapter 3.

4.4 Sensible answers include: shop less often: fewer eating occasions and less grazing, so more time drawing on stores (this helps only if you don't eat more at each meal); buy less: eating less overall, an energy deficit; extend the space: more muscle, giving more room to store glucose as glycogen and more tissue to take glucose up; use it up faster: moving more, which burns fuel and helps muscles take up glucose. They are not equal partners. In Part 2, the energy deficit does most of the work of emptying the cupboards, and the others support it. Mark: give yourself the mark for three sensible answers out of four.

4.5 D. The response opposes the change: too high is brought down, too low is brought up. Negative describes the direction, not harm (A). B describes positive feedback, which amplifies a change.

4.6 Temperature target: about 37 °C (98.6 °F). Blood glucose, in the chapter's simplified model: sensor, the beta and alpha cells in the pancreas monitor blood glucose; control centre, the pancreas, setting how much insulin and glucagon to release; target, a healthy range rather than one exact number, and one that shifts somewhat, for example after meals; effectors, the liver, muscle and fat tissue, responding to insulin and glucagon. Other signals, including stress hormones, also nudge the system, as Chapter 4 explains. Mark: give yourself the mark for three of the four glucose cells.

4.7 A. Too much and too little glucose both do harm, and the brain in particular needs a steady supply, so glucose is held within a range in both directions. B mixes up the hormones: low glucose turns insulin release down and glucagon's influence up.

4.8 Not marked. One good prediction: if the liver, muscle and fat respond weakly to insulin, glucose runs higher after meals and the liver keeps releasing glucose when it should hold back. The pancreas senses the higher glucose and releases more insulin. While it can keep that up, glucose may look almost normal; once it can't, glucose climbs. That is close to the story of Chapter 3.

Marked questions right: ____ out of 7 Sure but wrong: ____ (redo these after a day or two)

Several wrong? Try this set again in a day or two, after rereading the sections The fed and the fasted state and Homeostasis: maintaining internal balance

5 Your lively liver

About 15 minutes
Close the book first

Chapter section: Your lively liver

The densest set, for the organ at the centre of the whole story. Take it slowly.

5.1 Decode the names. Scientific names are built from parts with plain meanings. Use the key to work out what each liver process does, and write it in a few words of your own. S U G

● ● ○ ○ ○ UNDERSTAND

gluco	glucose	glycogen	stored glucose (animal starch)
neo	new	genesis	making, creating
lysis	breaking apart	lipo	fat
de novo	from scratch	glyco	sugar

glyco · genesis	
glycogen · o · lysis	
gluco · neo · genesis	
de novo · lipo · genesis	

5.2 a. Mark ↑ (more) or ↓ (less) for each process in each state. b. Between meals, which two processes run side by side? S U G

● ● ● ○ ○ CONNECT

What the liver does	Fed state	Fasted state
Storing glucose as glycogen		
Breaking glycogen down		
Making new glucose		
Making new fat		

5.3 About how much glucose can your liver store as glycogen? S U G

● ○ ○ ○ ○ RECALL

○ A 10 g ○ B 100 g ○ C 400 g ○ D 1 kg

5.4 The liver makes new glucose from several raw materials. Which of these is not one of them? S U G

● ● ● ○ ○ CONNECT

○ A lactate from working muscles
○ B glycerol from broken-down fat
○ C certain amino acids
○ D fatty acid chains from stored fat

5.5 During an ordinary overnight fast, where does the glucose in your blood mainly come from? S U G

● ● ● ○ ○ CONNECT

○ A muscle glycogen released into the blood
○ B liver glycogen alone
○ C liver glycogen plus new glucose
○ D new glucose alone

5.6 In tracer studies of people with fatty liver, where did the largest share of the liver fat come from? S U G

● ● ● ○ ○ CONNECT

○ A fatty acids already in the blood
○ B sugar converted to fat in the liver
○ C fat from recent meals
○ D alcohol converted to fat in the liver

5.7 The liver section closes with an encouraging point about liver fat. What is it, and why is it good news for someone just starting out? S U G

● ● ● ○ ○ CONNECT

Turn the page to check your answers.

5 Your lively liver

Mark each question ✓, ½ or ✗

5.1 Glycogenesis: making glycogen, linking glucose together to store it Note, this one is the anomaly in naming conventions. You can think of it as glycogen·(gen)esis, with the second 'gen' removed to avoid repetition. Glycogenolysis: breaking glycogen apart to release glucose. Gluconeogenesis: making new glucose, from materials that aren't glucose. De novo lipogenesis: making new fat from scratch, here from glucose and fructose. You don't need the names for the rest of the book, but once you can take them apart, you can rebuild them whenever you meet them. Mark: give yourself the mark for three of the four.

5.2

Process	Fed	Fasted
Storing as glycogen	↑	↓
Breaking glycogen down	↓	↑
Making new glucose	↓	↑
Making new fat	↑	↓

b Breaking glycogen down and making new glucose. The arrows show more or less, not on or off: these processes speed up and slow down rather than switching cleanly, and between meals the liver both breaks down glycogen and makes new glucose. Mark: the table plus part b, allowing one slip.

5.3 B. About 100 g (~¼ lb). If you chose C, you have the figure for your muscles; you will need it in Set 7.

5.4 D. The chapter lists lactate, glycerol and certain amino acids. The everyday fatty acid chains of stored fat can't be turned into a useful net supply of glucose in humans, although the glycerol backbone they were attached to can. This goes a small step beyond the book.

5.5 C. Both run together overnight, and new glucose takes a bigger share as glycogen falls; with prolonged fasting it becomes the main source, because liver glycogen is largely used up within about a day. B is a common belief, but making new glucose is already under way during an ordinary night. A is wrong because muscle glycogen is a local store, used by the muscle itself.

5.6 A. In these studies, over half came from fatty acids already circulating, mostly released by fat tissue; around a quarter was newly made in the liver; the rest came more directly from food fat. The exact proportions vary between people and diets, and liver fat-making (B) is a real contributor, larger when sugar intake is high. The finding is still important: the biggest supply line ran from the body's fat stores, which is why Part 2 centres on draining them.

5.7 Liver fat can begin improving surprisingly quickly once it starts to fall. Chapter 7 shows liver fat dropping within days of strict energy restriction, with the liver's glucose control improving alongside it, often before much weight has come off.

FROM ANDREW

This is the densest set in the workbook. If it went less well than the others, reread "Your lively liver" once, then try 5.1 and 5.2 again in a day or two without looking. The liver is where reversal tends to show up first, so it repays the effort taken to understand it.

Marked questions right: ____ out of 7

Sure but wrong: ____ (redo these after a day or two)

Several wrong? Try this set again in a day or two, after rereading the section Your lively liver

6 Pancreas, insulin and glucagon

About 12 minutes
Close the book first

Chapter sections: Your pragmatic pancreas · Insulin and glucagon keep blood glucose stable

The sensor and its two messengers. Get these clear and the story of insulin resistance in Chapter 3 will read like a sequel.

6.1 In the islets of Langerhans, beta cells make _____ and alpha cells make _____. S U G

● ○ ○ ○ ○ RECALL

- ○ A glucagon; insulin
- ○ B insulin; digestive enzymes
- ○ C insulin; glucagon
- ○ D digestive enzymes; glucagon

6.2 A hormone is best described as… ● ○ ○ ○ ○ RECALL S U G

- ○ A a gut substance that breaks food down
- ○ B a nerve signal from brain to organ
- ○ C a nutrient the body can't make
- ○ D a signal carried in the blood to cells

6.3 In the bowling-lane picture, what is the ball, what are the bumpers, and which bumper acts when the ball drifts towards the too low gutter? ● ● ○ ○ ○ UNDERSTAND S U G

6.4 Using the chapter's simplified summary of insulin's effects (Table 2.1), tick the tissue or tissues where each effect is listed. ● ● ● ○ ○ CONNECT S U G

Effect of insulin	Liver	Muscle	Fat
↓ glucose output	□	□	□
↑ glucose uptake	□	□	□
↓ breakdown of muscle protein	□	□	□
↑ amino acid uptake	□	□	□
↓ fat breakdown	□	□	□
↑ fat uptake from the blood	□	□	□

6.5 Which message best sums up insulin's overall effect? ● ● ○ ○ ○ UNDERSTAND S U G

- ○ A “Fuel has stopped: release stores”
- ○ B “Clear glucose; ignore the rest”
- ○ C “Fuel has arrived: use and store it”
- ○ D “Store fat; stop burning glucose”

6.6 In normal circumstances, glucagon's effects are mostly centred on… ● ● ○ ○ ○ UNDERSTAND S U G

- ○ A the liver
- ○ B the muscles
- ○ C fat tissue
- ○ D the brain

6.7 When blood glucose rises after a meal, beta cells release insulin… ● ● ● ○ ○ CONNECT S U G

- ○ A as a single steady release that lasts until glucose is normal
- ○ B as a rapid first burst, followed by a longer, sustained release
- ○ C only once the meal has been fully absorbed, a few hours later
- ○ D only as fresh insulin, because beta cells keep no ready-made supply

6.8 It is 3 a.m. You last ate at 7 p.m. and your brain still needs glucose. Using the words insulin, glucagon, liver, glycogen and new glucose, explain how your blood glucose is being held up. S U G

● ● ● ● ○ APPLY

Turn the page to check your answers.

6 Pancreas, insulin and glucagon

Mark each question ✓, ½ or ✗

6.1 C. A memory hook: put both pairs in alphabetical order. Alpha goes with Glucagon and Beta with Insulin: A before B, G before I. The pancreas does also make digestive enzymes, but not in these cells.

6.2 D. A signalling molecule that travels in the blood to the cells it acts on. A describes a digestive enzyme and C an essential nutrient, two ideas from Sets 1 and 2 that are easy to blur with hormones.

6.3 The ball is blood glucose; the bumpers are insulin and glucagon. Glucagon guards the too low side and insulin the too high side. Together they form a negative-feedback system.

6.4 ↓ glucose output: liver · ↑ glucose uptake: all three · ↓ muscle protein breakdown: muscle · ↑ amino acid uptake: muscle · ↓ fat breakdown: fat · ↑ fat uptake: fat The second row is the point: insulin acts across the whole body. The table is a summary of each tissue's main responses, so treat it as a map rather than a complete list. Mark: give yourself the mark for five rows of six.

6.5 C. A is glucagon's message. Insulin is a general fed-state signal for nourishment, growth, maintenance and storage, and it helps clear fat from the blood as well as glucose (so B is wrong). D turns one of its effects into the whole story.

6.6 A. Glucagon mostly acts on the liver, prompting it to break down glycogen, make new glucose and release glucose into the blood. Protecting the brain's supply (D) is the purpose, but the liver is where glucagon does that work.

6.7 B. A first burst, then a sustained release; the burst comes from ready-made insulin stored in the beta cells, which is why D is wrong. Looking ahead: the first burst is one of the earliest things lost in Chapter 3, and its loss helps explain bigger spikes after meals.

6.8 Model answer: Hours after eating, glucose and insulin have drifted down, easing the brake on the liver's glucose release. Glucagon from the alpha cells prompts the liver to break down glycogen and make new glucose, which it releases into the blood. New glucose takes a growing share as glycogen runs down. The balance between the two hormones shifts gradually through the night rather than flipping like a switch.

Marked questions right: ____ out of 8 Sure but wrong: ____ (redo these after a day or two)

Several wrong? Try this set again in a day or two, after rereading the sections Your pragmatic pancreas and Insulin and glucagon keep blood glucose stable

7 Muscle and fat tissue

About 12 minutes
Close the book first

Chapter sections: Muscle – the big glucose sponge · Fat tissue – the good, the bad, and the metabolically ugly

Your biggest glucose sink and your three fat depots. These two sections set up most of Part 2.

7.1 Muscle makes up roughly what share of your bodyweight? ● ○ ○ ○ ○ RECALL S U G

○ A 10% ○ B 25% ○ C 40% ○ D 70%

7.2 Using the chapter's figure, roughly what share of the glucose absorbed from a meal goes into muscle? ● ● ○ ○ ○ UNDERSTAND S U G

○ A Under 10% ○ B 30–50% ○ C About 75% ○ D About 90%

7.3 The two signals that make muscles take in glucose are… ● ● ○ ○ ○ UNDERSTAND S U G

○ A movement and glucagon ○ B insulin and glucagon
○ C leptin and insulin ○ D movement and insulin

7.4 What is a GLUT4, and why does the number of them on the cell surface affect your blood glucose? ● ● ● ○ ○ CONNECT S U G

7.5 Using what you know about GLUT4, explain why a short walk after dinner could help your blood glucose even when your muscles respond poorly to insulin. ● ● ● ● ○ APPLY S U G

7.6 Label each statement with the fat it describes: S subcutaneous, V visceral or E ectopic fat. ● ● ○ ○ ○ UNDERSTAND S U G

	a. The fat you can pinch under your skin		e. Some of what it releases drains straight to the liver
	b. Fat stored inside organs such as the liver and pancreas		f. Its name comes from the Greek for “out of place”
	c. Fat around and between the organs in your abdomen		g. Clearing it from liver, pancreas and muscle leads to reversal
	d. In normal amounts, a comparatively safe store for surplus energy		h. This buffers any excess food intake when healthy

7.7 Two people carry the same total amount of body fat. Which difference between them would tell you most about their risk of blood glucose problems? ● ● ● ○ ○ CONNECT S U G

○ A How much fat sits in and around their organs
○ B How much fat each eats in their diet
○ C How much fat each can pinch under the skin
○ D Which of them weighs more overall

7.8 Two men weigh 90 kg each. One stores most of his excess fat under the skin; the other carries more of it around and inside his organs. Who would you expect to struggle more with glucose control, and why? Mention the liver. ● ● ● ● ○ APPLY S U G

Turn the page to check your answers.

7 Muscle and fat tissue

Mark each question ✓, ½ or ✗

7.1 C. Around 40%, spread across over 600 muscles. By sheer size, muscle is one of your biggest fuel-burning tissues.

7.2 B. Roughly 30–50%, part stored as glycogen (about 400 g across the body) and part burned. It is an approximate range from research studies: the real share varies with the meal, how active you are and how well your muscles respond to insulin. Either way, muscle is a major destination, which is why defending it is central to lasting remission.

7.3 D. Movement and insulin. Glucagon (A, B) mainly acts on the liver, and leptin (C) is a hormone released by fat tissue.

7.4 A GLUT4 is a glucose transporter, one of the glucose portals that insulin and movement bring to the surface of muscle and fat cells. More on the surface means faster glucose uptake, so blood glucose falls more quickly.

7.5 Movement is a separate signal from insulin. Working muscles bring GLUT4s to the surface by their own route, and research shows this route usually keeps working well in type 2 diabetes. So glucose can still be pulled out of the blood when the insulin route is struggling. Looking ahead: Chapter 11 turns this into a practical habit.

7.6 a S · b E · c V · d S · e V · f E · g E · h S Small amounts of visceral fat and very small amounts of ectopic fat are normal; the trouble comes when they accumulate. Mark: give yourself the mark for six of the eight.

7.7 A. Where the fat sits tells you most here. That doesn't make the amount irrelevant: more fat overall generally means more chance of it spilling into the wrong places, and individual biology plays a part too, as Chapter 3 shows with the personal fat threshold. Dietary fat (B) is about what you eat, not where body fat is stored.

7.8 Model answer: The second man. Visceral fat releases fatty acids and inflammatory molecules, and some of what it releases drains straight to the liver through the portal circulation. Fat accumulating inside the liver upsets its switching between storing and releasing glucose. Subcutaneous fat, in normal amounts, is a comparatively safe store. Looking ahead: Chapter 3 takes this further.

Marked questions right: ____ out of 8 Sure but wrong: ____ (redo these after a day or two)

Several wrong? Try this set again in a day or two, after rereading the sections Muscle – the big glucose sponge and Fat tissue – the good, the bad, and the metabolically ugly

8 Join it all up

About 20 minutes
Close the book first

Draws on the whole of Chapter 2.

Everything mixed together, the way you will meet it in real life. Expect this set to be harder than the others; that is the point of it.

8.1 Follow the sandwich. You eat a cheese sandwich on buttered wholemeal bread. Answer briefly for each step. ● ● ● ● ○ APPLY S U G

a. The starch in the bread: broken into what, and where?	
b. The fibre in the bread: what happens to it?	
c. The protein in the cheese: what reaches your bloodstream?	
d. The butter: which route does most of its fat take?	
e. As the meal is absorbed: which organ handles most of the glucose first, and what is the pancreas doing?	
f. Later in the fed state: where does a large share of the glucose go, and what signals send it there?	
g. Several hours later, with no snacks: how is the hormone balance changing, and what is your liver doing?	

8.2 Spot the errors. Your friend Gary has been reading online. Find the seven mistakes and correct them. ● ● ● ● ○ APPLY S U G

> *"After you eat, your pancreas sends insulin straight to your muscles first, and insulin is the only thing that gets glucose into them. The fat in your dinner goes straight to your liver through the portal vein. Overnight, glucagon tells your muscles to release their glycogen into the blood. Most of the fat in a fatty liver comes from the liver turning sugar into fat, and the pinchable fat round your middle is the most dangerous kind. And skipping breakfast is bad because the fasted state is unhealthy."*

8.3 Explain it to a friend. In five sentences or fewer, and explaining any jargon you use, describe how your body keeps blood glucose steady between breakfast and lunch. ● ● ● ○ ○ CONNECT S U G

8.4 Predict Chapter 3. You haven't read it yet, so guess boldly. ● ● ● ● ● LOOK AHEAD S U G

a. Subcutaneous fat copes with surplus energy by enlarging its cells and making new ones. Suppose it can no longer keep up with a continuing surplus. Where might the extra go?

b. A muscle cell already crammed with fuel keeps receiving insulin's message to take in more. What might the cell do to protect itself, and what would that do to blood glucose?

c. Your pancreas responds mainly to blood glucose and can't see what is happening inside cells. If cells start responding less to insulin, what will the pancreas do? Would a standard glucose test pick it up straight away?

Turn the page to check your answers.

8 Join it all up

Mark each question ✓, ½ or ✗

8.1 a Into glucose, mainly by enzymes in the intestines; the glucose is then absorbed.
b You can't digest it; gut microbes break some of it down, and it feeds them.
c Mainly single amino acids.
d Bile disperses it and enzymes split the triglycerides; most then travels in lymph and joins the blood near the neck, missing the liver at first.
e The liver, via the portal vein. The beta cells release more insulin, a quick first burst and then a longer release, and the liver takes up glucose and turns down its own release.
f A large share, roughly 30–50% on the chapter's figure, goes into muscle, signalled by insulin, and by movement if you are active. Fat tissue takes up some glucose and fat too.
g Insulin has drifted down and glucagon's influence has grown. The liver is releasing glucose from glycogen and making new glucose, and making little new fat.
Mark: the whole two-tick mark for five or more parts; just one tick for three or four.

8.2 Corrections:
1 Insulin goes into the portal vein, so the liver gets it first. 2 Movement also gets glucose into muscle. 3 Most dietary fat travels in lymph and misses the liver at first. 4 Glucagon acts mostly on the liver; muscle glycogen is a local store for the muscle itself. 5 In tracer studies, most liver fat came from fatty acids released by fat tissue, with around a quarter made in the liver. 6 Pinchable subcutaneous fat is the comparatively safe kind; visceral and ectopic fat cause the trouble when they accumulate. 7 The fasted state is normal and healthy (whether skipping breakfast suits you is a separate question). Mark: the mark for five or more; ½ for three or four.

8.3 Example: After breakfast, glucose from the food reaches your liver first, and your pancreas releases more insulin. Insulin prompts your liver, muscles and fat to take in glucose and store some, and tells the liver to hold back its own glucose. As the meal runs out, insulin drifts down and glucagon's influence grows, so the liver releases stored glucose and makes some new glucose. Both hormones are present all the time; it is the balance between them that changes, nudging glucose back towards the middle of its healthy range.

8.4 Not marked. Chapter 3's answers, in outline: a More of it spill over into visceral fat and into organs as ectopic fat. The limit is gradual and differs from person to person, rather than a fixed ceiling. b It becomes less responsive to insulin: insulin resistance. That protects the cell but leaves more glucose in the blood. c It releases more insulin, and keeps raising it. Glucose can look nearly normal on a standard test for years while insulin runs high, which is why the problem often goes unnoticed. These are simplified models; Chapter 3 fills in the detail.

> FROM ANDREW
> *If 8.4 felt like guesswork, that's fine. Trying to predict before you read helps you notice more when you do read, even when the predictions turn out wrong. Keep your answers in mind as you start Chapter 3.*

Marked questions right: ____ out of 3 Sure but wrong: ____ (redo these after a day or two)

SPA CED REVIEW

Return ticket

Use this page twice, after a gap each time

Memory fades fastest in the first few days, and each successful recall after a gap slows the fading. Come back to this page a day or two after finishing the sets, then again about a week later, wherever you have got to in the book. There are no answers here. Answer from memory, tick the round, then check against the answer shown.

	Question	First return	Second return
R1	Name the blood vessel that carries blood from the gut to the liver. See 3.1	☐	☐
R2	Which two signals bring GLUT4s to the surface of muscle cells? See 7.3	☐	☐
R3	Which two liver processes increase after a meal? See 5.2	☐	☐
R4	In the tracer studies, where did the largest share of liver fat come from? See 5.6	☐	☐
R5	Where does glucagon mostly act, and what does it prompt there? See 6.6	☐	☐
R6	Name the three fat depots. Which two cause trouble when they accumulate? See 7.6	☐	☐
R7	What does bile do, and what do the fat-digesting enzymes do? See 2.6	☐	☐
R8	What is negative feedback? Give the blood glucose example. See 4.5 and 4.6	☐	☐
R9	Three-minute brain dump: close the book and, on a blank sheet or aloud, recall everything you can from Chapter 2. Then compare it with your first attempt to see how much more you can now recall. See 1.1	☐	☐

Can you do these without the book?

- ☐ I can explain what carbohydrate, protein and fat are broken down into.
- ☐ I can sketch the two routes from gut to bloodstream.
- ☐ I can describe the fed and fasted states with the shopping analogy.
- ☐ I can explain negative feedback using temperature and glucose.
- ☐ I can say how the liver's four fuel processes change when fed and when fasted.
- ☐ I can say where most liver fat came from in the tracer studies.
- ☐ I can explain what insulin and glucagon do, and which cells make them.
- ☐ I can explain why muscle is the big glucose sponge and what GLUT4 does.
- ☐ I can tell subcutaneous, visceral and ectopic fat apart.

FROM ANDREW

These sets give you a clear picture of how a healthy body handles a meal: taking it apart, routing it, storing it and drawing on it again later. Chapter 3 uses the same organs, hormones and processes to explain what goes wrong in diabetes, so this picture is your reference point for the rest of the book. Any box you couldn't tick points to the set to revisit first.