NUTRITION · STUDY GUIDE

Exam 2 Study Guide

This guide covers the two fuel chapters that most people have strong opinions about: carbohydrates and lipids. The goal is to replace slogans with mechanisms. You will sort sugars, starches and fibers, follow glucose through insulin and glucagon, and then sort fats by shape, follow them through bile and the lymph, and read a lipid panel. Work one chapter at a time, run the worked examples with a calculator, and finish each chapter with its ten self-test items.

WHAT THIS GUIDE COVERS

- Chapter 3 · monosaccharides, disaccharides and polysaccharides; soluble and insoluble fiber; starch digestion and SGLT1 and GLUT5; insulin and glucagon; glycemic index and load; the carbohydrate RDA, AMDR, fiber AI and added sugars.
- Chapter 4 · triglycerides, phospholipids and sterols; chain length, saturation, cis and trans; the two essential fatty acids; bile, micelles and chylomicrons; lipoproteins; fat functions; LDL, HDL and intake targets.

CHAPTER 3

Carbohydrates

Read it in full: **Chapter 3 in the textbook**. Practice it in the lab: **Starch to Glucose** and **The Blood Glucose Curve**.

What to know

Carbohydrates are built from sugar units. What separates table sugar from bread is how many units are linked and how the links are angled. That architecture decides whether your enzymes can take the molecule apart. Digestible carbohydrate gives 4 kcal/g, the same as protein, less than fat (9) and alcohol (7).

A **monosaccharide** is one sugar unit. Glucose is the body's reference fuel and the brain's main one. Fructose, in fruit and honey, is the sweetest and is handled mostly by the liver. Galactose

comes bound in milk sugar. A **disaccharide** is two units: sucrose is glucose plus fructose, lactose is glucose plus galactose, and maltose is glucose plus glucose. All six are "sugars," and all must end up as monosaccharides before they can be absorbed.

A **polysaccharide** is a long chain of glucose. Starch is the plant store, as straight amylose or branched amylopectin. Branches give enzymes more chain ends to attack, so amylopectin digests faster. Glycogen is the animal store, even more branched, kept in the liver (about 100 g) and muscle (about 400 g). Cellulose is also glucose, but its beta 1,4 bonds cannot be cut by any human enzyme. Lactase, though, cuts the beta 1,4 bond of lactose fine, so the rule is specific to cellulose.

Fiber resists digestion in the small intestine. **Soluble** fiber disperses in water, and the viscous kinds (beta-glucan in oats and barley, pectin, guar gum, psyllium) form a gel. A gel slows stomach emptying and glucose absorption. Viscous fibers also bind bile acids, so the liver pulls cholesterol from the blood to replace them. That is why oat beta-glucan and psyllium modestly lower LDL, a strong finding. Inulin dissolves without gelling. **Insoluble** fiber (cellulose, most hemicelluloses, lignin) holds water, adds bulk and speeds transit, though for relieving constipation the trial evidence is strongest for psyllium.

Gut bacteria ferment fiber into gas and short chain fatty acids (acetate, propionate and butyrate). Butyrate fuels the cells lining the colon. Some energy is recovered, so fermentable fiber counts about 2 kcal/g. Resistant starch acts like fiber: starch trapped in intact grains and legumes, the starch of green bananas, and starch that retrogrades when cooked potatoes, rice or pasta cool.

The fiber AI is 14 g per 1,000 kcal: 38 g for men 19 to 50, 30 g for men 51+, 25 g for women 19 to 50, 21 g for women 51+, 28 g in pregnancy and 29 g in lactation. US adults average about 15 g. There is no UL. Raise fiber gradually, with fluid, to avoid gas and cramping.

Starch digestion starts with salivary amylase, which stomach acid stops. Pancreatic amylase works in the duodenum, and the brush border enzymes maltase, sucrase and lactase finish. Glucose and galactose enter by SGLT1, a sodium-linked active transporter. Fructose enters by GLUT5, facilitated diffusion. All three leave the cell by GLUT2 and go by the portal vein to the liver, which turns most fructose and galactose into glucose or glycogen. Lactose intolerance is a shortage of lactase, not an allergy to milk protein.

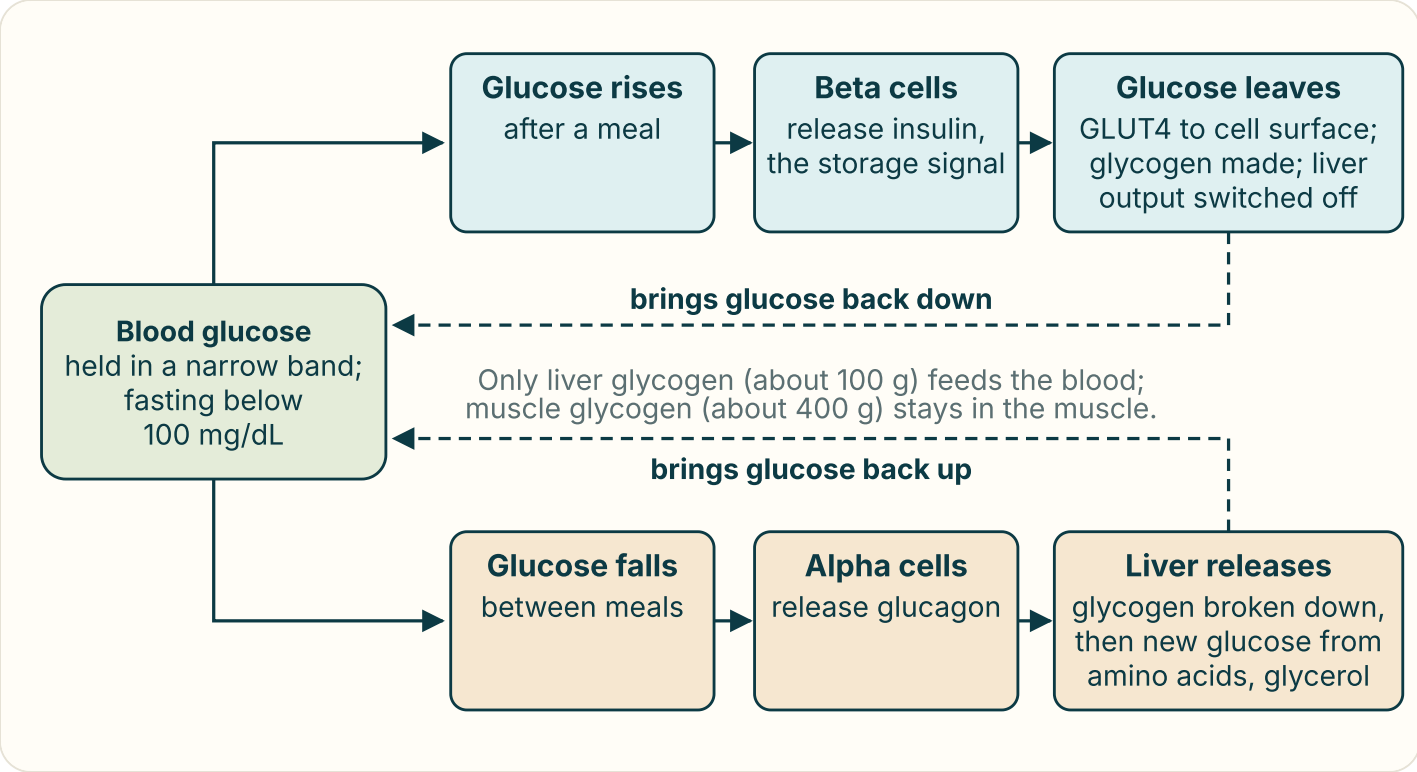
Blood glucose is held in a narrow band, fasting below 100 mg/dL in a person without diabetes. When it rises, pancreatic **beta** cells release **insulin**, the storage signal. It moves GLUT4 to muscle and fat cell surfaces, builds glycogen, and shuts off liver glucose output. When it falls, **alpha** cells release **glucagon**, which breaks down liver glycogen (glycogenolysis) and then drives gluconeogenesis from amino acids and glycerol. Only liver glycogen can feed the blood. Muscle glycogen stays in the muscle. The brain uses about 120 g of glucose a day.

The **glycemic index** compares a 50 g available carbohydrate portion of a food with pure glucose (100) over two hours: 55 or below is low, 56 to 69 medium, 70 or above high. The **glycemic load** = GI × grams of available carbohydrate in a real serving ÷ 100. A GL of 10 or below is low and 20 or above is high. Both shift with ripeness, cooking, cooling, the rest of the meal and the person.

The carbohydrate RDA is 130 g/day for everyone 1 year and older, based on the brain's glucose use. It rises to 175 g in pregnancy and 210 g in lactation. The AMDR is 45 to 65% of energy, and there is no UL. US guidelines keep added sugars under 10% of energy from age 2 and avoid them under age 2. The link between free sugars and dental caries is strong. For type 2 diabetes, carbohydrate quality matters most: whole grains, legumes and fiber track with lower risk, and sugar-sweetened drinks with higher risk. Type 1 diabetes is autoimmune and not caused by diet.

LOCK THESE IN

- Sucrose = glucose + fructose. Lactose = glucose + galactose. Maltose = glucose + glucose.
- Starch and glycogen have alpha bonds. Cellulose has beta 1,4 bonds no human enzyme can cut.
- Viscous soluble fiber lowers LDL modestly and slows glucose. Insoluble fiber adds bulk.
- SGLT1 for glucose and galactose (active, with sodium). GLUT5 for fructose. GLUT2 out the far side.
- Insulin from beta cells lowers glucose. Glucagon from alpha cells raises it.
- Liver glycogen about 100 g feeds the blood. Muscle glycogen about 400 g feeds only that muscle.
- GL = GI × grams of available carbohydrate ÷ 100.
- RDA 130 g (175 pregnancy, 210 lactation); AMDR 45 to 65%; fiber 14 g per 1,000 kcal.



Insulin down, glucagon up. Two hormones from the pancreas push blood glucose back toward its narrow band after a meal and between meals.

Carbohydrate numbers and formulas

Item	Value	Group or note
Energy	4 kcal/g digestible; fiber about 2 kcal/g	Fat 9, protein 4, alcohol 7
Carbohydrate RDA	130 g/day	All 1 year and older; 175 g pregnancy, 210 g lactation
Infant AI	60 g (0 to 6 mo), 95 g (7 to 12 mo)	Infants have AIs, not an RDA
AMDR	45 to 65% of energy	Ages 1 and older; no UL
Fiber AI	14 g per 1,000 kcal	38 g men 19 to 50; 25 g women 19 to 50; 28 g pregnancy
Fiber AI, 51+	30 g men; 21 g women	Falls with energy intake
Added sugars	Under 10% of energy	Age 2+; avoid under age 2
Glycemic index	Low 55 or less; medium 56 to 69; high 70+	50 g available carb vs glucose = 100
Glycemic load	GI × g carb ÷ 100	Low 10 or less; high 20 or more
Fasting glucose	Below 100 mg/dL (5.6 mmol/L)	Person without diabetes
Stores	Liver about 100 g; muscle about 400 g	Brain uses about 120 g/day

Where starch is taken apart

Site	Enzyme	Acts on	Product
Mouth	Salivary amylase	Starch	Dextrins, maltose
Stomach	None active	Not applicable	Acid stops amylase
Small intestine	Pancreatic amylase	Starch, dextrins	Maltose, short chains
Brush border	Maltase, sucrase, lactase	Disaccharides	Monosaccharides
Colon	Bacterial fermentation	Fiber, resistant starch	Short chain fatty acids, gas

Worked examples

WORKED EXAMPLE 1 · GLYCEMIC INDEX VERSUS GLYCEMIC LOAD

Food A has a GI of 72, but one serving holds only 6 g of available carbohydrate. Food B has a GI of 50 and a serving holds 40 g. Which serving has the larger glycemic load?

STEP 1 · WRITE THE FORMULA

GL = GI × grams of available carbohydrate ÷ 100.

STEP 2 · FOOD A

72 × 6 ÷ 100 = 4.3, a **low** GL (10 or below).

STEP 3 · FOOD B

50 × 40 ÷ 100 = 20.0, a **high** GL (20 or above).

THE LESSON

Food A has the higher GI but the far lower GL, because GI ignores how much carbohydrate a serving holds. That is exactly why the GL was invented.

WORKED EXAMPLE 2 · THE RDA IS A FLOOR, THE AMDR IS A RANGE

Imani eats 1,600 kcal a day. What carbohydrate range does the AMDR give her, and what share of her calories would the 130 g RDA alone supply?

STEP 1 · LOW END OF THE AMDR

1,600 × 0.45 = 720 kcal, and 720 ÷ 4 = **180 g**.

STEP 2 · HIGH END

1,600 × 0.65 = 1,040 kcal, and 1,040 ÷ 4 = **260 g**.

STEP 3 · THE RDA AS A SHARE

130 g × 4 = 520 kcal, and 520 ÷ 1,600 = 32.5% of her energy.

WHY THEY DIFFER

The 130 g RDA is set to cover the brain's glucose use. The AMDR describes the range where groups meet nutrient needs with low chronic disease risk. Meeting one does not automatically mean meeting the other.

WORKED EXAMPLE 3 · FIBER TARGET AND GAP

Lucas is 35 and eats about 2,600 kcal a day. His fiber intake is 15 g. What is his energy-scaled fiber target, and how far short is he?

STEP 1 · SCALE THE AI

14 g per 1,000 kcal × 2,600 kcal ÷ 1,000 = 36.4 g. That is close to the 38 g AI for men 19 to 50.

STEP 2 · FIND THE SHARE MET

15 ÷ 36.4 = 0.41, so he gets about 41% of the target.

STEP 3 · FIND THE GAP

36.4 − 15 = 21.4 g short.

HOW TO CLOSE IT

Raise it over several weeks, with fluid, because a sudden jump outruns the gut microbes and causes gas and cramping.

WORKED EXAMPLE 4 · ADDED SUGARS ON A LABEL

A bottled drink lists 39 g of added sugars. What share of a 2,000 kcal day is that, and how much of the 10% cap is left?

STEP 1 · TURN GRAMS INTO KCAL

39 g × 4 kcal/g = 156 kcal.

STEP 2 · FIND THE SHARE

156 ÷ 2,000 = 7.8% of the day's energy.

STEP 3 · FIND THE CAP

10% of 2,000 = 200 kcal, and 200 ÷ 4 = 50 g.

STEP 4 · FIND WHAT IS LEFT

50 − 39 = 11 g of added sugars, or 44 kcal, before the cap.

TRAPS PEOPLE FALL INTO

- **Calling all "complex" carbohydrates slow.** Finely milled starch digests fast. Structure and the rest of the meal matter more than chain length.
- **Saying humans cannot cut any beta bond.** Lactase cuts the beta 1,4 bond of lactose. It is cellulose's beta 1,4 bond that no human enzyme cuts.
- **Thinking muscle glycogen can raise blood glucose.** Muscle lacks the enzyme to release free glucose. Only liver glycogen feeds the blood.
- **Using GI as a grocery ranking.** GI ignores portion size, shifts with cooking and cooling, and says nothing about nutrient quality.
- **Mixing up the two hormones' cells.** Beta cells make insulin. Alpha cells make glucagon.
- **Confusing lactose intolerance with milk allergy.** Intolerance is a lactase shortage. Allergy is an immune reaction to milk protein.
- **Saying "sugar causes diabetes."** Sugar-sweetened drinks are linked to higher type 2 risk, much of it through energy intake. Type 1 is autoimmune.
- **Forgetting the fiber AI is energy-scaled.** It is 14 g per 1,000 kcal, which is why the gram targets differ by age and sex.

Chapter 3 self-test · ten items

1. Which pair of monosaccharides makes up lactose?

A. Glucose and glucose
B. Glucose and galactose
C. Glucose and fructose
D. Fructose and galactose

B. Glucose and galactose Lactose, the milk sugar, is glucose plus galactose. Sucrose is glucose plus fructose, and maltose is two glucoses.

2. Why does amylopectin usually digest faster than amylose?

A. It is made of fructose instead of glucose
B. Its beta bonds are easier for enzymes
C. Its branches give enzymes more chain ends
D. It is absorbed whole without any digestion

C. Its branches give enzymes more chain ends Enzymes attack chain ends, and a branched molecule offers many ends at once.

3. Oat beta-glucan lowers LDL cholesterol mainly by which mechanism?

A. Binding bile acids, so the liver uses up cholesterol
B. Blocking pancreatic lipase from splitting any fat
C. Raising HDL through fermentation in the colon
D. Speeding transit so that less fat can be absorbed

A. Binding bile acids, so the liver uses up cholesterol Viscous soluble fiber binds bile acids into the stool. The liver pulls cholesterol from the blood to make new bile acids.

4. Which transporter brings fructose into the intestinal cell?

A. GLUT2, on the lumen-facing side
B. GLUT4, moved to the cell by insulin
C. SGLT1, by sodium-linked transport
D. GLUT5, by facilitated diffusion

D. GLUT5, by facilitated diffusion Fructose uses GLUT5, which needs no energy. Glucose and galactose use SGLT1, and all three exit through GLUT2.

5. Twelve hours after a meal, which source keeps blood glucose steady at first?

A. Fermentation of fiber in the colon
B. Breakdown of liver glycogen
C. Breakdown of muscle glycogen
D. Release of glucose from fat cells

B. Breakdown of liver glycogen Glucagon drives glycogenolysis in the liver. Muscle glycogen cannot be released into the blood.

6. A food has a GI of 60 and a serving holds 25 g of available carbohydrate. What is its glycemic load?

A. 15
B. 24
C. 35
D. 6

A. 15 GL = 60 × 25 ÷ 100 = 15, which is medium (between 10 and 20).

7. Which statement about the carbohydrate RDA is correct?

A. It is set as an AI because data are thin
B. It is 175 g/day for all adults and teens
C. It is 45 to 65% of energy for all adults
D. It is 130 g/day, based on brain glucose use

D. It is 130 g/day, based on brain glucose use The RDA is 130 g/day for ages 1 and older. The 45 to 65% figure is the AMDR, and 175 g applies to pregnancy.

8. What is the total fiber AI for a woman aged 30 who is pregnant?

A. 25 g/day
B. 21 g/day
C. 28 g/day
D. 38 g/day

C. 28 g/day Pregnancy raises the fiber AI to 28 g/day, reflecting higher energy needs. 25 g is the value for women 19 to 50 who are not pregnant.

9. Which diet and disease link does the chapter call among the best established?

A. Starch and colorectal cancer risk
B. Fructose and fatty liver disease
C. Total carbohydrate and type 1 diabetes
D. Free sugars and dental caries

D. Free sugars and dental caries How often and how much free sugar is eaten is strongly linked to tooth decay. Fructose harm at normal intakes is preliminary, and type 1 diabetes is autoimmune.

10. A cooked potato is chilled overnight. What happens to some of its starch?

A. It retrogrades into resistant starch
B. It becomes glycogen inside the cells
C. It turns into cellulose with beta bonds
D. It breaks down into free fructose

A. It retrogrades into resistant starch Cooling lets some starch retrograde. It then escapes small intestine digestion and is fermented in the colon, which lowers the GI.

Lipids

Read it in full: **Chapter 4 in the textbook**. Practice it in the lab: **Saturated, Unsaturated, Trans** and **Cholesterol Traffic**.

What to know

Lipids are defined by behavior, not shape: they dissolve poorly in water and well in organic solvents. Their backbone is mostly carbon and hydrogen with little oxygen, which makes them hydrophobic and energy-rich. Three families matter in nutrition: triglycerides, phospholipids and sterols.

A **triglyceride** is a glycerol backbone with three fatty acids attached by ester bonds. It makes up about 95% of the lipid you eat and nearly all of what you store. A fat is solid at room temperature and an oil is liquid, but both are triglycerides and both give 9 kcal/g.

A **phospholipid** swaps one fatty acid for a phosphate group, giving a water-loving head and two water-fearing tails. Phospholipids form the bilayer of every cell membrane and work as emulsifiers. Lecithin in egg yolk is the classic example. The liver makes all you need, so none are essential. A **sterol** has four fused rings. Cholesterol is found only in animal foods, and the body makes about 800 to 1,000 mg a day. It stiffens membranes and is the starting material for bile acids, vitamin D and the steroid hormones. Plants make phytosterols, which compete with cholesterol for absorption.

A fatty acid is a carbon chain with an acid group at one end. By length: short chain under 6 carbons, medium chain 6 to 12, long chain over 12. By saturation: a **saturated** chain has no carbon to carbon double bonds and is straight, so it packs tightly and is solid at room temperature. A **monounsaturated** chain has one double bond (oleic acid in olive oil). A **polyunsaturated** chain has two or more. A cis double bond kinks the chain, keeping oils liquid. Double bonds also go rancid faster.

In a **trans** double bond the hydrogens sit on opposite sides, so the chain straightens and acts like a saturated fat. Partial hydrogenation was the big industrial source. Industrial trans fat raises LDL, lowers HDL and is linked to coronary heart disease. This evidence is strong. The FDA withdrew

GRAS status from partially hydrogenated oils, with compliance through 2020 to 2021. Ruminant trans fat from dairy and beef occurs at much lower intakes, and the evidence there is less clear.

Humans cannot place a double bond past the ninth carbon counted from the acid end. So two fatty acids are essential. **Linoleic acid** (18:2, omega-6) is in soybean, corn, sunflower and safflower oils, nuts and seeds. **Alpha-linolenic acid** (ALA, 18:3, omega-3) is in flaxseed, chia, walnuts, canola and soybean oil. The body converts ALA to EPA and DHA, but poorly. The omega number counts from the methyl end to the first double bond. Both have AIs, not RDAs. Deficiency is rare and shows up as scaly dermatitis, hair loss, poor wound healing and, in infants, poor growth.

Fat digestion is a surface area problem. Lingual and gastric lipase start a little. In the duodenum, CCK squeezes the gallbladder and releases pancreatic enzymes. Bile salts emulsify the fat (bile has no enzymes). Pancreatic lipase with colipase makes monoglycerides and free fatty acids, and bile salts carry them in micelles to the cell. Short and medium chain fatty acids go straight into the portal vein. Long chain ones are rebuilt into triglycerides and packed into **chylomicrons**, which enter the lacteal and the lymph and reach the blood near the left subclavian vein. Lipoprotein lipase on capillary walls strips their triglycerides.

Lipoproteins are named by density: more lipid and less protein means lower density. Chylomicrons carry dietary fat from the gut. VLDL carries liver-made triglyceride out. IDL is the in-between step. LDL delivers cholesterol to tissues. HDL, the densest, carries cholesterol back to the liver (reverse cholesterol transport). Fat malabsorption from gallbladder, bile duct or pancreas problems causes steatorrhea and puts vitamins A, D, E and K at risk.

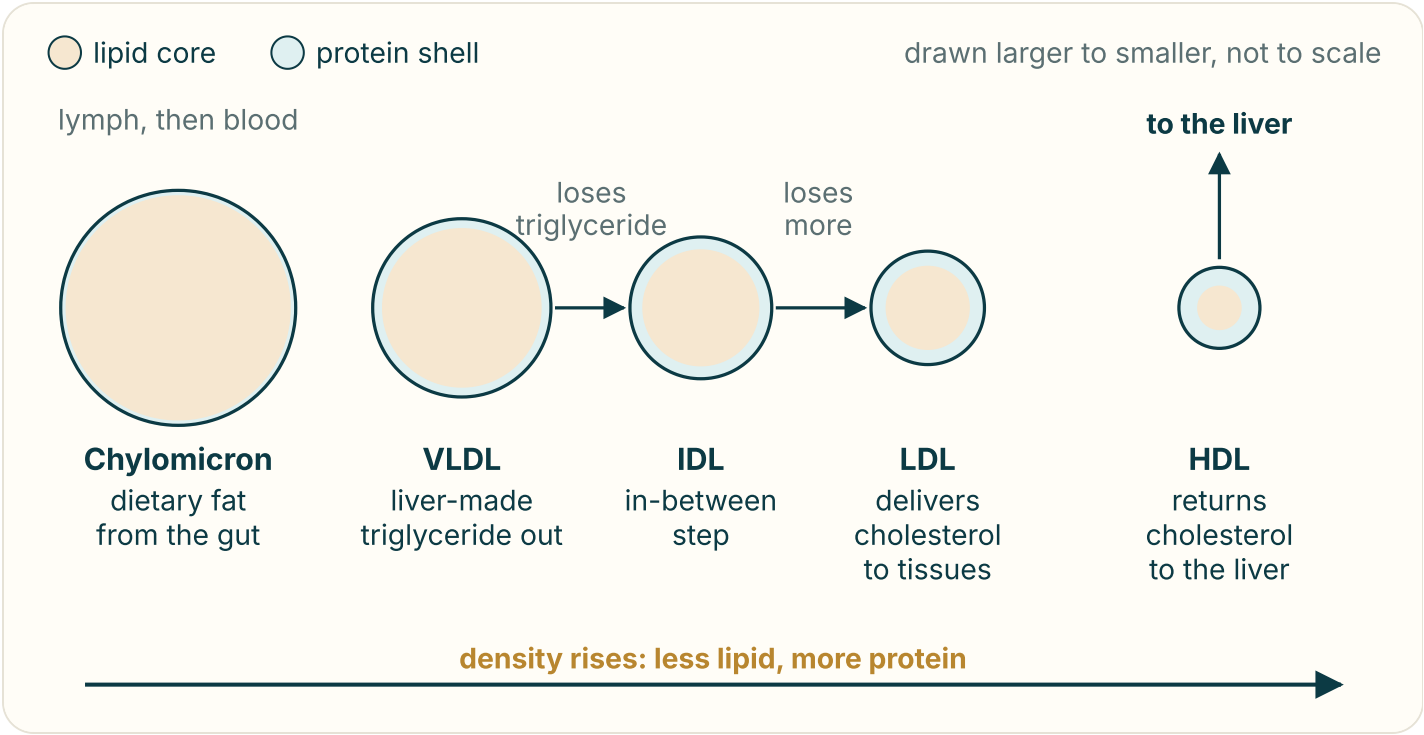
Fat stores energy almost without water, while glycogen holds about 3 to 4 g of water per gram. So the body carries perhaps 1,500 to 2,000 kcal of glycogen but tens of thousands of kcal in fat. Subcutaneous fat insulates, visceral fat cushions organs, and adipose tissue makes hormones such as leptin and adiponectin. The fat AMDR is 30 to 40% at ages 1 to 3, 25 to 35% at 4 to 18, and 20 to 35% for adults.

LDL is causally tied to atherosclerosis, with evidence from cohorts, genetics and trials. Low HDL predicts risk, but drugs that raised HDL did not cut events: a marker is not a cause. The key diet finding is the **replacement effect**: swapping saturated fat for polyunsaturated fat lowers LDL and

modestly lowers events, while swapping it for refined carbohydrate does little. Keep saturated fat under 10% of calories and trans fat as low as possible. There is no numeric cholesterol limit now. Omega-3 supplements have shown little benefit in general populations, though eating fish is linked to lower risk.

LOCK THESE IN

- Triglyceride = glycerol + 3 fatty acids, about 95% of dietary fat, 9 kcal/g.
- Cholesterol is only in animal foods. The body makes about 800 to 1,000 mg a day.
- Cis kinks the chain. Trans straightens it and acts like saturated fat.
- Essential: linoleic acid (omega-6) and alpha-linolenic acid (omega-3). Both have AIs.
- Bile emulsifies and has no enzymes. Lipase with colipase does the cutting.
- Long chain fats ride chylomicrons into the lymph. Short and medium chain go to the portal vein.
- Density order, low to high: chylomicron, VLDL, IDL, LDL, HDL.
- Replace saturated fat with polyunsaturated, not refined carbohydrate. Saturated fat under 10%.



Lipoproteins by density. Less lipid and more protein means a denser particle. VLDL becomes IDL and then LDL as it loses triglyceride.

Fat targets and essential fatty acid values

Target	Value	On 2,000 kcal or group
Total fat AMDR	20 to 35% (adults); 25 to 35% (4 to 18); 30 to 40% (1 to 3)	About 44 to 78 g/day for adults
Saturated fat	Under 10% of calories, age 2+	Under about 22 g/day
Trans fat	As low as possible	Partially hydrogenated oils removed in the US
Linoleic acid AMDR	5 to 10% of energy	About 11 to 22 g/day
Linoleic acid AI	17 g men 19 to 50; 12 g women 19 to 50	14 g men 51+; 11 g women 51+; 13 g pregnancy and lactation
ALA AMDR	0.6 to 1.2% of energy	About 1.3 to 2.7 g/day
ALA AI	1.6 g men; 1.1 g women	1.4 g pregnancy; 1.3 g lactation
Seafood	About 8 oz (two servings) a week	Adults
Cholesterol	No numeric limit	Keep as low as practical within an adequate diet

Lipoproteins, least dense to most dense

Particle	Made by	Main cargo	Job
Chylomicron	Small intestine	Dietary triglyceride	Carries absorbed fat from gut to tissues by lymph
VLDL	Liver	Liver-made triglyceride	Delivers triglyceride to muscle and fat tissue
IDL	From VLDL in the blood	Triglyceride and cholesterol	Becomes LDL or is cleared
LDL	From IDL in the blood	Cholesterol	Delivers cholesterol to tissues
HDL	Liver and intestine	Cholesterol and protein	Returns cholesterol to the liver

Worked examples

WORKED EXAMPLE 1 · THE FAT AMDR IN GRAMS

Turn the adult fat AMDR of 20 to 35% into grams for a 2,000 kcal day.

STEP 1 · LOW END IN KCAL

2,000 × 0.20 = 400 kcal.

STEP 2 · HIGH END IN KCAL

2,000 × 0.35 = 700 kcal.

STEP 3 · DIVIDE BY 9

400 ÷ 9 = 44.4 g and 700 ÷ 9 = 77.8 g, so about **44 to 78 g** of fat a day.

CHECK IT A SECOND WAY

The book gives the same 44 to 78 g range. Divide by 9, not 4, because fat carries 9 kcal/g.

WORKED EXAMPLE 2 · A SATURATED FAT SWAP

Jordan eats 2,200 kcal a day with 30 g of saturated fat. What share of calories is that? If 12 g of it is replaced with polyunsaturated fat at the same calories, what is the new share?

STEP 1 · KCAL FROM SATURATED FAT

30 × 9 = 270 kcal.

STEP 2 · SHARE NOW

270 ÷ 2,200 = 12.3%, which is above the 10% target.

STEP 3 · AFTER THE SWAP

30 − 12 = 18 g, and 18 × 9 = 162 kcal. Then 162 ÷ 2,200 = 7.4%.

WHY THE SWAP MATTERS

Total fat and total calories did not change. Swapping saturated for polyunsaturated fat lowers LDL. Swapping it for refined starch would do little.

WORKED EXAMPLE 3 · THE ESSENTIAL FATTY ACID RANGES

For a 2,000 kcal day, find the gram ranges for linoleic acid (AMDR 5 to 10%) and alpha-linolenic acid (AMDR 0.6 to 1.2%). Compare them with the AIs for a woman aged 25.

STEP 1 · LINOLEIC ACID

5% = 100 kcal and 10% = 200 kcal. Divide by 9: 11.1 to 22.2 g.

STEP 2 · ALPHA-LINOLENIC ACID

0.6% = 12 kcal and 1.2% = 24 kcal. Divide by 9: 1.3 to 2.7 g.

STEP 3 · THE AIS

A woman 19 to 50 has an AI of 12 g linoleic acid and 1.1 g ALA.

READ IT

Her linoleic acid AI of 12 g sits inside the range. Her ALA AI of 1.1 g sits a little below the 1.3 g low end. The AI is a minimum adequacy figure; the AMDR is a pattern range.

WORKED EXAMPLE 4 · FOLLOW A TABLESPOON OF OIL

A tablespoon of canola oil is about 14 g of fat, mostly long chain triglycerides. Give its energy and follow it from the duodenum to the blood.

STEP 1 · ENERGY

14 × 9 = **126 kcal**.

STEP 2 · SIGNAL

Fat entering the duodenum releases CCK, which squeezes bile from the gallbladder and calls out pancreatic enzymes.

STEP 3 · DIGEST

Bile salts emulsify the droplets. Pancreatic lipase with colipase splits each triglyceride into a monoglyceride and two free fatty acids. Micelles carry them to the brush border.

STEP 4 · REPACK

Inside the cell they are rebuilt into triglycerides and packed into chylomicrons.

STEP 5 · EXIT

Chylomicrons enter the lacteal, travel through the lymph and thoracic duct, and join the blood near the left subclavian vein. Lipoprotein lipase then unloads them in muscle and fat tissue.

TRAPS PEOPLE FALL INTO

- **Thinking a liquid oil has fewer calories than a solid fat.** Both are triglycerides at 9 kcal/g.
- **Trusting "cholesterol-free" on a plant oil.** No plant oil ever had cholesterol. Read the fatty acid panel instead.
- **Calling trans fat a kind of saturated fat.** It is unsaturated, but the straight chain makes it behave like saturated fat.
- **Counting omega numbers from the acid end.** The omega number counts from the methyl end to the first double bond.
- **Sending all fat into the lymph.** Short and medium chain fatty acids go straight to the portal vein.
- **Getting the density order backwards.** More lipid means lower density. Chylomicrons are least dense; HDL is most dense.
- **Treating HDL as a proven target.** Low HDL predicts risk, but raising it with drugs did not cut events.
- **Thinking any swap away from saturated fat helps.** Replacing it with refined carbohydrate gives little or no benefit.

Chapter 4 self-test · ten items

1. Which lipid family makes up about 95% of the fat in the diet?

A. Phospholipids

B. Cholesterol esters

C. Triglycerides

D. Phytosterols

C. Triglycerides Triglycerides are what people mean by "fat," about 95% of dietary lipid and nearly all stored fat.

2. Why are saturated fats usually solid at room temperature?

A. Their double bonds kink the chains apart
B. Their straight chains pack tightly together
C. They contain more oxygen than other fats
D. They are made of short chain fatty acids

B. Their straight chains pack tightly together No double bonds means straight chains that stack closely. Cis double bonds kink chains and keep oils liquid.

3. Why are linoleic acid and ALA essential?

A. The liver breaks them down faster than others
B. They carry the fat-soluble vitamins alone
C. They are found only in fish and algae oils
D. Humans cannot add double bonds past carbon 9

D. Humans cannot add double bonds past carbon 9 Human enzymes cannot place a double bond beyond the ninth carbon from the acid end, so omega-6 and omega-3 must come from food.

4. What is the ALA Adequate Intake for men aged 19 and older?

A. 1.6 g/day
B. 1.1 g/day
C. 17 g/day
D. 1.4 g/day

A. 1.6 g/day Men 19+ have an ALA AI of 1.6 g/day. 1.1 g is for women, 1.4 g for pregnancy, and 17 g is the linoleic acid AI for men 19 to 50.

5. A classmate says bile digests fat. Which correction is right?

A. It carries chylomicrons into the lymph
B. It emulsifies fat but contains no enzymes
C. It splits triglycerides into fatty acids
D. It is made by the gallbladder from glucose

B. It emulsifies fat but contains no enzymes Bile is made by the liver from cholesterol and stored in the gallbladder. Its salts act as a detergent. Lipase does the splitting.

6. A fatty acid with 8 carbons is absorbed. Where does it go first?

A. Into the portal vein toward the liver
B. Into HDL for return to the liver
C. Into a micelle that stays in the gut
D. Into a chylomicron and the lymph

A. Into the portal vein toward the liver Medium chain fatty acids (6 to 12 carbons) are water-soluble enough to go straight to the portal vein bound to albumin.

7. Which lipoprotein carries cholesterol from tissues back to the liver?

A. VLDL
B. LDL
C. HDL
D. IDL

C. HDL HDL performs reverse cholesterol transport. LDL delivers cholesterol out to tissues.

8. A person with blocked bile ducts has pale, greasy stools. Which vitamins are most at risk?

A. Thiamin, riboflavin and niacin
B. Vitamin C and the B vitamins
C. Vitamin B12 and folate
D. Vitamins A, D, E and K

D. Vitamins A, D, E and K Without bile, fat is not absorbed well, and the fat-soluble vitamins travel with fat.

9. Saturated fat is cut from a diet. Which replacement is linked to lower LDL and fewer events?

A. Industrial trans fat from shortening
B. Refined starch such as white bread
C. Extra coconut oil in place of butter
D. Polyunsaturated fat from plant oils

D. Polyunsaturated fat from plant oils The replacement effect: swapping toward polyunsaturated fat lowers LDL. Refined carbohydrate gives little benefit, and coconut oil raises LDL like other saturated fats.

10. On a 2,000 kcal day, how many grams of saturated fat stay under the 10% target?

A. About 22 g
B. About 50 g
C. About 11 g
D. About 78 g

A. About 22 g 10% of 2,000 is 200 kcal, and 200 ÷ 9 = 22.2 g. Using 4 kcal/g by mistake gives 50 g.

Cram sheet

Everything from chapters 3 and 4 in one place. Cover the right column and see if you can rebuild each row.

Numbers to know

Item	Value	Note
Energy	Carb 4, fat 9, protein 4, alcohol 7 kcal/g	Fermentable fiber about 2
Carbohydrate RDA	130 g; 175 g pregnancy; 210 g lactation	Ages 1 and older
Carbohydrate AMDR	45 to 65% of energy	No UL
Fiber AI	14 g/1,000 kcal: 38 g men, 25 g women (19 to 50)	30 g and 21 g at 51+; 28 g pregnancy; 29 g lactation
Added sugars	Under 10% of energy, age 2+	None under age 2
GI bands	Low 55 or less; high 70 or more	GL low 10 or less; high 20 or more
Glycogen	Liver about 100 g; muscle about 400 g	Brain about 120 g glucose/day
Fat AMDR	20 to 35% adults; 25 to 35% ages 4 to 18; 30 to 40% ages 1 to 3	44 to 78 g on 2,000 kcal
Saturated fat	Under 10% of calories	Under about 22 g on 2,000 kcal
Linoleic acid	AMDR 5 to 10%; AI 17 g men, 12 g women (19 to 50)	Omega-6, 18:2
ALA	AMDR 0.6 to 1.2%; AI 1.6 g men, 1.1 g women	Omega-3, 18:3
Cholesterol made	About 800 to 1,000 mg/day	No numeric intake limit

Equations

Name	Equation	Units
Glycemic load	GL = GI × g available carb ÷ 100	no unit
Fiber target	g = 14 × kcal ÷ 1,000	g/day
Grams from an AMDR	g = kcal × fraction ÷ kcal per g	g/day
Share of calories	% = g × kcal per g ÷ total kcal × 100	percent

Rules that are not equations

Topic	The rule
Disaccharides	Sucrose = glu + fru; lactose = glu + gal; maltose = glu + glu.
Transporters	SGLT1 (glucose, galactose, with sodium); GLUT5 (fructose); GLUT2 out; GLUT4 moved by insulin.
Hormones	Insulin from beta cells stores; glucagon from alpha cells releases.
Fiber	Viscous soluble gels and lowers LDL; insoluble adds bulk; fermentation makes butyrate.
Fatty acid shape	Saturated straight; cis kinked; trans straight.
Fat routes	Long chain to chylomicrons and lymph; short and medium chain to portal vein.
Lipoproteins	Chylomicron, VLDL, IDL, LDL, HDL from least to most dense.
Evidence	LDL causal; HDL a marker; replacement effect is the key diet lever.

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