NUTRITION · STUDY GUIDE

Exam 3 Study Guide

This guide covers protein and the vitamins. Protein is about shape: sequence makes the fold, and the fold does the job. The vitamins are about solubility: whether a vitamin dissolves in fat or water predicts how it is absorbed, stored and overdosed. There are a lot of names and numbers here, so build your own tables as you go. Work one chapter at a time, try each worked example with the steps covered, and finish with the ten self-test items.

WHAT THIS GUIDE COVERS

- Chapter 5 · amino acid structure, the nine indispensable amino acids, four levels of structure, denaturation, protein digestion, functions and nitrogen balance, protein quality, complementary proteins, the RDA by life stage.
- Chapter 6 · what a vitamin is, fat-soluble versus water-soluble, vitamins A, D, E and K, the eight B vitamins as coenzymes, vitamin C and scurvy, bioavailability, cooking losses and supplement evidence.

CHAPTER 5

Proteins and Amino Acids

Read it in full: **Chapter 5 in the textbook**. Practice it in the lab: **Fill the Limiting Amino Acid** and **Denature a Protein**.

What to know

Every amino acid has the same frame: a central alpha carbon holding an amino group, a carboxyl group, a hydrogen and a side chain (the R group). Only the side chain differs, and it sets the amino acid's personality: water-loving or water-fearing, acidic or basic, small or bulky. Twenty amino acids build human proteins.

Protein is about 16% nitrogen by weight, which is why food labs estimate protein as nitrogen × 6.25. The nitrogen is also why the body cannot simply stockpile extra protein. It must strip the

nitrogen off and excrete it as urea before the carbon skeleton can be burned or stored. Protein gives 4 kcal/g.

Nine amino acids are **indispensable** (essential): histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Dispensable ones can be made. **Conditionally indispensable** ones are normally made but cannot keep up in illness, injury, prematurity or an inherited disorder. Tyrosine is the clear case: it is made from phenylalanine, but a person with PKU lacks that enzyme, so tyrosine becomes indispensable and phenylalanine is restricted under medical care.

A peptide bond joins the carboxyl group of one amino acid to the amino group of the next and releases water. The order of amino acids is the **primary** structure, set by a gene. One swap can change everything: in sickle cell disease, valine replaces glutamic acid at position six of beta-globin. Hydrogen bonds along the backbone make the **secondary** structure (alpha helix and beta sheet). The whole chain folds into a **tertiary** shape held by side chain forces and disulfide bridges. Several chains together, as in hemoglobin's four subunits, make **quaternary** structure. Shape is function.

Denaturation unfolds a protein. Heat, acid or alkali, whipping, alcohol, some salts and heavy metals, and UV light all do it. It breaks the weak forces of secondary, tertiary and quaternary structure, but leaves the peptide bonds intact. Cooking an egg is denaturation, not digestion. Denatured protein is more open, so cooking usually makes protein easier to digest.

Protein digestion skips the mouth: saliva has no protease. In the stomach, hydrochloric acid (about pH 1.5 to 3.5) denatures protein and turns pepsinogen into pepsin, which works best in strong acid. In the duodenum, secretin brings bicarbonate and CCK brings pancreatic zymogens. Enteropeptidase on the brush border turns trypsinogen into trypsin, and trypsin activates the rest. Trypsin, chymotrypsin and elastase cut inside the chain, carboxypeptidase trims from the end, and brush border peptidases finish. Amino acids and di and tripeptides ride the portal vein to the liver. The body also recycles about 250 to 300 g of its own protein a day.

Protein jobs: structure (collagen is the most abundant protein in the body; keratin, elastin, actin, myosin), enzymes, many hormones (insulin, glucagon, growth hormone, leptin), transport

(hemoglobin, albumin, transferrin, lipoproteins, membrane pumps), antibodies, fluid balance, acid base buffering near pH 7.4, clotting (fibrinogen to fibrin) and, reluctantly, energy. Albumin holds water in the blood by osmotic pull, so very low plasma protein can cause edema, although in childhood undernutrition that is not the whole story.

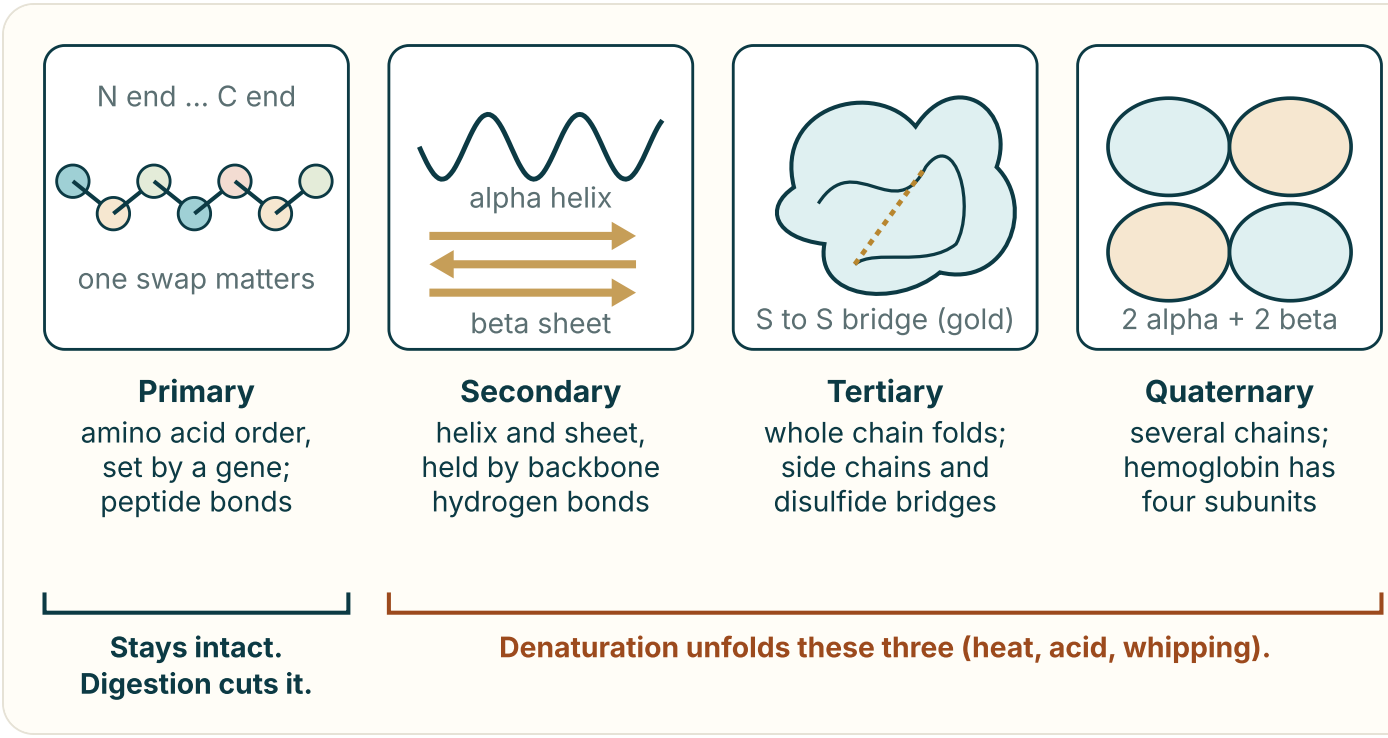
Nitrogen balance compares nitrogen in with nitrogen out. Healthy adults sit at zero. Growth, pregnancy and recovery are positive. Severe illness, burns, immobility or poor intake are negative. Adequate carbohydrate is protein sparing, because it keeps the body from burning amino acids for glucose.

Protein quality combines amino acid pattern and digestibility. Complete proteins supply all nine indispensable amino acids in good proportions: eggs, dairy, meat, poultry, fish, soy and quinoa. The scarcest one in a food is its **limiting amino acid**. Grains tend to be low in lysine and legumes low in methionine. PDCAAS is capped at 1.00; DIAAS measures at the end of the small intestine and is not capped. Complementary proteins such as beans and rice cover each other's gaps, and they do not need to be eaten at the same meal, because the amino acid pool works across the day.

The adult RDA is **0.8 g/kg/day** for ages 19+, both sexes, and the EAR is 0.66 g/kg. Pregnancy and lactation raise it to 1.1 g/kg. The AMDR is 10 to 35% of calories for adults (10 to 30% at ages 4 to 18, 5 to 20% at 1 to 3). There is no UL, because data were too thin. Expert groups suggest about 1.2 to 2.0 g/kg for athletes in heavy training and 1.0 to 1.2 g/kg for adults over about 65, as guidance, not DRIs. Marasmus is wasting from too little energy and protein. Kwashiorkor shows edema, a fatty liver and skin and hair changes, and its cause is unresolved. Well-planned vegetarian and vegan diets are adequate. Vitamin B12 is the firm planning need for vegans.

LOCK THESE IN

- The side chain is the only part that differs between amino acids.
- Nine indispensable: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine.
- Protein is about 16% nitrogen, so protein = nitrogen × 6.25.
- Denaturation unfolds the shape and keeps the peptide bonds. Digestion cuts the bonds.
- Enteropeptidase activates trypsin, and trypsin activates the other pancreatic zymogens.
- Grains are limited in lysine, legumes in methionine. Complements can be eaten hours apart.
- RDA 0.8 g/kg (19+); 1.1 g/kg in pregnancy and lactation; AMDR 10 to 35%; no UL.
- Positive nitrogen balance in growth and recovery; negative in illness and poor intake.



Shape is function. Denaturation unfolds the upper three levels but leaves the peptide bonds of the primary structure intact.

Protein numbers and formulas

Item	Value	Group or note
Energy	4 kcal/g	Same as carbohydrate
Nitrogen content	About 16% of protein by weight	Protein = N × 6.25
RDA, adults	0.8 g/kg/day	Ages 19+, both sexes; about 56 g (70 kg) or 46 g (57 kg)
EAR, adults	0.66 g/kg/day	The median requirement
Pregnancy and lactation	1.1 g/kg/day	About 71 g/day
Infants	AI about 9.1 g (0 to 6 mo); RDA 1.2 g/kg (7 to 12 mo)	Highest need per kg
Children	1.05 g/kg (1 to 3); 0.95 g/kg (4 to 13); 0.85 g/kg (14 to 18)	RDA per kg falls with age
AMDR	10 to 35% (adults); 10 to 30% (4 to 18); 5 to 20% (1 to 3)	No UL set
Expert guidance	1.2 to 2.0 g/kg athletes; 1.0 to 1.2 g/kg over 65	Not DRIs
Turnover	About 250 to 300 g/day	More than people eat
Digestibility	Above 90% for animal foods and refined soy	Lower for whole legumes and grains

Protein in common portions (approximate)

Food	Portion	Protein
Cooked chicken, beef or fish	3 oz (85 g)	21 to 26 g
Greek yogurt, plain	6 oz (170 g)	15 to 18 g
Cooked lentils	1 cup	About 18 g
Cooked black beans or chickpeas	1 cup	14 to 15 g
Firm tofu	1/2 cup	About 10 g
Milk or fortified soy milk	1 cup	About 8 g
Cooked quinoa	1 cup	About 8 g
Peanut butter	2 tbsp	About 7 g
Large egg	1	About 6 g

Worked examples

WORKED EXAMPLE 1 · PROTEIN RDA THROUGH PREGNANCY

Elena weighs 64 kg. Find her protein EAR and RDA, then her RDA in pregnancy.

STEP 1 · EAR

0.66 g/kg × 64 kg = 42.2 g/day.

STEP 2 · RDA

0.8 g/kg × 64 kg = **51.2 g/day**.

STEP 3 · PREGNANCY

1.1 g/kg × 64 kg = **70.4 g/day**, about 19 g more.

WHY PER KILOGRAM

A per kg figure fits the actual person. The 46 g "female" value in DRI tables assumes a 57 kg reference woman.

WORKED EXAMPLE 2 · PROTEIN AS A SHARE OF CALORIES

Marcus eats 2,200 kcal and 110 g of protein a day. What share of his calories is protein, and is it inside the AMDR?

STEP 1 · KCAL FROM PROTEIN

110 × 4 = 440 kcal.

STEP 2 · SHARE

440 ÷ 2,200 = 0.20, so **20%**.

STEP 3 · COMPARE

The adult AMDR is 10 to 35%, so 20% is inside it.

PER KG TOO

If Marcus weighs 82 kg, his RDA is 0.8 × 82 = 65.6 g. His 110 g is well above that, which is common in high-income countries.

WORKED EXAMPLE 3 · NITROGEN BALANCE

A patient recovering from surgery eats 90 g of protein in a day and loses 16 g of nitrogen in urine, stool and skin. What is the nitrogen balance?

STEP 1 · PROTEIN TO NITROGEN

Protein is about 16% nitrogen, so divide by 6.25: 90 ÷ 6.25 = 14.4 g N in.

STEP 2 · SUBTRACT

14.4 − 16 = **−1.6 g N** per day.

STEP 3 · READ IT

A negative balance means body protein is being lost faster than it is replaced, which is common after surgery or burns.

CHECK IT A SECOND WAY

Multiply back: 1.6 g N × 6.25 = 10 g of protein lost from the body each day.

WORKED EXAMPLE 4 · A PLANT-BASED DAY

A vegan day includes 1 cup lentils, 2 tbsp peanut butter, 1 cup fortified soy milk, 1/2 cup firm tofu and 1 cup quinoa. Use the portion table to estimate protein, and compare with the RDA for a 70 kg man.

STEP 1 · ADD THE PORTIONS

18 + 7 + 8 + 10 + 8 = **51 g**.

STEP 2 · FIND THE RDA

0.8 × 70 = 56 g.

STEP 3 · COMPARE

The listed foods supply about 51 g, so the rest of the day's meals and snacks need to add about 5 g more.

QUALITY

Lentils (low in methionine) and quinoa and soy (complete) cover each other. Timing does not matter. The firm planning item here is vitamin B12, not protein.

TRAPS PEOPLE FALL INTO

- **Calling denaturation digestion.** A fried egg is denatured, yet every peptide bond is still there.
- **Reading "incomplete" as "missing an amino acid."** It means one indispensable amino acid is low relative to need, not absent.
- **Insisting complements share a meal.** That rule was withdrawn. The amino acid pool works across the day.
- **Saying protein digestion starts in the mouth.** Saliva has no protease. Chemistry starts with stomach acid and pepsin.
- **Forgetting the units of the RDA.** It is 0.8 g per kg of body weight per day, not 0.8 g per day.
- **Treating no UL as proof of safety.** No UL means the data were too thin to set one.
- **Blaming kwashiorkor on protein alone.** That explanation is now incomplete; the mechanism is unresolved.

Chapter 5 self-test · ten items

1. Glycine and leucine behave very differently in a protein. Which part of their structure explains why?

A. The carboxyl group (COOH)
B. The alpha carbon atom itself
C. The side chain (R group)
D. The amino group (NH_2)

C. The side chain (R group) The alpha carbon, amino group, carboxyl group and hydrogen are shared. Only the side chain changes.

2. A person with PKU cannot convert phenylalanine. Which amino acid becomes indispensable for them?

A. Leucine
B. Alanine
C. Valine
D. Tyrosine

D. Tyrosine Tyrosine is normally made from phenylalanine. Without that enzyme it must come from the diet, so it is conditionally indispensable.

3. A food sample contains 3.2 g of nitrogen. About how much protein does it hold?

A. 20 g
B. 32 g
C. 12 g
D. 16 g

A. 20 g Protein is about 16% nitrogen, so multiply by 6.25: 3.2 × 6.25 = 20 g.

4. Heating an egg white turns it solid. Which bonds are still intact afterward?

A. The side chain attractions
B. The peptide bonds in the chain
C. The hydrogen bonds of the helix
D. The water-avoiding inner core

B. The peptide bonds in the chain Denaturation breaks the weak forces of the fold but leaves the primary structure, the peptide bonds, in place.

5. Which level of structure does hemoglobin have that a single folded chain does not?

A. Secondary structure
B. Tertiary structure
C. Primary structure
D. Quaternary structure

D. Quaternary structure Hemoglobin is four folded subunits assembled together, which is quaternary structure.

6. What activates trypsinogen in the small intestine?

A. Enteropeptidase on the brush border
B. Bile salts released by CCK
C. Hydrochloric acid in the stomach
D. Pepsin carried in from the stomach

A. Enteropeptidase on the brush border Enteropeptidase converts trypsinogen to trypsin, which then activates the other pancreatic zymogens. Acid activates pepsinogen.

7. Which person is most likely in positive nitrogen balance?

A. A bedridden older adult
B. A healthy adult at steady weight
C. A pregnant woman eating enough
D. An adult with a severe burn

C. A pregnant woman eating enough Growth and pregnancy build new tissue, so more nitrogen is kept than lost. A healthy steady adult sits at zero.

8. Rice is low in lysine and beans are low in methionine. What does the chapter say about combining them?

A. They must be eaten in the same bite
B. They complement even if eaten hours apart
C. They only work if eaten within one hour
D. They cannot complete each other at all

B. They complement even if eaten hours apart The circulating amino acid pool lets proteins eaten across the day complement one another. The same meal rule was retracted.

9. What is the protein RDA for a 75 kg adult who is breastfeeding?

A. About 71 g/day
B. About 90 g/day
C. About 83 g/day
D. About 60 g/day

C. About 83 g/day Lactation raises the RDA to 1.1 g/kg. 1.1 × 75 = 82.5 g, about 83 g. 0.8 × 75 = 60 g is the non-pregnant value.

10. Low plasma albumin can lead to edema mainly because albumin normally does what?

A. Holds water inside blood vessels
B. Carries oxygen through the blood
C. Buffers stomach acid in digestion
D. Builds collagen in vessel walls

A. Holds water inside blood vessels Albumin is too big to leave capillaries, and its osmotic pull keeps water in the bloodstream.

Vitamins

Read it in full: **Chapter 6 in the textbook**. Practice it in the lab: **The Fat-Soluble Four: A, D, E, K** and **The B-Vitamin Matchup**.

What to know

A vitamin is an organic compound the body needs in small amounts (mg or µg) and cannot make, or cannot make enough of. Remove it and a specific deficiency disease appears; restore it and the disease resolves. Vitamins give 0 kcal/g. Many B vitamins are part of the machinery that releases energy from food, but they are not fuel. Two near exceptions: skin makes vitamin D under UVB light, and gut bacteria make some vitamin K and biotin.

Thirteen vitamins split by solubility. The four **fat-soluble** vitamins (A, D, E, K) travel with fat, need bile and micelles, ride chylomicrons in the lymph and are stored in the liver and fat tissue. Deficiency is slow, and toxicity from supplements is a real risk. The nine **water-soluble** vitamins (eight B vitamins and C) go straight into portal blood, are stored in small amounts and spill into urine. Deficiency can come in weeks, so intake needs to be regular. B12 is the exception, with liver stores lasting years. Anything that hurts fat absorption (cystic fibrosis, liver disease, bariatric surgery, celiac disease) puts A, D, E and K at risk first.

Vitamin A comes preformed (retinol) from liver, dairy fat, egg yolk and fortified foods, and as provitamin A carotenoids (mostly beta-carotene) from sweet potato, carrot, pumpkin, mango and dark greens. Intakes use RAE: 1 µg RAE = 1 µg retinol = 12 µg dietary beta-carotene = 24 µg of other provitamin A carotenoids. It makes rhodopsin for dim light vision, guides epithelial cells as retinoic acid, and supports immunity. Deficiency moves from night blindness to xerophthalmia and blindness. The UL is 3,000 µg/day of preformed vitamin A, which is teratogenic in early pregnancy. Food carotenoids only tint the skin. RDA 900 µg RAE men, 700 women, 770 pregnancy, 1,300 lactation.

Vitamin D is made in skin from 7-dehydrocholesterol (D3) or eaten as D2 from UV-exposed mushrooms or D3 from oily fish, egg yolk and fortified milks. The liver makes 25-hydroxyvitamin D, the form measured on labs. The kidney makes calcitriol, the active hormone, which raises calcium and phosphate absorption. Deficiency causes rickets in children and

osteomalacia in adults. RDA 15 µg (600 IU) for ages 1 to 70 and 20 µg (800 IU) over 70; infants AI 10 µg (400 IU). 1 µg = 40 IU. UL 100 µg (4,000 IU). Toxicity comes from supplements, never sunlight. Skeletal benefits are strong; non-skeletal claims mostly failed in large trials.

Vitamin E (alpha-tocopherol) is the antioxidant inside membranes, protecting polyunsaturated fats. Sources are plant oils, nuts and seeds, avocado and greens. RDA 15 mg for adults, 19 mg in lactation. Deficiency is rare and tied to fat malabsorption. UL 1,000 mg from supplements; high doses can affect clotting. **Vitamin K** (K1 from leafy greens and plant oils, K2 from fermented foods and gut bacteria) lets clotting factors II, VII, IX and X and bone proteins bind calcium. Deficiency means bleeding. AI 120 µg men, 90 µg women, with no UL. Newborns get a dose at birth.

The eight B vitamins act as **coenzymes**: thiamin as TPP, riboflavin as FAD and FMN, niacin as NAD^+ and $NADP^+$, pantothenic acid as coenzyme A, B6 as PLP, biotin on carboxylases, folate as THF, and B12 as methyl and adenosylcobalamin. They run glycolysis, the citric acid cycle, the electron transport chain, amino acid and fat metabolism and DNA synthesis.

Learn the classic pairings. Thiamin deficiency causes beriberi (wet is heart failure, dry is neuropathy) and, with heavy alcohol use, Wernicke-Korsakoff syndrome. Riboflavin deficiency cracks the lip corners and inflames the tongue; riboflavin is light-sensitive. Niacin deficiency causes pellagra: dermatitis, diarrhea, dementia and death. About 60 mg of tryptophan makes 1 mg of niacin, so intakes are niacin equivalents (NE). B6 deficiency causes a microcytic anemia, and B6 above the 100 mg UL can cause neuropathy. Folate and B12 deficiency both cause megaloblastic anemia.

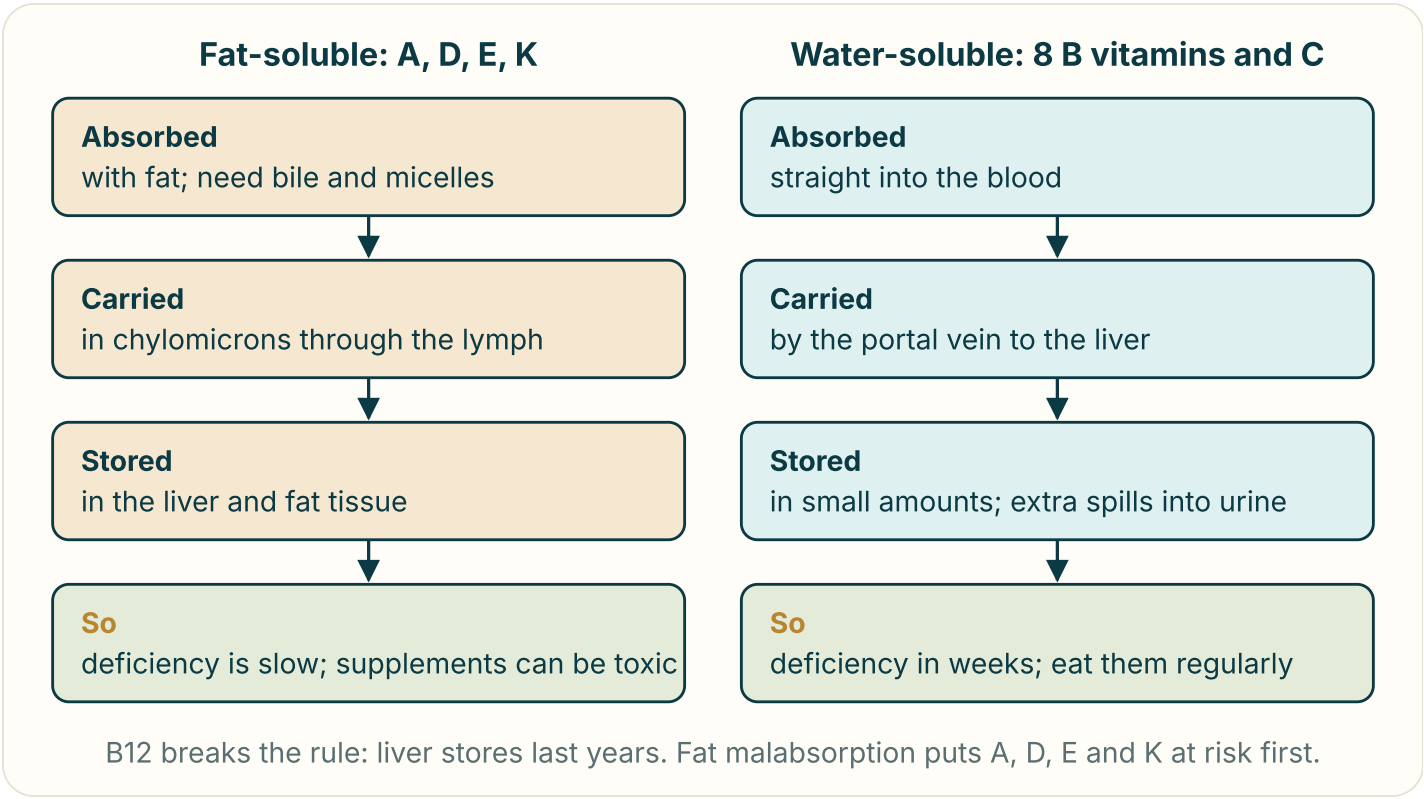
Folate RDA is 400 µg DFE (600 in pregnancy, 500 in lactation). Taking 400 µg of folic acid before conception and in early pregnancy cuts neural tube defects, one of the strongest findings in nutrition. B12 (RDA 2.4 µg) is found naturally only in animal foods, plus fortified foods and supplements, so vegans need a reliable source. Its absorption needs stomach acid, intrinsic factor and the terminal ileum. B12 deficiency also damages nerves, sometimes for good. High folic acid can hide the anemia while nerve damage continues, which is why the folic acid UL is 1,000 µg.

Vitamin C keeps iron reduced so the enzymes that hydroxylate proline and lysine in collagen can work. It is also needed for carnitine and norepinephrine, it regenerates vitamin E, and it boosts non-heme iron absorption by reducing ferric to ferrous iron. Sources include peppers, guava, kiwi, broccoli, strawberries, citrus, tomatoes and potatoes. RDA 90 mg men, 75 mg women, 85 pregnancy, 120 lactation, plus 35 mg for people who smoke. UL 2,000 mg. Scurvy, after one to three months of near-zero intake, is collagen failure: bleeding gums, perifollicular hemorrhages, corkscrew hairs, bruising and poor wound healing. James Lind's 1747 trial on HMS Salisbury found that only citrus cured it.

Bioavailability is the share you actually absorb. Chopping and gentle cooking free carotenoids, fat helps A, D, E and K, and folic acid is absorbed better than food folate. Boiling and draining loses the most vitamin C, thiamin and folate; steaming, microwaving and keeping the cooking liquid hold more. Baking soda destroys thiamin and C, and light degrades riboflavin. Frozen produce often matches or beats "fresh." US supplements are not pre-approved for safety or effect. Strong uses: folic acid before pregnancy, vitamin K at birth, vitamin D for breastfed infants, B12 for vegans and many older adults. Routine multivitamins have not prevented disease, and high-dose beta-carotene raised lung cancer in people who smoked.

LOCK THESE IN

- Fat-soluble A, D, E, K: stored, slow to run low, toxic in excess. Water-soluble B and C: regular intake needed.
- Vitamins give 0 kcal. B vitamins are coenzymes in energy pathways.
- 1 µg RAE = 12 µg dietary beta-carotene. Preformed A UL 3,000 µg; it is teratogenic.
- Vitamin D: 1 µg = 40 IU. RDA 15 µg (600 IU), 20 µg (800 IU) over 70. UL 100 µg.
- Thiamin: beriberi and Wernicke-Korsakoff. Niacin: pellagra. Folate and B12: megaloblastic anemia.
- B12 needs intrinsic factor and the terminal ileum, and is natural only in animal foods.
- Vitamin C: collagen hydroxylation and non-heme iron. RDA 90 men, 75 women, +35 for smoking.
- Water-soluble does not mean risk-free: B6, niacin, folic acid and C all have ULs.



Solubility sets the rules. How a vitamin is absorbed, carried and stored predicts how fast deficiency appears and whether excess builds up.

Key vitamins: roles, sources, deficiency and limits (adults)

Vitamin	Main role	Good sources	Deficiency	Reference intake and UL
A	Night vision (rhodopsin); epithelium; immunity	Liver, dairy fat, egg yolk; sweet potato, carrot, greens	Night blindness, xerophthalmia	RDA 900 / 700 µg RAE; UL 3,000 µg preformed
D	Calcium and phosphate absorption; bone	Skin with UVB; oily fish, egg yolk, fortified milk	Rickets, osteomalacia	RDA 15 µg (600 IU), 20 µg over 70; UL 100 µg
E	Antioxidant in membranes	Plant oils, nuts, seeds, avocado	Rare; neuropathy, hemolysis	RDA 15 mg; UL 1,000 mg supplemental
K	Carboxylates clotting factors and bone proteins	Leafy greens, plant oils, fermented foods	Bleeding; newborn VKDB	AI 120 / 90 µg; no UL
B1 thiamin	TPP in carbohydrate metabolism	Whole and enriched grains	Beriberi; Wernicke-Korsakoff	RDA 1.2 / 1.1 mg
B2 riboflavin	FAD, FMN	Milk, enriched grains	Cheilitis, glossitis	RDA 1.3 / 1.1 mg
B3 niacin	NAD^+, $NADP^+$	Enriched grains; tryptophan (60 mg = 1 mg NE)	Pellagra: 4 Ds	RDA 16 / 14 mg NE; UL 35 mg supplemental
B6	PLP in amino acid metabolism	Varied foods	Microcytic anemia, neuropathy	RDA 1.3 mg (19 to 50); UL 100 mg
Folate	THF in DNA synthesis	Leafy greens, legumes, liver, fortified flour	Megaloblastic anemia; neural tube defects	RDA 400 µg DFE, 600 pregnancy; UL 1,000 µg folic acid
B12	Cobalamins in DNA and nerve function	Animal foods; fortified foods	Megaloblastic anemia plus nerve damage	RDA 2.4 µg

Vitamin	Main role	Good sources	Deficiency	Reference intake and UL
C	Collagen hydroxylation; non-heme iron uptake	Peppers, citrus, kiwi, broccoli, potatoes	Scurvy	RDA 90 / 75 mg; +35 smoking; UL 2,000 mg
B5, biotin	Coenzyme A; carboxylases	Widespread	Rare	AI 5 mg; AI 30 µg

Worked examples

WORKED EXAMPLE 1 · ADDING UP VITAMIN A IN RAE

A day's food supplies 6,000 µg of dietary beta-carotene and 200 µg of preformed retinol. Find the total in RAE and compare it with the RDA for an adult woman.

STEP 1 · CONVERT THE BETA-CAROTENE

6,000 ÷ 12 = 500 µg RAE.

STEP 2 · ADD THE RETINOL

500 + 200 = **700 µg RAE**.

STEP 3 · COMPARE

The RDA for adult women is 700 µg RAE, so she meets it exactly.

THE UL CHECK

The 3,000 µg UL counts preformed retinol only. Her 200 µg is far below it, and the beta-carotene does not count toward the UL at all.

WORKED EXAMPLE 2 · IU AND MICROGRAMS FOR VITAMIN D

A supplement label reads 2,000 IU of vitamin D. How many micrograms is that? How does it compare with the RDA and UL for a 40-year-old?

STEP 1 · CONVERT

1 µg = 40 IU, so 2,000 ÷ 40 = **50 µg**.

STEP 2 · COMPARE WITH THE RDA

The RDA for ages 1 to 70 is 15 µg (600 IU). The dose is about 3.3 times the RDA.

STEP 3 · COMPARE WITH THE UL

The adult UL is 100 µg (4,000 IU). The dose is half the UL.

CHECK IT A SECOND WAY

15 × 40 = 600 IU and 100 × 40 = 4,000 IU, so the conversions match the book's paired numbers.

WORKED EXAMPLE 3 · NIACIN EQUIVALENTS

Sofia's day supplies 10 mg of preformed niacin and 600 mg of tryptophan. Find her niacin equivalents and compare with the adult women's RDA.

STEP 1 · CONVERT TRYPTOPHAN

About 60 mg of tryptophan makes 1 mg of niacin, so 600 ÷ 60 = 10 mg NE.

STEP 2 · ADD

10 + 10 = **20 mg NE**.

STEP 3 · COMPARE

The RDA for adult women is 14 mg NE, so she is above it.

WHY NE EXISTS

Tryptophan spares niacin. A diet low in both, such as an untreated maize diet, is the setting where pellagra appeared.

WORKED EXAMPLE 4 · WHOSE VITAMIN C NUMBER?

Find the vitamin C RDA for three adults: a man who does not smoke, a woman who smokes, and a woman who is breastfeeding.

STEP 1 · THE MAN

90 mg/day.

STEP 2 · THE WOMAN WHO SMOKES

75 + 35 = **110 mg/day**, because smoking raises oxidative turnover.

STEP 3 · THE BREASTFEEDING WOMAN

120 mg/day.

THE LESSON

"The RDA for vitamin C is 90 mg" is only true for adult men. Always name the group.

TRAPS PEOPLE FALL INTO

- **Saying "you just pee out the extra."** B6 above 100 mg can cause neuropathy, and niacin and folic acid have ULs too.

- **Counting beta-carotene toward the vitamin A UL.** The UL is for preformed vitamin A. Food carotenoids only tint the skin.
- **Mixing IU and micrograms.** 1 µg of vitamin D is 40 IU. Write the unit every time.
- **Blaming sunlight for vitamin D toxicity.** Skin synthesis limits itself. Toxicity comes from supplements.
- **Treating folic acid as the fix for every large-cell anemia.** It can hide B12 deficiency while nerve damage continues.
- **Thinking vegans can get B12 from unfortified plants.** B12 is natural only in animal foods; fortified foods or supplements are needed.
- **Assuming fresh beats frozen.** Frozen produce often holds as much or more vitamin C.
- **Assuming supplements are pre-approved.** In the US they are not reviewed for safety or effect before sale.

Chapter 6 self-test · ten items

1. Which feature puts vitamins at higher toxicity risk when they are fat-soluble?

A. They are stored in liver and fat tissue
B. They leach out into the cooking water
C. They need intrinsic factor to absorb
D. They are destroyed quickly by cooking

A. They are stored in liver and fat tissue Fat-soluble vitamins accumulate because they are stored and poorly excreted.

2. A meal supplies 3,600 µg of dietary beta-carotene. How many µg RAE is that?

A. 3,600 µg RAE
B. 300 µg RAE
C. 150 µg RAE
D. 600 µg RAE

B. 300 µg RAE 1 µg RAE = 12 µg dietary beta-carotene, so 3,600 ÷ 12 = 300.

3. Which organ makes calcitriol, the active form of vitamin D?

A. The skin
B. The liver
C. The kidney
D. The pancreas

C. The kidney The liver makes 25-hydroxyvitamin D, and the kidney adds the second hydroxyl to make calcitriol.

4. Why do newborns get a dose of vitamin K at birth?

A. They cannot absorb any fat during the first months
B. Their livers store too much vitamin K before birth
C. Breast milk is too rich in vitamin K to be safe for them
D. Little crosses the placenta and their gut is not yet colonized

D. Little crosses the placenta and their gut is not yet colonized Placental transfer is limited, human milk is low in vitamin K, and the newborn gut lacks bacteria, so a dose prevents bleeding.

5. A man with long-term heavy alcohol use develops confusion, unsteady gait and abnormal eye movements. Which vitamin is most likely low?

A. Riboflavin
B. Niacin
C. Thiamin
D. Biotin

C. Thiamin This is Wernicke encephalopathy, from thiamin deficiency, which can progress to Korsakoff syndrome.

6. Dermatitis, diarrhea and dementia point to a deficiency of which vitamin?

A. Biotin (vitamin B7)
B. Niacin (vitamin B3)
C. Folate (vitamin B9)
D. Thiamin (vitamin B1)

B. Niacin (vitamin B3) These are the "Ds" of pellagra. Death is the fourth if it is untreated.

7. Which statement about vitamin B12 is correct?

A. It needs intrinsic factor and is absorbed in the ileum
B. It is plentiful in unfortified leafy green plants
C. It is absorbed mostly in the stomach with acid
D. It is stored only briefly, so deficiency comes fast

A. It needs intrinsic factor and is absorbed in the ileum Acid and pepsin free it, intrinsic factor binds it, and the terminal ileum absorbs it. Liver stores last years.

8. Why does scurvy cause bleeding gums and poor wound healing?

A. Red blood cells cannot make enough hemoglobin
B. Bone cannot absorb calcium without the vitamin
C. Clotting factors cannot be carboxylated at all
D. Collagen cannot be hydroxylated and cross-linked

D. Collagen cannot be hydroxylated and cross-linked Vitamin C keeps the hydroxylase enzymes working. Without it, collagen is weak.

9. Which cooking method loses the most vitamin C from broccoli?

A. Boiling in lots of water, then draining
B. Steaming over a small amount of water
C. Microwaving with a splash of water
D. Stir-frying briefly in a little oil

A. Boiling in lots of water, then draining Vitamin C is water-soluble and heat-labile. Boiling and pouring away the water throws out what leached.

10. Which supplement use does the chapter rate as strongly supported?

A. Daily multivitamins to prevent cancer
B. High-dose vitamin E for heart health
C. Folic acid before and in early pregnancy
D. Beta-carotene for people who smoke

C. Folic acid before and in early pregnancy Periconceptional folic acid cuts neural tube defects. The other three showed no benefit or, for beta-carotene, harm.

ONE PAGE

Cram sheet

Everything from chapters 5 and 6 in one place. Cover the right column and see if you can rebuild each row.

Protein numbers

Item	Value	Note
RDA	0.8 g/kg (19+); 1.1 g/kg pregnancy and lactation	EAR 0.66 g/kg
AMDR	10 to 35% adults; 10 to 30% ages 4 to 18; 5 to 20% ages 1 to 3	No UL
Nitrogen	Protein = N × 6.25	Protein about 16% N
Expert guidance	1.2 to 2.0 g/kg athletes; 1.0 to 1.2 g/kg over 65	Not DRIs
Limiting amino acids	Grains low in lysine; legumes low in methionine	Complements work across the day

Vitamin numbers (adults, per day)

Vitamin	RDA or AI	UL
A	900 µg RAE men; 700 women; 770 pregnancy; 1,300 lactation	3,000 µg preformed
D	15 µg (600 IU) ages 1 to 70; 20 µg (800 IU) over 70	100 µg (4,000 IU)
E	15 mg; 19 mg lactation	1,000 mg supplemental
K	AI 120 µg men; 90 µg women	None set
Thiamin	1.2 mg men; 1.1 mg women; 1.4 mg pregnancy	None
Niacin	16 mg NE men; 14 mg NE women	35 mg supplemental
B6	1.3 mg (19 to 50); 1.7 men, 1.5 women (51+)	100 mg
Folate	400 µg DFE; 600 pregnancy; 500 lactation	1,000 µg folic acid
B12	2.4 µg; 2.6 pregnancy; 2.8 lactation	None
C	90 mg men; 75 women; 85 pregnancy; 120 lactation; +35 smoking	2,000 mg
Choline	AI 550 mg men; 425 mg women	Classed separately

Conversions and rules

Topic	The rule
RAE	1 µg RAE = 1 µg retinol = 12 µg dietary beta-carotene = 24 µg other carotenoids.
Vitamin D units	1 µg = 40 IU.
Niacin equivalents	60 mg tryptophan = 1 mg NE.
Structure	Primary = sequence; secondary = helix and sheet; tertiary = fold; quaternary = subunits.
Denaturation	Breaks the fold, keeps peptide bonds.
Protein digestion	Acid and pepsin; then trypsin (from enteropeptidase), chymotrypsin, elastase, carboxypeptidase; then brush border peptidases.
Deficiency pairs	Thiamin: beriberi. Niacin: pellagra. C: scurvy. D: rickets, osteomalacia. A: xerophthalmia. Folate and B12: megaloblastic anemia.
Cooking	Steam, microwave, keep the liquid. Avoid baking soda with vegetables.

Dr. Garg Learning · CC BY-SA 4.0