What Goes Wrong in Type 2 Diabetes?

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

How the healthy system from Chapter 2 becomes overloaded, step by step, and why that points straight to the way back.

1 Excess energy from any source ends up as fat

Every cell needs energy all the time, from food just eaten or from fuel stored earlier. Absorbed fuels enter **shared energy pathways**, like several doors leading into one hotel lobby. They arrive by different routes, but the body must decide whether to use the energy now or store it, and no fuel gets a free pass.

Carbohydrate is burned or stored as glycogen, but that store is small: about 400 g in muscle and 100 g in the liver. When plenty of carbohydrate arrives, the body burns more of it and less fat, leaving more food fat to be stored. Turning carbohydrate into new fat does happen, but much less than people think. Dietary fat goes more directly into storage, carried in tiny fat-rich particles that hand fatty acids to fat and muscle as they pass. Insulin makes storage easier, but it isn't an on/off switch: there is no **"fat storage mode"**. A whole packet of butter barely moves glucose or insulin, yet its surplus energy is still stored as body fat. Protein can be burned as fuel too, so extra protein adds to the energy total.

> *Your metabolism does not see what was on your plate. When more energy keeps coming in than is used, fat stores grow.*

2 The protective buffer phase

A regular surplus goes mostly into subcutaneous fat. As it fills, fat cells grow larger and new ones form, so fat tissue acts as a **buffer** that shields the organs from excess fuel. For a while, fat tissue is solving the problem by growing, not causing it. Visceral fat starts to rise and small amounts of ectopic fat collect in the liver, muscle and pancreas, but the organs are still fairly well protected. This is the **preclinical phase**: health is starting to slip, but no one has noticed yet.

3 Personal fat threshold

Everyone has a different capacity to store fat safely, set mainly by genes and partly by life history. Push past it and you have crossed your **personal fat threshold**. (It is about storing body fat, not the fat in your diet.) It can't be measured directly, but family history and years of blood tests give clues, and it is more a gradual change than a sharp line. It helps explain why diabetes can suddenly speed up after years of slow change, and why two people of the same weight can sit on opposite sides of it. Strained fat tissue also responds less to insulin, so it holds stored fat less tightly and more **free fatty acids** leak out. The buffer has become the first casualty.

4 Energy toxicity and spillover

Now there is less safe room for incoming energy, and stored fat is held less tightly. More fatty acids circulate, and fat **spills over** into visceral fat and into organs as ectopic fat. Visceral fat adds inflammatory signals that worsen insulin resistance, and releases fatty acids between meals, some straight to the liver.

The liver fills with fat. This is **MASLD** (metabolic dysfunction-associated steatotic liver disease, once called NAFLD), which can progress to **MASH**, with inflammation and injury, and in some people to **fibrosis**, **cirrhosis** and liver cancer. Muscles receive more glucose and fatty acids than they can use, while insulin keeps pushing glucose in, like the **oshiya** who cram passengers onto packed Japanese trains. Fat droplets collect in and between muscle cells, like marbling in meat. The droplets aren't the main harm: long-term oversupply and mishandled fat disrupt insulin's signal.

Fuels now stay in the blood longer. Glucose runs higher after meals and between them, circulating fats rise, and blood vessels and other tissues start to suffer. This state is called **energy toxicity**. In the kitchen, the cupboards are full, the counter is piled high and food is on the floor and behind the appliances… knock knock, another delivery.

5 Insulin resistance: cellular self-defence

An overloaded cell keeps getting insulin's message to take in more. Responding less protects the cell, but leaves more glucose in the blood: good for the cell, bad for the body. **Insulin resistance** means responding less strongly than normal to a given amount of insulin. Resistant muscle takes up less glucose; in a resistant liver, insulin is less able to turn down glucose output; in resistant fat tissue, insulin's hold on stored fat weakens. In the kitchen, it is chewing gum on the door knocker: deliveries pile up outside instead.

The pancreas responds mainly to blood glucose and can't see inside cells. As glucose creeps up, the beta cells release more insulin, then more again, so that enough GLUT4 reaches the cell surface. This **compensation** can keep glucose looking normal on standard tests for years, perhaps over a decade, while insulin runs high and is seldom measured.

6 When the pancreas can't keep up

In susceptible people, years of high demand and an unhealthy fuel mix gradually impair the beta cells. Leaking fat tissue releases more fatty acids, a fatty liver exports more triglyceride, and fat collects in and around the pancreas. Beta cells become impaired **without necessarily dying**: they respond less to glucose and lose their timing. One early loss is the **first-phase insulin response**, the quick burst within minutes of eating that holds back the liver as meal glucose arrives, so glucose rises higher and stays up longer. Raised glucose then harms the beta cells too (**glucose toxicity**), creating a **vicious circle**. Compensation fails, glucose climbs, and **symptoms** appear: thirst, tiredness, frequent urination and blurred vision. By diagnosis, four defects feed each other:

Where	What has gone wrong
Fat tissue	Can't contain the surplus; leaks fatty acids
Liver	Fatty, insulin resistant; releases too much glucose
Muscle	Insulin resistant; takes up less glucose
Pancreas	Can no longer compensate

Diagnosis feels sudden, but it ends years of silent change. Figure 3.1 pictures a tap filling a big subcutaneous bucket that overflows into liver, muscle and pancreas buckets.

7 Lean diabetics: the same problem, differently

With a low personal fat threshold, spillover starts at much lower body fat, and ectopic fat can collect without much weight gain. Lifestyle drivers such as sleep, stress and inactivity (Chapter 4) may also play a larger part. Mika was slimmer than her friends, yet her HbA1c was 7.3% (56 mmol/mol). Losing about 6 kg (14 lb), snacking less, starting resistance training and sleeping better brought it to 6.0% (42 mmol/mol) in five months.

8 There is a silver lining

Because excess energy drives the harmful visceral and ectopic fat, the solution is clear: reverse the surplus and drain the fat. Clear the cupboards, clean behind the appliances, and the door knocker can work again. When the excess fat goes, beta-cell function can recover and the liver and muscles can respond to insulin again. For most people, the physiology is not permanently broken.

JOINING IT UP

In one major route into type 2 diabetes, surplus energy fills safe storage, spills into organs, makes cells resist insulin and finally outruns the pancreas. People differ in how much fat they can store safely and how vulnerable their pancreas is, so it can happen at any weight. Part 2 shows how to run it backwards.

Bold words are new terms from the chapter