Your Body in Good Health

Read it before the workbook, or after it as a quick review

How a healthy body takes food apart, moves it, stores it and keeps blood glucose steady: the picture you need before Chapter 3.

1 What food becomes

We need four kinds of thing from food: materials to make, repair and run the body; food-energy; fibre; and water. **Nutrients** your body can't make, or can't make enough of, are called **essential**. Energy comes from **fuels**, mainly carbohydrates and fats, which your cells burn with oxygen. It is measured in **Calories (kcal)** or **kilojoules (kJ)**. Burning fuel also makes some **metabolic water**.

Carbohydrates. Single sugars, called **monosaccharides** (**glucose**, **fructose** and **galactose**), are absorbed as they are. **Disaccharides** are pairs: table sugar, **sucrose**, is glucose joined to fructose. **Starch** is a long chain of glucose, like beads on a necklace. **Digestive enzymes** in the intestines snip the links so the sugars can be absorbed. **Fibre** is also a chain of sugars, but with links we can't break. Our gut microbes can break some of them, and fibre feeds them.

Protein. Proteins are chains (**polypeptides**) of **amino acids**. There are 20 kinds, and 9 are **essential**. Stomach acid unfolds the chains, enzymes cut them down, and mainly single amino acids reach the blood. A **protein quality** score combines the balance of essential amino acids with how well they are absorbed. Animal proteins score highest, soy and pea protein close behind, and mixing plant proteins (rice and lentils) fills the gaps. **Leucine**, an amino acid that signals muscle to grow, is lower in plant foods.

Fat. Fats are **lipids**. Most are **triglycerides**: a **glycerol** backbone carrying three **fatty acid** chains. A **saturated** fatty acid holds all the hydrogen it can; an **unsaturated** one has a double bond, and in **omega-3** fat the first double bond is at carbon 3. Fat doesn't mix with water, so the gallbladder releases **bile**, a natural soap that breaks fat into small droplets. Enzymes then snip off chains, leaving **monoglycerides**, **free fatty acids** and glycerol.

> *Whatever is on your plate, the body ends up with the same short list: sugars, amino acids, fatty acids, glycerol, vitamins, minerals and water.*

2 Gut plumbing

Most absorbed nutrients (sugars, amino acids, water and minerals) pass into blood vessels that join the **portal vein**, which runs straight to the **liver**. The pancreas adds its hormones to the same blood, so the liver gets the incoming food and the instructions about it early. This **first pass** through the liver is a main control on blood glucose after meals. Most fat takes a different route: it travels in **lymph**, the fluid of the **lymphatic system**, and joins the blood near the base of the neck, missing the liver at first. In diabetes, the liver stores less of the incoming glucose and keeps releasing its own.

3 Fed and fasted

In the **fed state**, nutrients are arriving: you use some and store the rest. In the **fasted state**, you draw on those stores until the next meal. Both are normal, and you move between them every day. Think of shopping: some food stays on the counter for now, the rest goes in the cupboards for later. Shop too much for too long and the cupboards overflow, and food ends up where it shouldn't be. The fixes work in the body too: shop less often, buy less, add cupboard space or use food up faster.

4 Homeostasis

Homeostasis means “staying the same”: keeping temperature, acidity, fluids, salts and glucose within narrow ranges. It works by **negative feedback**, meaning the response pushes against the change. A **sensor** detects the level, a **control centre** compares it with a target, the **set-point**, and **effectors** correct it. Body temperature (about 37 °C) is held by sweating and shivering. Blood glucose is held in the same way, because too much and too little are both harmful.

5 Your lively liver

The liver is the centre of glucose control, with four main fuel processes:

Process	What it does	Fed	Fasted
Glycogenesis	Glucose → **glycogen**	↑	↓
Glycogenolysis	Glycogen → glucose	↓	↑
Gluconeogenesis	Makes new glucose	↓	↑
De novo lipogenesis	Makes new fat	↑	↓

The liver stores about 100 g of glycogen. New glucose is made from lactate, glycerol and some amino acids, and new fat from glucose and fructose. After a meal the liver is a **buffer**, or shock absorber, soaking up glucose; between meals it supplies glucose. Glycogen runs low within about a day without food, and new glucose takes over. The arrows mean more or less, not on or off. In tracer studies, over half of liver fat came from fatty acids in the blood, mostly from fat tissue, a quarter was made in the liver and the rest came from food fat. Alcohol adds to it. Too much liver fat upsets the switching: it is an early step towards diabetes, and one of the first things to improve.

6 Pancreas, insulin and glucagon

The pancreas senses blood glucose; in its **islets of Langerhans**, **beta cells** make **insulin** and **alpha cells** make **glucagon**. A **hormone** is a signalling molecule carried in the blood. Picture glucose as a bowling ball with the bumpers up: insulin stops it going too high, glucagon stops it going too low. Insulin comes as a quick first burst after eating, then a longer release. Its message is “fuel has arrived: use it and store it”: the liver stores more and releases less glucose, muscle takes in glucose and amino acids and makes more protein, and fat tissue takes in fuel and releases less fat. Glucagon, the fasted-state signal, acts mainly on the liver, which breaks down glycogen, makes new glucose and releases it, protecting the brain's supply.

7 Muscle, the big glucose sponge

Over 600 muscles make up about 40% of your bodyweight and hold about 400 g of glycogen. Muscle takes in roughly 30–50% of the glucose from a meal. Two signals open the way, **movement** and **insulin**: both bring **GLUT4** transporters, little “glucose portals”, to the cell surface. More GLUT4 means glucose leaves the blood faster. That is why protecting muscle is central to lasting remission.

8 Fat tissue

Adipose tissue (fat tissue) is an active organ that stores energy, sends signals and affects hunger. Where fat sits counts for more than how much. **Subcutaneous fat**, the fat you can pinch, is a comparatively safe store that mops up fuel after meals and releases **leptin** and **adiponectin**, which help other organs stay sensitive to insulin. **Visceral fat** sits around the abdominal organs. In excess it releases inflammatory molecules and fatty acids, some straight to the liver. **Ectopic fat**, from the Greek for “out of place”, is fat inside organs not designed to store it, such as the liver, pancreas and muscle. It is at the heart of diabetes, and clearing it leads to reversal.

JOINING IT UP

Food becomes a few simple pieces, the liver sees most of them first, and insulin and glucagon move it between storing and releasing. Chapter 3 shows what happens when too much keeps arriving.