Nutrition

Health Science 2310
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Chapter 4: Carbohydrates

Carbohydrates

important energy source, especially for nerve cells

One of the 3 macronutrients

Composed of the atoms carbon, hydrogen, oxygen

Good sources include fruits, vegetables, and grains

Glucose = Carbs

The most abundant carbohydrate
Produced by plants through photosynthesis
Found in plants as a component of disaccharides and complex carbohydrates
Principal form of carbohydrate found in blood

What Are Carbohydrates?

Simple carbohydrates contain 1 or 2 molecules

Monosaccharides contain only 1 molecule

Glucose, fructose, galactose, and ribose

mono = (GFGR)

Disaccharides contain 2 molecules

Lactose, maltose, sucrose

disacch = (LMS)

Monosaccharides

Glucose

Most abundant sugar molecule in our diet; good energy source

Fructose

Sweetest natural sugar; found in fruit, high-fructose corn syrup

Galactose

Does not occur alone in foods; binds with glucose to form lactose

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Disaccharides

Complex carbohydrates

Figure 4.4 Polysaccharides include starch, glycogen, and fibre.

Starch
Storage form of glucose in plants; found in grains, legumes, and tubers

Glycogen
Storage form of glucose in animals; stored in liver and muscles

Fibre
Forms the support structures of leaves, stems, and plants

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Complex Carbohydrates

Plants store glucose starch as polysaccharides

we cannot use
complex polysaccharides
but digest it as glucose

Grains, legumes, and tubers are good sources of dietary starch

Energy

Fuel daily activity + exercise = carbohydrates and fats

Each gram of carbohydrate = 17 kJ/ 4 kcal

Red blood cells need glucose for their energy

Sufficient energy from carbohydrates *prevents* ketones production

Excessive alt energy ketones = high blood acidity damages body tissues

intense exercise, carbohydrate will supply 2/3 or more of the total energy needed

Sources high in fibre reduce risk for obesity, heart disease, and diabetes

Complex Carbohydrates

Glycogen

Animals glucose = glycogen

Stored in the liver and muscles

Not found in food

Not a source of dietary carbohydrate

Figure 4.7 How fibre might help decrease blood cholesterol levels. **(a)** When eating a high-fibre diet, fibre binds to the bile that is produced from cholesterol, resulting in relatively more cholesterol being excreted in the feces. **(b)** When a lower-fibre diet is consumed, less fibre (and thus less cholesterol) is bound to bile and excreted in the feces.

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Fibre

Dietary fibre: the non-digestible part of plants Grains, rice, seeds, legumes, fruits

Functional fibre: carbohydrate w/ health effects, added to foods

Cellulose, guar gum, pectin, psyllium

Total fibre = dietary + functional fibre

(solubility: digested by bacteria in the colon)

Found in citrus fruits, berries, oats, and beans

Reduces risk for CVD & diabetes by lowering blood cholesterol and glucose levels

Insoluble fibres

do not dissolve in water

Found in whole grains (e.g., wheat, rye, brown rice), grain husks, vegetables

Promote regular bowel movements and reduce risk for diverticulosis,

The **AI of Fibre** = 14 grams per 1,000 kcal (25g women; 38g men)

Why Do We Need Carbohydrates? Fibre

May reduce the risk of colon cancer, heart disease

Can enhance weight loss

prevents hemorrhoids, constipation, and diverticulosis

May lower the risk for type 2 diabetes

Digestion of Carbohydrates

Most chemical digestion of carbohydrates occurs in the small intestine

Pancreatic amylase

Enzyme secreted into the small intestine (mucosal cells) digests starch (carbs) into maltose (disacch) then converts it to glucose monosaccharides and then enter the bloodstream provide immediate energy

Excess glucose is converted to glycogen and stored in the liver and muscles

Digestion of Carbohydrates

Fibre passes through small intestine undigested and enters the colon
Remaining fibre adds bulk to stools and is excreted

Figure 4.8 A review of carbohydrate digestion and absorption.

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Storage of Glycogen

Regulation of Blood Glucose: Insulin

Insulin hormone secreted by the pancreas

Helps transport glucose from the blood into cells
liver and muscles to take up glucose and convert it to glycogen

Glucagon secreted by the pancreas. Stimulates the breakdown of glycogen to glucose to make glucose available to cells of the body
Stimulates gluconeogenesis—the production of “new” glucose from amino acids

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Regulation of Blood Glucose: Glucagon

Regulation of Blood Glucose

Glycemic index

A measure of a food's ability to raise blood glucose levels

Foods with a low glycemic index = mild fluctuations in blood glucose level

Are better for people with diabetes

Are generally higher in fibre

May reduce the risk of heart disease, colon cancer, and prostate cancer

How Much Carbohydrate?

RDA is 130 g/day just to supply the brain with glucose

45–65% of daily calories intake should be in the form of carbohydrates

Focus on foods high in fibre and low in added sugars

Adult Canadians: 50% of energy from carbs – 21% is from added sugar

Sugars added to foods = soft drinks, cookies, candy, fruit drinks
Unexpected sources include peanut butter, flavoured rice mixes, canned soups
Added sugars are the same as natural sugars, but have fewer vitamins, minerals and fibre

PROBLEMS

Problems associated with eating too much sugar

Can cause dental problems and tooth decay
No association with childhood hyperactivity proven; long-term effects not known
Associated with increased levels of “bad cholesterol”
Associated with decreased levels of “good cholesterol”
Does not cause diabetes but may contribute to obesity
Most North Americans eat far too little fibre-rich carbohydrate

Alternative Sweeteners

sweeteners: Sucrose, fructose, honey, brown sugar

17 kJ/ 4 kcal energy per gram

Sugar alcohols = 2–3 kcal energy per gram

Have decreased glycemic response and increase risk for tooth caries

Non-nutritive (alternative) sweeteners = little or no energy

Developed to sweeten foods without usual risks

No ADI has been set for saccharin (e.g., “Sweet ‘N Low”), but Health Canada is considering its use as a sweetener in certain foods (2010). ADIs have been established for

aspartame (e.g., “Equal”) acesulfame-K (e.g., “Sweet One,” “Sunette”) sucralose (e.g., “Splenda”)

Alternative Sweeteners

Stevia

Plant-based sweetener

Leaves and compounds from leaves can be used to sweeten food

Stevia and extracts have been approved by Health Canada for use in Natural Health Products as both a medicinal and non-medicinal ingredient (2010)

In Depth: Diabetes

Diabetes

Inability to regulate blood glucose levels

3 types:

Type 1 diabetes

Type 2 diabetes

Gestational diabetes

Uncontrolled diabetes can cause infections, nerve damage, kidney damage, blindness, seizures, stroke, cardiovascular disease, and can be fatal

TABLE 1 Symptoms of Type 1 and Type 2 Diabetes

Type 1 Diabetes	Type 2 Diabetes*
Frequent urination	Any of the type 1 symptoms
Unusual thirst	Frequent infections
Extreme hunger	Blurred vision
Unusual weight loss	Cuts/bruises that are slow to heal
Extreme fatigue	Tingling/numbness in the hands or feet
Irritability	Recurring skin, gum, or bladder infections

Source: Adapted from the American Diabetes Association, Diabetes Basics. Symptoms. www.diabetes.org/diabetes-basics/symptoms/.

*Some people with type 2 diabetes experience no symptoms.

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DIABETES

Type 1 diabetes = 10% of all cases

Body does not produce enough insulin

Creates high blood sugar (glucose) levels, and key sign: frequent urination

May lead to ketoacidosis, coma, death

May be an autoimmune disease Most frequently diagnosed in adolescents, and has a genetic link

Type 2 diabetes

Develops progressively over time

Body cells become insensitive or unresponsive to insulin

Obesity is most common trigger

Variations include insulin resistance, impaired fasting glucose, and pre-diabetes

Eventually the pancreas may become unable to produce any insulin

Who is at risk?

Obesity, genetics, physical inactivity, and poor diet increase overall risk

Metabolic syndrome (high waist circumference, high blood pressure, high blood lipids and glucose) increases risk for type 2 diabetes

Increased age increases risks, but younger people and even children are now commonly diagnosed

Prevention and control

Eat a healthful diet, get daily exercise, keep a healthful body weight

Eating slightly fewer carbohydrates and slightly more protein and fat may help regulate blood glucose levels; consult a dietitian

Prevention and control

Avoid alcoholic beverages, which can cause hypoglycemia

Healthful lifestyle choices can prevent or delay onset of type 2 diabetes

Oral medications and/or insulin injections may be required once diabetes has been diagnosed

Chapter 5: Fats

What Are Fats?

Fats are one type of lipid that do not dissolve in water

3 types of lipids are found in foods

Triglycerides

Phospholipids

Sterols

Fatty Acids

Triglycerides = 3 fatty acids (chains of carbon atoms surrounded by hydrogen atoms)

Glycerol: a 1-carbon alcohol that is the backbone of a triglyceride

Level of **Saturation** = how many hydrogen atoms surround each carbon *-defines shape of fat*

Saturated fatty acids no double bonds, **solid** at room temperature

coconut oil, animal fats, butter, and lard are high in saturated fatty acids

Monounsaturated lack hydrogen atoms in **one region**; **one** double bond

Unsaturated fatty acids do not stack together well, liquid at room temp.

Polyunsaturated lack hydrogen atoms in **multiple locations**; 2+ dbl. bonds

TRANS FAT *Some naturally found in cow's milk, beef and lamb*

Saturated and trans fats lower "good" cholesterol and raise the "bad" cholesterol

Note: Each double bond causes the loss of two hydrogen atoms

Triglycerides

Fatty acids can differ in length of their carbon chain Short (<6), medium (6–12), or long (>14)

Level of **Saturation** = how many hydrogen atoms surround each carbon

Figure 5.1 **(a)** A triglyceride consists of three fatty acids attached to a three-carbon glycerol backbone. **(b)** Structure of glycerol. **(c)** Structure of a fatty acid showing the carboxyl carbon (α) and the methyl carbon (ω) ends.

Source: (Thompson, Janice; Manore, Melinda; Vaughan, Linda, The Science of Nutrition, 2nd Ed., ©2011. Reprinted and Electronically reproduced by permission of Pearson Education, Inc., Upper Saddle River, New Jersey.)

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Fatty Acids

TEST Q

(a) Saturated fatty acid

(b) Unsaturated fatty acid

Figure 5.2 An atom of carbon has four attachment sites. In fatty acid chains, two of these sites are filled by adjacent carbon atoms. **(a)** In saturated fatty acids, the other two sites are always filled by two hydrogen atoms. **(b)** In unsaturated fatty acids, at one or more points along the chain, a double bond to an adjacent carbon atom takes up one of the attachment sites that would otherwise be filled by hydrogen.

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Triglycerides

Unsaturated fatty acids = plants

2 exceptions are coconut and palm kernel oil

The hydrogen atoms at the unsaturated region can be arranged in different positions

Cis: same side of the carbon chain Trans: opposite sides of the chain

Triglycerides

Hydrogenation: the *addition* of hydrogen atoms to unsaturated fatty acids
Converts liquid fats (oils) into a semisolid or solid form

Used to create margarine from plant oil which creates trans fatty acids
food label as partially **hydrogenated oil**

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Phospholipids

Phospholipids have Glycerol

2 fatty acids
Phosphate Soluble in water
not required in our diet, we make it

Important components of cell membranes

Sterols

Sterols: lipids containing multiple rings of carbon atoms

Essential components of cell membranes and many hormones

Cholesterol is the major sterol found in the body

(a) Sterol ring structure

(b) Cholesterol

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Major Sources of Dietary Fat

Figure 5.4 Major sources of dietary fat.

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How Does Our Body Break Down Fats?

Digestion of lipids begins in the small intestine
Lipids not digested or absorbed easily because they are insoluble in water

As fat enters the small intestine:
Bile is produced by the liver and stored in the gall bladder
gall bladder secretes Bile into the small intestine which disperses fat into smaller fat droplets

Pancreatic enzymes break triglycerides into 2 separate fatty acids and a monoglyceride

Fat enters the mucosal cell as a micelle (fatty acids, monoglycerides, phospholipids, and sterols)

Digestion of Fats

Digestion of Fats

In the intestinal mucosal cell:
Fatty acids are reattached to the monoglyceride to re-form triglycerides
A small amount of protein is added to the lipids, forming a chylomicron

Chylomicron: a lipoprotein produced by cells lining the small intestine
Composed of triglycerides surrounded by phospholipids and proteins
Soluble in water

Figure 5.9 Lipid digestion and absorption. **(a)** in the presence of enzymes, triglycerides are broken down into fatty acids and monoglycerides. **(b)** These products, along with free cholesterol and other products, are trapped in the micelle, a spherical compound made up of bile salts and phospholipids. The micelle then transports these lipid digestion products to the intestinal mucosal cell, and these products are then absorbed into the cell.

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Structure of a Lipoprotein

Chylomicrons are the transport vehicles that remove absorbed fats from the small intestine
Travel through the lymphatic system
Are transferred to the bloodstream

Short- and medium-chain fatty acids are absorbed more quickly because they are not arranged into chylomicrons

Digestion of Fats

Once the chylomicron gets to a cell in the body, the triglycerides in the chylomicrons must be disassembled by lipoprotein lipase into 2 fatty acids and a monoglyceride before they can pass through the cell membrane
After entering the cell, the 2 fatty acids and monoglyceride re-form a triglyceride
The triglyceride can be
Used immediately for energy
Used to make lipid-containing compounds
Stored in liver and muscle cells

Energy

Fat is very energy dense, 37 kJ/(9 kcal)/gram
Much of the energy used during rest comes from fat
Fat is used for energy during exercise, especially after glycogen is depleted
Fat is also used for energy storage

The Role of Fat

Vitamins A, D, E, and K are soluble in fat which is required for their transport

Fat is essential to many body functions
Cell membrane structure
Nerve cell transmissions
Protection of internal organs
Insulation to retain body heat

Fat provides flavour and texture to foods

Fat contributes to making us feel satiated because
Fats are more energy dense than carbohydrates or protein
Fats take longer to digest

Fats Contain Essential Fatty Acids

Essential fatty acids must be obtained in the diet

Linoleic and alpha-linolenic acid are essential

Linoleic acid (Omega-6 fatty acid): vegetable and nut oils

Converted by the body to arachidonic acid for blood clotting and blood pressure

Alpha-linolenic acid (Omega-3 fatty acid)

dark green leafy vegetables, fish and fish oils, and flax and flaxseed oil
Converted to EPA and DHA regulators of inflammation, blood clotting, and blood pressure

Fats Contain Essential Fatty Acids

Figure 5.14 The two essential fatty acids: linoleic acid, an omega-6 fatty acid with 18 carbons and two double bonds, C18:2n-6, and alpha-linolenic acid, an omega-3 fatty acid with 18 carbons and three double bonds, C18:3n-3.

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Select Beneficial Fats

DRI for Linoleic Acid

AI: 14 – 17 g/day for adult men
11 – 12 g/day for adult women

DRI: Alpha-Linoleic Acid

AI: 1.6 g/day for adult men
1.1 g/day for adult women

Cardiovascular disease
Dysfunction of the heart or blood vessels
Can result in heart attack or stroke

TABLE 5.2 Omega-3 Fatty Acid Content of Selected Foods

Food Item	Total Omega-3	DHA	EPA*
	g/serving		
Flaxseed oil, 15 mL (1 Tbsp)	7.25	0.00	0.00
Salmon oil (fish oil), 15 mL (1 Tbsp)	4.39	2.48	1.77
Sardine oil, 15 mL (1 Tbsp)	3.01	1.45	1.38
Flaxseed, whole, 15 mL (1 Tbsp)	2.50	0.00	0.00
Herring, Atlantic, broiled, 90 g (3 oz.)	1.83	0.94	0.77
Anchovies w/oil, each	1.76	0.65	1.10
Herring oil, 15 mL (1 Tbsp)	1.53	0.57	0.85
Salmon, Coho, steamed, 90 g (3 oz.)	1.34	0.71	0.46
Canola oil, 15 mL (1 Tbsp)	1.28	0.00	0.00
Sardines, Atlantic, w/ bones and oil, 90 g (3 oz.)	1.26	0.43	0.40
Trout, rainbow fillet, baked, 90 g (3 oz.)	1.05	0.70	0.28
Walnuts, English, 15 mL (1 Tbsp)	0.66	0.00	0.00
Halibut, fillet, baked, 90 g (3 oz.)	0.53	0.31	0.21
Shrimp, canned, 90 g (3 oz.)	0.47	0.21	0.25
Tuna, white, in oil, 90 g (3 oz.)	0.38	0.19	0.04
Crab, Alaska King, steamed, 90 g (3 oz.)	0.36	0.10	0.25
Scallops, broiled, 90 g (3 oz.)	0.31	0.14	0.17
Tuna, light, in water, 90 g (3 oz.)	0.23	0.19	0.04
Avocado, Calif., fresh, whole	0.22	0.00	0.00
Spinach, cooked, 250 mL (1 cup)	0.17	0.00	0.00

Note: *EPA = eicosapentaenoic acid; DHA = docosahexaenoic acid.
Data from Food Processor SQL, Version 10.3, ESHA Research, Salem, OR.

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Functions of Various Blood Lipoproteins

TABLE 1 Descriptions and Functions of the Various Blood Lipoproteins

Lipoprotein	Description	Primary Function
Chylomicrons	Formed in the gut after a meal, these lipoproteins are released into the lymph system and then into the blood Largest of the lipoproteins, with the lowest density After triglycerides are removed from this lipoprotein, a chylomicron remnant remains and is taken up by the liver	Transports dietary fat into the blood and transports it to the tissues of the body
Very low-density lipoproteins (VLDLs)	Formed in the liver (80% of production) and the intestine (20% of production)	Transports endogenous lipids, especially triglycerides, to the various tissues of the body
Low-density lipoproteins (LDLs)	Formed in the blood from VLDL Transformation from VLDL to LDL occurs as the triglycerides are removed from the VLDL	Transports cholesterol to the cells of the body
High-density lipoproteins (HDLs)	Synthesized in the liver and released into the blood Move in the blood through the body, picking up free cholesterol	Transports cholesterol from tissues back to the liver

Source: Based on information from Heart and Stroke Foundation of Canada, Living with Cholesterol: Cholesterol and Healthy Living; p. 183: Based on Heart and Stroke Foundation of Canada, Cholesterol Article Updates, Nov. 7, 2005. www. heartandstroke.ca.

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The intake of certain types of fats can protect against heart disease

Diets high in omega-3 fatty acids (along with moderate exercise) can reduce inflammation and increase HDL ("good") cholesterol levels

Low-density lipoproteins (LDLs) are often called "bad" cholesterol because of their role in transporting cholesterol throughout the body

How Much Fat Should We Eat?

AMDR for fat 20%–35% of calories should be from fat

Athletes and highly active people may need more energy from carbohydrates and can reduce their fat intake to 20%–25% of total calories

Current Advice: Limit Saturated Fatty Acids and Trans Fats

New research suggests natural trans fats may actually protect against CVD
Not all saturated fatty acids behave in the same way
Now there is strong evidence that saturated fats have NO significant relationship to CVD (2010)

Role of Saturated Fat in Cardiovascular Disease?

The effect of lowering saturated fatty acid intakes may depend upon what replaces the saturated fat

The relationship between saturated fatty acids and CVD varies, depending upon how CVD is measured

What Does This Mean?

Advice to eat less saturated fatty acid to lower the risk of CVD may be too simplistic

More research is needed to understand what happens when saturated fatty acids are replaced with monounsaturated fatty acids, polyunsaturated fatty acids, and carbohydrates

Avoid Industrial Trans Fatty Acids

Many health professionals feel diets high in trans fatty acids increase the risk of heart disease even more than diets high in saturated fat (2009)

Health Canada requires food manufacturers to list the amount of trans fatty acids/serving on the Nutrition Facts table

Globally, legislators and food policy experts are lobbying for the labelling of trans fatty acids on menus and/or the elimination of industrial trans fatty acids from restaurants and other ready-to-eat foods

Recognize the Fat in Foods

- Visible fats are those we can see in foods or can easily see have been added to foods, such as dressing, chicken skin, and so on

- Hidden fats are those added to processed or prepared foods to improve texture or taste, which we may not be aware of, or that occur naturally

Select Beneficial Fats

Switch to healthful fats without increasing total fat intake

Increase intake of omega-3 fatty acids (see Table 5.2, next slide)

Healthful fats include essential fatty acids, but also polyunsaturated and monounsaturated fats in general

In Depth: Cardiovascular Disease

The 3 most common forms
Coronary heart disease
Stroke
Hypertension

Atherosclerosis is a disease in which artery walls build up lipid deposits and scar tissue, impairing blood flow
The stiffness that results is commonly called “hardening of the arteries”
The result is that the heart must work harder to push blood through the vessels

Modifiable risk factors for cardiovascular disease include
Being overweight
Physical inactivity
Smoking
Diabetes
Inflammation
Abnormal blood lipids

Approximately 1 in 5 Canadian adults have hypertension

Lifestyle changes to help prevent or Control cardiovascular disease

- Don’t smoke
- Have a healthy diet
- Achieve and maintain a healthy body weight
- Participate in regular physical activity

Prescription medications can improve
blood lipids and blood pressure

- for some individuals, lifestyle changes are not enough to control lipids
- a variety of medications can be prescribed
- however, individuals taking such medications should also continue to practice healthy lifestyle changes

Chapter 6: Proteins

What Are Proteins?

Proteins: large complex molecules composed of amino acids

Contain: Carbon, Hydrogen, Oxygen and Nitrogen

Primary source of nitrogen in the diet

20 different amino acids are used to make proteins

Amino Acids

Essential amino acids
Cannot be produced by our bodies
Must be obtained from food
9 of 20 are essential

Nonessential amino acids
Can be made by our bodies
Made by transferring amino groups (transamination)

TABLE 6.1 Amino Acids of the Human Body

Essential Amino Acids	Nonessential Amino Acids
These amino acids must be consumed in the diet.	*These amino acids can be manufactured by the body.*
Histidine	Alanine
Isoleucine	Arginine
Leucine	Asparagine
Lysine	Aspartic acid
Methionine	Cysteine
Phenylalanine	Glutamic acid
Threonine	Glutamine
Tryptophan	Glycine
Valine	Proline
	Serine
	Tyrosine

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Structure of an Amino Acid

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How Are Proteins Made?

Transcription: use of the genetic information in DNA to make RNA. mRNA copies the genetic information and carries it to the ribosome

Translation: conversion of genetic information in RNA to assemble amino acids in the proper sequence to synthesize a protein on the ribosome

How Are Proteins Made?

Figure 6.3 Amino acid bonding. Two amino acids join together to form a dipeptide. By combining multiple amino acids, proteins are made.

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Protein Turnover: Synthesis and Breakdown

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Gene Expression

1 Part of the DNA unwinds, and a section of its genetic code is transcribed to the mRNA inside the nucleus.

2 The mRNA leaves the nucleus via a nuclear pore and travels to the cytoplasm.

3 Once the mRNA reaches the cytoplasm, it binds to a ribosome. The code on the mRNA is translated into the instructions for a specific order of amino acids.

4 Amino acids are added to the growing amino acid chain, and eventually a complete protein is produced.

5 Once the synthesis of the new protein is complete, the protein is released from the ribosome. The protein may go through further modifications in the cell, or can be functional in its current state.

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Protein Organization Determines Function

Protein structure has 4 levels

Primary structure: Sequential order of amino acids

Secondary structure:

- Spiral shape due to chemical bonding between the amino acids

Tertiary and quaternary structure

- Further folding into a unique 3-D shape that may be globular or fibrous

Levels of Protein Structure

Protein Shape Determines Function

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Protein Function

Proteins lose shape (denaturation) when subjected to

Heat
Acids and bases
Heavy metals
Alcohol
Other damaging substances

Denaturation results in an irreversible loss in protein function

examples are cooking

Proteins in the Diet

Incomplete protein: *insufficient essential amino acids quantities*
Growth and health are compromised
Considered a “low-quality” protein

Complete protein: sufficient amounts of all 9 essential amino acids
Considered a “high-quality” protein

Mutual supplementation: combining 2 incomplete proteins to make a complete protein

Complementary proteins: 2 protein sources that together supply all 9 essential amino acids Example: beans and rice

Food Combinations

Food with limiting amino acid	+	Foods high in limiting amino acid	→	Complementary food combination
Legumes: limited in methionine and cysteine	+	Grains Nuts and Seeds	→	· Red beans and rice · Rice and lentils · Rice and black-eyed peas · Hummus (garbanzo beans and sesame seeds)
Grains: limited in lysine	+	Legumes	→	· Peanut butter and bread · Barley and lentil soup · Corn tortilla and beans
Vegetables: limited in lysine, methionine, and cysteine	+	Legumes (lysine) Grains (methionine and cysteine) Nuts and Seeds (methionine and cysteine)	→	· Tofu and broccoli with almonds · Spinach salad with pine nuts and kidney beans
Nuts and Seeds: limited in lysine and isoleucine	+	Legumes	→	· Lentil soup with slivered almonds · Sesame seeds with mixed bean salad

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Why Do We Need Proteins?

Cell growth, repair, and maintenance Enzymes
Hormones Fluid and electrolyte balance pH balance
Antibodies to protect against disease Energy source

Digestion of Proteins:

- Digestion of proteins begins in the stomach
- Hydrochloric acid breaks down protein structure (denatures)
- Hydrochloric acid activates pepsin
- Pepsin: an enzyme that breaks down proteins into short polypeptides and amino acids

How Do We Break Down Proteins?

Digestion of proteins continues in the small intestine

Pancreatic enzymes called proteases complete the digestion of proteins into single amino acids

Indigestible proteins are of lower quality for nutrition

Protein Quality

The quantity of essential amino acids in a protein determines its quality

Protein digestibility

- Animal protein sources (meat, dairy),
- soy products + legumes 70% are highly digestible
- Grains and vegetable proteins are less digestible

How Much Protein Should We Eat?

People who require more protein include
Children
Adolescents
Pregnant or lactating women
Athletes and active people
Vegetarians

Recommended Dietary Allowance (RDA)

0.8 grams of protein per kilogram of body weight/day
10–35% of total energy intake should be from protein

CCHS 2007 results show that the average protein intake among adults is 16.8% of energy

Nitrogen Balance

Nitrogen balance describes the relationship between how much nitrogen (or protein) we consume and excrete each day

How Much Protein Should We Eat?

TABLE 6.2 Recommended Protein Intakes

Group	Protein Intake (grams per kilogram* body weight per day)
Most adults†	0.8
Nonvegetarian endurance athletes‡	1.2 to 1.4
Nonvegetarian strength athletes‡	1.2 to 1.7
Vegetarian endurance athletes‡	1.3 to 1.5
Vegetarian strength athletes‡	1.3 to 1.8

*To convert body weight to kilograms, divide weight in pounds by 2.2.
Weight (lb)/2.2 = Weight (kg)
Weight (kg) × protein recommendation (g/kg body weight/day) = protein intake (g/day)
†Food and Nutrition Board, Institute of Medicine. 2002. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients)*, pp. 465–608. Washington, DC: National Academies Press.
‡American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada. 2009. Joint Position Statement. Nutrition and athletic performance. *Med. Sci. Sports Exerc.* 41(3):709–731.

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Most Canadians meet or exceed the RDA for dietary protein

Many foods besides meat can be good protein sources, including dairy products, legumes, eggs, nuts, and whole grains

“New” food sources of protein include quorn, quinoa, and amaranth

Protein Content of Common Foods

TABLE 6.3 Protein Content of Commonly Consumed Foods

Food	Serving Size	Protein (g)
Beef:		
Ground, lean, baked (15% fat)	3 oz	22
Prime rib, broiled (1/8-in. fat)	3 oz	18
Top sirloin, broiled (1/8-in. fat)	3 oz	23
Poultry:		
Chicken breast, broiled, no skin (bone removed)	1/2 breast	29
Chicken thigh, bone and skin removed	1 thigh	13.5
Turkey breast, roasted, Louis Rich	3 oz	15
Seafood:		
Cod, cooked	3 oz	19
Salmon, Chinook, baked	3 oz	22
Shrimp, steamed	3 oz	18
Tuna, in water, drained	3 oz	22
Pork:		
Pork loin chop, broiled	3 oz	25
Ham, roasted, lean	3 oz	20
Dairy:		
Whole milk (3.3% fat)	8 fl. oz	7.9
1% milk	8 fl. oz	8.5
Skim milk	8 fl. oz	8.8
Low-fat, plain yogurt	8 fl. oz	13
American cheese, processed	1 oz	6
Cottage cheese, low-fat (2%)	1 cup	27
Soy Products:		
Tofu	3.3 oz	7
Tempeh, cooked	3.3 oz	18
Soy milk beverage	1 cup	7
Beans:		
Refried	1/2 cup	7
Kidney, red	1/2 cup	7.7
Black	1/2 cup	7
Nuts:		
Peanuts, dry roasted	1 oz	6.7
Peanut butter, creamy	2 tbsp.	8
Almonds, blanched	1 oz	6
Cereals, Grains, and Breads:		
Oatmeal, quick instant	1 cup	5.4
Cheerios	1 cup	3
Grape-Nuts	1/2 cup	6
Raisin Bran	1 cup	5
Brown rice, cooked	1 cup	5
Whole-wheat bread	1 slice	2.7
Bagel, 3 1/2 -in.-diameter	1 each	7
Vegetables:		
Carrots, raw (7.5 × 1 1/8 in.)	1 each	0.7
Broccoli, raw, chopped	1 cup	2.6
Collards, cooked from frozen	1 cup	5
Spinach, raw	1 cup	0.9

Source: Values obtained from U.S. Department of Agriculture, Agricultural Research Service. 2009. USDA National Nutrient Database for Standard Reference, Release 22. Nutrient Data Laboratory Home Page, www.ars.usda.gov/ba/bhnrc/ndl.

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Can Vegetarian Diets Provide Protein?

Vegetarianism: a diet that does not include meat (including poultry) or seafood, or products containing those foods
There are many versions of vegetarianism
There are many reasons to adopt a vegetarian diet
4% of Canadian adults follow vegetarian diets

inactive male 84kg: 2 tbsp peanut butter, 3oz chicken or beef 1 cup milk

Why Vegetarianism?

vegetarianism because of
Religious reasons
Ethical reasons
Concerns over food safety
Ecological reasons
Health benefits

Types of Vegetarian Diets

TABLE 6.4 Terms and Definitions of a Vegetarian Diet

Type of Diet	Foods Consumed	Comments
Semivegetarian (also called partial vegetarian or flexitarian)	Vegetables, grains, nuts, fruits, legumes; sometimes seafood, poultry, eggs, and dairy products	Typically excludes or limit red meat; may also avoid other meats
Pescovegetarian	Similar to semivegetarian but excludes poultry	*Pesco* means "fish," the only animal source of protein in this diet
Lacto-ovo-vegetarian	Vegetables, grains, nuts, fruits, legumes, dairy products (*lacto*) and eggs (*ovo*)	Excludes animal flesh and seafood
Lacto-vegetarian	Similar to lacto-ovo-vegetarian but excludes eggs	Relies on milk and cheese for animal sources of protein
Ovovegetarian	Vegetables, grains, nuts, fruits, legumes, and eggs	Excludes dairy, flesh, and seafood products
Vegan (also called strict vegetarian)	Only plant-based foods (vegetables, grains, nuts, seeds, fruits, legumes)	May not provide adequate vitamin B_{12}, zinc, iron, or calcium
Macrobiotic diet	Vegan-type of diet; becomes progressively more strict until almost all foods are eliminated; at the extreme, only brown rice and small amounts of water or herbal tea are consumed	Taken to the extreme, can cause malnutrition and death
Fruitarian	Only raw or dried fruit, seeds, nuts, honey, and vegetable oil	Very restrictive diet; deficient in protein, calcium, zinc, iron, vitamin B_{12}, riboflavin, and other nutrients

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Health Benefits of Vegetarianism

Lower intake of fat and total energy
Lower blood pressure
Reduce the risk of heart disease
Fewer digestive problems
Reduce the risk of some types of cancer
Reduce the risk for kidney disease, kidney stones and gallstones
Challenges of Vegetarianism

- Vegetarian diets can be low in some vitamins and minerals (iron, calcium, zinc, vitamins D, B2 and B12)
- Vegetarians must plan a balanced and adequate diet
- Soy products are an excellent protein source
- Vegetarians should include complementary proteins
- Vegetarians should use a Vegetarian Food Guide to design the diet

Nutrients of Concern for Vegetarians

TABLE 6.5 Nutrients of Concern in a Vegan Diet

Nutrient	Functions	Non-Meat/Non-Dairy Food Sources
Vitamin B_{12}	Assists with DNA synthesis; protection and growth of nerve fibres	Vitamin B_{12}–fortified cereals, yeast, soy products, and other meat analogs; vitamin B_{12} supplements
Vitamin D	Promotes bone growth	Vitamin D–fortified cereals, margarines, and soy products; adequate exposure to sunlight; supplementation may be necessary for those who do not get adequate exposure to sunlight
Riboflavin (vitamin B_2)	Promotes release of energy; supports normal vision and skin health	Whole and enriched grains, green leafy vegetables, mushrooms, beans, nuts, and seeds
Iron	Assists with oxygen transport; involved in making amino acids and hormones	Whole-grain products, prune juice, dried fruits, beans, nuts, seeds, and leafy vegetables (such as spinach)
Calcium	Maintains bone health; assists with muscle contraction, blood pressure, and nerve transmission	Fortified soy milk and tofu, almonds, dry beans, leafy vegetables, and calcium-fortified juices
Zinc	Assists with DNA and RNA synthesis, immune function, and growth	Whole-grain products, wheat germ, beans, nuts, and seeds

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Can You Eat Too Much Protein?

The risks of too much dietary protein may include >200g per day

High cholesterol and heart disease
Diets high in protein from animal sources are associated with high cholesterol due to high saturated fat content
Possible bone loss
High-protein diets may cause excess calcium excretion, leading to bone loss

The risks of too much protein may include
Kidney disease
High-protein diets are associated with an increased risk of kidney disease, especially for people who may be susceptible to kidney disease
People with diabetes have increased rates of kidney disease

Protein-Energy Malnutrition (PEM)

Protein-energy malnutrition: a disorder caused by inadequate intake of protein and energy

There are 2 common, serious forms

Marasmus disease resulting from grossly inadequate intakes of protein, energy, and other nutrients

Marasmus symptoms include: Severe wasting of muscle tissue

Stunted physical growth Stunted brain development

Anemia Severely weakened immune system

Kwashiorkor

Protein-Energy Malnutrition (PEM)

Kwashiorkor: disease resulting from extremely low protein intake

Kwashiorkor symptoms include
Some weight loss and muscle wasting
Edema resulting in distention of the belly - starving pot-belly
Retarded growth and development

Kwashiorkor is often seen in children in developing countries, but can also be seen in Canada and the US

Protein-Energy Malnutrition (PEM)

PEM can affect children and adults in all countries
In Canada
Those in poverty in inner cities or isolated rural areas
Elderly (living alone)
Homeless
People with eating disorders
Drug or alcohol addiction
People living with AIDS or cancer

VITAMINS & MINERALS

In Depth: Vitamins and Minerals

Macronutrients

Carbohydrates, fats, proteins: these nutrients
Provide energy
Are required in relatively large amounts

Micronutrients

Vitamins and minerals
Do not supply energy
Are required in relatively small amounts
Assist with body functions (e.g., energy metabolism, maintenance of healthy cells and tissues)

Vitamins

Carbon-containing compounds
13 are essential
9 are soluble in water
4 are soluble in fat
Humans synthesize only small amounts of vitamins D and K

Fat-Soluble Vitamins

Characteristics of fat-soluble vitamins (A, D, E, K)

Large storage capability
Toxicity is possible
Deficiency symptoms may take many months to develop
May occur in numerous chemical forms

Fat-Soluble Vitamins

TABLE 1 Fat-Soluble Vitamins

Vitamin Name	Primary Functions	Recommended Intake*	Reliable Food Sources	Toxicity/Deficiency Symptoms
A (retinol, retinal, retinoic acid)	Required for ability of eyes to adjust to changes in light Protects colour vision Assists cell differentiation Required for sperm production in men and fertilization in women Contributes to healthy bone Contributes to healthy immune system	RDA: Men = 900 µg Women = 700 µg UL = 3000 µg/day	Preformed retinol: beef and chicken liver, egg yolks, milk Carotenoid precursors: spinach, carrots, mango, apricots, cantaloupe, pumpkin, yams	*Toxicity:* fatigue; bone and joint pain; spontaneous abortion and birth defects of fetuses in pregnant women; nausea and diarrhea; liver damage; nervous system damage; blurred vision; hair loss; skin disorders *Deficiency:* night blindness, xerophthalmia; impaired growth, immunity, and reproductive function
D (cholecalciferol)	Regulates blood calcium levels Maintains bone health Assists cell differentiation	RDA Adults aged 19 to 70 years = 15 µg /day Adults aged >70 years = 20 µg /day UL = 100 µg/day	Canned salmon and mackerel, milk, fortified cereals	*Toxicity:* hypercalcemia *Deficiency:* rickets in children; osteomalacia and/or osteoporosis in adults
E (tocopherol)	As a powerful antioxidant, protects cell membranes, polyunsaturated fatty acids, and vitamin A from oxidation Protects white blood cells Enhances immune function Improves absorption of vitamin A	RDA: Men = 15 mg/day Women = 15 mg/day UL = 1000 mg/day	Sunflower seeds, almonds, vegetable oils, fortified cereals	*Toxicity:* rare *Deficiency:* hemolytic anemia; impairment of nerve, muscle, and immune function
K (phylloquinone, menaquinone, menadione)	Serves as a coenzyme during production of specific proteins that assist in blood coagulation and bone metabolism	AI: Men = 120 µg/day Women = 90 µg/day	Kale, spinach, turnip greens, Brussels sprouts	*Toxicity:* none known *Deficiency:* impaired blood clotting; possible effect on bone health

*Abbreviations: RDA, Recommended Dietary Allowance; UL, upper limit; AI, Adequate Intake.

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Water-Soluble Vitamins

Characteristics of water-soluble vitamins (B-complex and C)

Minimal storage capability
Toxicity is rare
Deficiency symptoms occur quickly
Excreted in urine when tissues are saturated

Water-Soluble Vitamins

TABLE 2 Water-Soluble Vitamins

Vitamin Name	Primary Functions	Recommended Intake*	Reliable Food Sources	Toxicity/Deficiency Symptoms
Thiamin (vitamin B_1)	Required as enzyme cofactor for carbohydrate and amino acid metabolism	RDA: Men = 1.2 mg/day Women = 1.1 mg/day	Pork, fortified cereals, enriched rice and pasta, peas, tuna, legumes	*Toxicity:* none known *Deficiency:* beriberi; fatigue, apathy, decreased memory, confusion, irritability, muscle weakness
Riboflavin (vitamin B_2)	Required as enzyme cofactor for carbohydrate and fat metabolism	RDA: Men = 1.3 mg/day Women = 1.1 mg/day	Beef liver, shrimp, milk and other dairy foods, fortified cereals, enriched breads and grains	*Toxicity:* none known *Deficiency:* ariboflavinosis; swollen mouth and throat; seborrheic dermatitis; anemia
Niacin, nicotinamide, nicotinic acid	Required for carbohydrate and fat metabolism Plays role in DNA replication and repair and cell differentiation	RDA: Men = 16 mg/day Women = 14 mg/day UL = 35 mg/day	Beef liver, most cuts of meat/fish/poultry, fortified cereals, enriched breads and grains, canned tomato products	*Toxicity:* flushing, liver damage, glucose intolerance, blurred vision differentiation *Deficiency:* pellagra; vomiting, constipation, or diarrhea; apathy
Pyridoxine, pyridoxal, pyridoxamine (vitamin B_6)	Required as enzyme cofactor for carbohydrate and amino acid metabolism Assists synthesis of blood cells	RDA: Men and women aged 19 to 50 = 1.3 mg/day Men aged >50 and over = 1.7 mg/day Women aged >50 and over = 1.5 mg/day UL = 100 mg/day	Chickpeas (garbanzo beans), most cuts of meat/fish/poultry, fortified cereals, white potatoes	*Toxicity:* nerve damage, skin lesions *Deficiency:* anemia; seborrheic dermatitis; depression, confusion, and convulsions
Folate (folic acid)	Required as enzyme cofactor for amino acid metabolism Required for DNA synthesis Involved in metabolism of homocysteine	RDA: Men = 400 μg/day Women = 400 μg/day UL = 1000 μg/day	Fortified cereals, enriched breads and grains, spinach, legumes (lentils, chickpeas, pinto beans), greens (spinach, romaine lettuce), liver	*Toxicity:* masks symptoms of vitamin B12 deficiency, specifically signs of nerve damage *Deficiency:* macrocytic anemia; neural tube defects in a developing fetus; elevated homocysteine levels
Cobalamin (vitamin B_{12})	Assists with formation of blood Required for healthy nervous system function Involved as enzyme cofactor in metabolism of homocysteine	RDA: Men = 2.4 μg/day Women = 2.4 μg/day	Shellfish, all cuts of meat/fish/poultry, milk and other dairy foods, fortified cereals	*Toxicity:* none known *Deficiency:* pernicious anemia; tingling and numbness of extremities; nerve damage; memory loss, disorientation, and dementia
Pantothenic acid	Assists with fat metabolism	AI: Men = 5 mg/day Women = 5 mg/day	Meat/fish/poultry, shiitake mushrooms, fortified cereals, egg yolk	*Toxicity:* none known *Deficiency:* rare
Biotin	Involved as enzyme cofactor in carbohydrate, fat, and protein metabolism	RDA: Men = 30 μg/day Women = 30 μg/day	Nuts, egg yolk	*Toxicity:* none known *Deficiency:* rare
Ascorbic acid (vitamin C)	Antioxidant in extracellular fluid and lungs Regenerates oxidized vitamin E Assists with collagen synthesis Enhances immune function Assists in synthesis of hormones, neurotransmitters, and DNA Enhances iron absorption	RDA: Men = 90 mg/day Women = 75 mg/day Smokers = 35 mg more per day than RDA UL = 2000 mg	Sweet peppers, citrus fruits and juices, broccoli, strawberries, kiwi	*Toxicity:* nausea and diarrhea, nosebleeds, increased oxidative damage, increased formation of kidney stones in people with kidney disease *Deficiency:* scurvy; bone pain and fractures, depression, and anemia

*Abbreviations: RDA, Recommended Dietary Allowance; UL, upper limit; AI, Adequate Intake.

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Minerals

General properties of minerals

Inorganic

Cannot be synthesized by plants or animals
Not digested or broken down prior to absorption
2 classifications based on need
Characteristics of major minerals
Required in amounts of at least 100 mg/day
7 major minerals: sodium potassium phosphorous chloride
calcium magnesium sulphur

Major Minerals

TABLE 3 Major Minerals

Mineral Name	Primary Functions	Recommended Intake*	Reliable Food Sources	Toxicity/Deficiency Symptoms
Sodium	Fluid balance Acid–base balance Transmission of nerve impulses Muscle contraction	AI: Adults = 1.5 g/day (1500 mg/day)	Table salt, pickles, most canned soups, snack foods, cured luncheon meats, canned tomato products	*Toxicity:* water retention, high blood pressure, loss of calcium *Deficiency:* muscle cramps, dizziness, fatigue, nausea, vomiting, mental confusion
Potassium	Fluid balance Transmission of nerve impulses Muscle contraction	AI: Adults = 4.7 g/day (4700 mg/day)	Most fresh fruits and vegetables: potatoes, bananas, tomato juice, orange juice, melons	*Toxicity:* muscle weakness, vomiting, irregular heartbeat *Deficiency:* muscle weakness, paralysis, mental confusion, irregular heartbeat
Phosphorus	Fluid balance Bone formation Component of ATP, which provides energy for our bodies	RDA: Adults = 700 mg/day	Milk/cheese/yogurt, soy milk and tofu, legumes (lentils, black beans), nuts (almonds, peanuts and peanut butter), poultry	*Toxicity:* muscle spasms, convulsions, low blood calcium *Deficiency:* muscle weakness, muscle damage, bone pain, dizziness
Chloride	Fluid balance Transmission of nerve impulses Component of stomach acid (HCl) Antibacterial	AI: Adults = 2.3 g/day (2300 mg/day)	Table salt	*Toxicity:* none known *Deficiency:* dangerous blood acid–base imbalances, irregular heartbeat
Calcium	Primary component of bone Acid–base balance Transmission of nerve impulses Muscle contraction	AI: Adults aged 19 to 50 = 1000 mg/day Adults aged > 50 = 1200 mg/day UL= 2500 mg/day	Milk/yogurt/cheese (best-absorbed form of calcium), sardines, collard greens and spinach, calcium-fortified juices	*Toxicity:* mineral imbalances, shock, kidney failure, fatigue, mental confusion *Deficiency:* osteoporosis, convulsions, heart failure
Magnesium	Component of bone Muscle contraction Assists more than 300 enzyme systems	RDA: Men aged 19 to 30 = 400 mg/day Men aged >30 = 420 mg/day Women aged 19 to 30 = 310 mg/day Women aged >30 = 320 mg/day UL = 350 mg/day	Greens (spinach, kale, collard greens), whole grains, seeds, nuts, legumes (navy and black beans)	*Toxicity:* none known *Deficiency:* low blood calcium, muscle spasms or seizures, nausea, weakness, increased risk for chronic diseases, such as heart disease, hypertension, osteoporosis, and type 2 diabetes
Sulphur	Component of certain B vitamins and amino acids Acid–base balance Detoxification in liver	No DRI	Protein-rich foods	*Toxicity:* none known *Deficiency:* none known

*Abbreviations: RDA, Recommended Dietary Allowance; UL, upper limit; AI, Adequate Intake; DRI, Dietary Reference Intake.

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Trace Minerals

Characteristics of trace minerals

Required in amounts of less than 100 mg/day

Body contains less than 5 g

8 trace minerals: selenium fluoride iodine chromium manganese iron zinc copper

Trace Minerals

TABLE 4 Trace Minerals

Mineral Name	Primary Functions	Recommended Intake*	Reliable Food Sources	Toxicity/Deficiency Symptoms
Selenium	Required for carbohydrate and fat metabolism	RDA: Adults = 55 µg/day UL = 400 µg/day	Nuts, shellfish, meat/fish/poultry, whole grains	*Toxicity:* brittle hair and nails, skin rashes, nausea and vomiting, weakness, liver disease *Deficiency:* specific forms of heart disease and arthritis, impaired immune function, muscle pain and wasting, depression, hostility
Fluoride	Development and maintenance of healthy teeth and bones	RDA: Men = 4 mg/day Women = 3 mg/day UL: 2.2 mg/day for children aged 4 to 8; children aged >8 = 10 mg/day	Fish, seafood, legumes, whole grains, drinking water (variable)	*Toxicity:* fluorosis of teeth and bones *Deficiency:* dental caries, low bone density
Iodine	Synthesis of thyroid hormones Temperature regulation Reproduction and growth	RDA: Adults = 150 µg/day UL = 1100 µg/day	Iodized salt, saltwater seafood	*Toxicity:* goitre *Deficiency:* goitre, hypothyroidism, cretinism in infant of mother who is iodine deficient
Chromium	Glucose transport Metabolism of DNA and RNA Immune function and growth	AI: Men aged 19 to 50 = 35 µg/day Men aged >50 = 30 µg/day Women aged 19 to 50 = 25 µg/day Women aged >50 = 20 µg/day	Whole grains, brewer's yeast	*Toxicity:* none known *Deficiency:* elevated blood glucose and blood lipids, damage to brain and nervous system
Manganese	Assists many enzyme systems Synthesis of protein found in bone and cartilage	AI: Men = 2.3 mg/day Women = 1.8 mg/day UL = 11 mg/day for adults	Whole grains, nuts, leafy vegetables, tea	*Toxicity:* impairment of neuromuscular system *Deficiency:* impaired growth and reproductive function, reduced bone density, impaired glucose and lipid metabolism, skin rash
Iron	Component of hemoglobin in blood cells Component of myoglobin in muscle cells Assists many enzyme systems	RDA: Adult men = 8 mg/day Women aged 19 to 50 = 18 mg/day Women aged >50 = 8 mg/day	Meat/fish/poultry (best-absorbed form of iron), fortified cereals, legumes, spinach	*Toxicity:* nausea, vomiting, and diarrhea; dizziness, confusion; rapid heartbeat, organ damage, death *Deficiency:* iron-deficiency microcytic (small red blood cells), hypochromic anemia
Zinc	Assists more than 100 enzyme systems Immune system function Growth and sexual maturation Gene regulation	RDA: Men 11 = mg/day Women = 8 mg/day UL = 40 mg/day	Meat/fish/poultry (best-absorbed form of zinc), fortified cereals, legumes	*Toxicity:* nausea, vomiting, and diarrhea; headaches, depressed immune function, reduced absorption of copper *Deficiency:* growth retardation, delayed sexual maturation, eye and skin lesions, hair loss, increased incidence of illness and infection
Copper	Assists many enzyme systems Iron transport	RDA: Adults = 900 µg/day UL = 10 mg/day	Shellfish, organ meats, nuts, legumes	*Toxicity:* nausea, vomiting, and diarrhea; liver damage *Deficiency:* anemia, reduced levels of white blood cells, osteoporosis in infants and growing children

*Abbreviations: RDA, Recommended Dietary Allowance; UL, upper limit; AI, Adequate Intake.

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Absorption of Micronutrients

Absorption depends on numerous factors

Chemical form (e.g., absorption of heme iron from meats, fish, poultry is ~25%, whereas non-heme iron from plant products is ~3–5%)
Numerous factors in foods bind micronutrients and prevent absorption
Other nutrients within a meal alter absorption

Supplementation of Micronutrients

Supplementation of micronutrients is controversial

Easier to develop toxicity with supplements
Some may be harmful to certain subgroups of consumers
Most minerals are better absorbed from food
Eating a variety of foods provides many other nutrients (e.g., phytochemicals)
Supplements may alter the balance between nutrients

Role in Disease Prevention and Treatment

Research studies have suggested a link between consumption of some micronutrients and disease

Adequate intake of these vitamins has been associated with lower disease risk
Vitamin C and cataracts
Vitamin D and colon cancer
Vitamin E and complications of diabetes
Vitamin K and osteoporosis

Adequate intake of these minerals has been associated with lower disease risk
Calcium and hypertension
Chromium and type 2 diabetes in older adults
Magnesium and muscle wasting in older adults
Selenium and certain types of cancer