

Chapter 24

Nutritional Pharmacology

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KEY TERMS AND DEFINITIONS

Carbohydrates—nutrients made up of hydrogen and oxygen (in the same proportions as in water), along with carbon. They include sugar, starch, and fiber. The primary function of carbohydrates is to provide the most efficient fuel (energy) for the cells. Carbohydrates provide approximately 3.4–4 kcal/g.

Lipids—a group of substances composed of carbon, hydrogen, and oxygen, which includes fats, phospholipids, and cholesterol. Fats are considered nutrients. Composed of carbon, hydrogen, and oxygen, fats of all types are the most calorie-dense of the energy nutrients, supplying 9 kcal/g.

Malnutrition—a condition in which the body is not being provided the proper amounts of nutrients to sustain health. While this term is usually used for undernutrition (insufficient nutrients), it can also be applied to overnutrition, especially when excessive amounts of fat or calories are consumed.

Minerals—inorganic elements that are included in a variety of substances used for body processes. They come from the earth, soil, and water and are absorbed by plants. Humans obtain minerals from the plants and animals they eat.

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Nutrients—specific substances found in food that perform one or more physiological or biochemical functions in the body that are necessary to sustain health. There are six classifications of nutrients: carbohydrate, protein, lipids, vitamins, minerals, and water.

Nutrition—the provision of nutrients to the body to sustain its processes. Enteral nutrition is delivery of nutrients via the gastrointestinal tract. Parenteral nutrition is delivery of nutrients using the intravenous route of administration.

Proteins—the essential building blocks of the body, they are substances composed of combined chains of amino acids. Dietary proteins are digested so that the body can recombine the amino acids to form human proteins. Nutritionally, they provide 4 kcal/g.

Recommended Dietary Allowance (RDA)—the average daily dietary intake level that is sufficient to meet the nutrient requirement of most healthy individuals.

Vitamins—essential nutrients that are necessary for a variety of biological processes, including growth, digestion, and nerve function. They are needed in small amounts and must be obtained from external sources, as the body does not produce them.

LEARNING OBJECTIVES

After completing this chapter, you should be able to

1. Identify the vitamins and minerals necessary to the human body, their functions, and key food sources.
2. List the three energy nutrients and the calories they contribute to the dietary intake.
3. List some reasons why nutritional and vitamin supplementation may be necessary.
4. List the benefits and risks of vitamin supplementation.
5. Identify the components of nutrition support formulations.
6. Review the preparation and administration of nutrition support.
7. Discuss obesity and list approved medication therapies for this condition.

Good **nutrition** is vital to good health for all people and essential for the healthy growth and development of children and adolescents. Major causes of disease and death in the United States are related to poor diet. According to the Surgeon General of the United States, what we eat influences long-term health more than anything other than smoking and taking in excessive amounts of alcohol. Specific diseases and conditions linked to poor food choices include cardiovascular disease, hypertension, dyslipidemia, type 2 diabetes, obesity, osteoporosis, constipation, diverticular disease, iron deficiency anemia, oral disease, **malnutrition**, and some cancers.

People do not always take in all the **nutrients** they need, but fortunately healthy people have reserves that will get them through short bouts of poor food choices. In the United States, malnutrition from low vitamin and mineral intake does not pose a significant threat, but overweight and obesity are major nutrition problems. An energy imbalance (more calories taken in than used) due to poor food choices and limited physical inactivity are the primary factors contributing to the steady increase in obesity seen in the United States since the 1970s. Health risks related to overweight and obesity include several chronic diseases, such as diabetes, hypertension, and heart disease. More than 70% of U.S. adults are overweight and about 40% are obese.¹ The U.S. Departments of Agriculture and Health and Human Services have published dietary guidelines for Americans. These are federal government recommendations to promote health, reduce the risk of chronic diseases, and reduce the prevalence of overweight and obesity through improved nutrition and physical activity.

The general recommendations described in the Dietary Guidelines for Americans are:²

1. Follow a healthy eating pattern at every life stage to meet nutrient needs, help achieve a healthy body weight, and reduce the risk of chronic disease.
2. Customize and enjoy nutrient-dense food and beverage choices to reflect personal preferences, cultural traditions, and budgetary considerations.
3. Focus on meeting food group needs with nutrient-dense foods and beverages, and stay within calorie limits. The core elements that make up a healthy dietary pattern include:
 - Vegetables of all types—dark green; red and orange; beans, peas, and lentils; starchy; and other vegetables
 - Fruits, especially whole fruit
 - Grains, at least half of which are whole grain

- Dairy, including fat-free or low-fat milk, yogurt, and cheese, and/or lactose-free versions and fortified soy beverages and yogurt as alternatives
 - Protein foods, including lean meats, poultry, and eggs; seafood; beans, peas, and lentils; and nuts, seeds, and soy products
 - Oils, including vegetable oils and oils in food, such as seafood and nuts
4. Limit foods and beverages higher in added sugars, saturated fat, and sodium, and limit alcoholic beverages.

Specifically, “An underlying premise of the Dietary Guidelines is that nutritional needs should be met primarily from foods and beverages—specifically, nutrient-dense foods and beverages. Nutrient-dense foods provide vitamins, minerals, and other health-promoting components and have no or little added sugars, saturated fat, and sodium. A healthy dietary pattern consists of nutrient-dense forms of foods and beverages across all food groups, in recommended amounts, and within calorie limits.”² The Guidelines also remind us that, “because foods provide an array of nutrients and other components that have benefits for health, nutritional needs should be met primarily through foods. Thus, the Dietary Guidelines translates the Academies’ nutrient requirements into food and beverage recommendations. The Dietary Guidelines recognizes, though, that in some cases, fortified foods and dietary supplements are useful when it is not possible otherwise to meet needs for one or more nutrients (e.g., during specific life stages such as pregnancy).”² The amount of each nutrient sufficient to meet the daily needs of healthy individuals is known as the **Recommended Dietary Allowance (RDA)**, although other, similar values include the newer Dietary Reference Intake (DRI).

PRACTICE POINT

While they are natural and necessary, nutrients are not harmless and safe in unlimited amounts. That is the reason for the RDA and DRI values.

CASE?

What foods are likely to be prohibited in Mrs. Broskie’s weight loss plan?

CASE STUDY

The Broskies have just moved to a new home they built on farmland that has been in their family for three generations. Mr. and Mrs. Broskie are both 39 years old. He is a paramedic and works for the local fire department. Mrs. Broskie has a degree in elementary education. They have two sons, 15-year-old Hugh and 7-year-old Henry, and a daughter, 6-month-old Helen (who is still nursing). Mrs. Broskie has gained a lot of weight in the past few years, and she is considering going on a low-carb diet that limits many foods but lets her continue to have fried eggs and bacon for breakfast and eat her favorite foods, meat and cheese.

ENERGY NUTRIENTS

Carbohydrates, fat, and **protein** are the only nutrients that provide energy. Alcohol also provides calories, but it is not a nutrient. The measurement unit for energy is the calorie—the energy needed to increase the temperature of 1 mL of water by 1°C. That is such a small value that we consider the energy value of food in kilocalories (usually called Calories with a capital C, as listed on food nutrition labels). A kilocalorie is equal to 1000 calories, and is the energy necessary to raise the temperature of 1,000 mL of water by 1°C.

Carbohydrates

Carbohydrates include sugar, starch, and fiber. Carbohydrates are made up of carbon, hydrogen, and oxygen. *Carbo* means carbon and *hydrate* means water. Dietary carbohydrates are estimated to provide 4 kilocalories (kcal or Calories, with a capital C) per gram (“/g”) and intravenous (IV) dextrose infusions are calculated at 3.4 kcal/g. The primary function of carbohydrate is to provide the most efficient fuel (energy) for the cells. A small amount of carbohydrate energy can be stored in the body in the form of glycogen. The energy is used for body movement but also for every process that takes place and by every cellular function. Complex carbohydrates (starch) are broken down to simple ones (sugars, usually glucose) in the body by digestive enzymes so they can circulate in the blood and reach every cell.

Simple carbohydrates consist of monosaccharides and disaccharides. These are commonly known as sugar and

include not only table sugar (sucrose, a disaccharide), but also the sugars found in milk (lactose) and fruit and vegetable sources (fructose). Blood sugar is a monosaccharide called glucose (also known as dextrose). Glucose can be eaten in food or beverage, but it is also made by the body. Simple sugars are also bound together to form the polysaccharides. Food sources for simple carbohydrates include table sugar, honey, syrups, sweets, candy, soda, and other sweetened beverages.

Complex carbohydrates include starch, which is composed of long chains of simple sugars (polysaccharides), and fiber, which is made up of monosaccharides. Fiber cannot be digested by humans but plays an important role in maintaining digestive health. Good food sources for starch include breads and cereals from wheat, rice, oats, and barley, and starchy vegetables like corn, peas, legumes (kidney beans, navy beans, black beans, etc.), and potatoes. Good food sources for fiber are whole grains, seeds, nuts, vegetables, and fruits. There is no RDA for carbohydrates, but the recommendation is that, for healthy individuals, 45% to 65% of total calories should come from carbohydrates and that not more than 10% of total calories should come from added sugars.²

PRACTICE POINT

A 12-ounce can of sugar-sweetened (nondiet) soda contains 33 g of sugar.

CASE?

What macronutrients will be replacing the carbohydrates Mrs. Broskie has eliminated from her diet?

Lipids

Lipids are a group of substances that includes fats, phospholipids, and cholesterol, as well as other types of substances not relevant to nutrition. Lipids, like carbohydrates, are composed of carbon, hydrogen, and oxygen. The fats are considered nutrients; cholesterol and phospholipids are not. Humans make both cholesterol and phospholipids, so they do not need to acquire them from food. Fats of all types are the most calorie-dense of the energy nutrients, supplying 9 kcal (Calories)/g.

Saturated Fats

Saturated fats are those that are solid at room temperature (except for coconut and palm oils). Chemically, the saturated fats contain long chains of fatty acids whose carbon bonds are fully taken up and no hydrogen can be introduced.

Unsaturated Fats

Unsaturated fats are liquid at room temperature and are divided into polyunsaturated (more than one double bond with carbons that can take up hydrogen) and monounsaturated fats (only one double bond).

Trans Fats

Trans fats are found in nature, but the majority of dietary trans fats are found in foods that have been chemically modified. The production of trans fat requires adding hydrogen to polyunsaturated fats (liquid oils) under pressure. This makes the oils into a soft solid (stick margarine is one example). Trans fats were widely found in processed foods until recently when, due to their propensity to contribute to cardiovascular disease, the processed food manufacturers were forced to state the amount of trans fat on the nutrition facts label. Since then, trans fats have been removed from or included in significantly lower amounts in many foods.

Triglycerides

Triglycerides are the common form of fat found in food and in the body, either stored as body fat or circulating in the blood. Chemically, they have a glycerol base (a three-carbon "skeleton") on which three fatty acids, usually a combination of saturated and unsaturated fatty acids, are attached.

Phospholipids

Phospholipids are widely dispersed in foods as well as made by the human body. They are not essential nutrients although they are a component of cell membranes and supply fatty acids for cellular metabolism, blood clotting, and cellular regeneration. The structure of a phospholipid is similar to a triglyceride, but one of the fatty acids has been replaced with one of several phosphorus-containing compounds.

Cholesterol

Cholesterol is made by animals and humans (but not plants). It is a component of cell membranes, hormones (including sex hormones, cortisol, and others), and bile. It is not a nutrient because the body can manufacture it. It cannot be utilized to produce energy because it has a different structure than fatty acids.

PRACTICE POINT

People may make more cholesterol than necessary based on saturated and trans fat intake or genetic predisposition. High levels of circulating cholesterol contribute to cardiovascular disease. (This is discussed in Chapter 17.)

Lipids are necessary structural components of many body parts, as well as necessary body substances such as hormones. Each body cell contains fat as a part of the cell membrane. There is a layer of fat under the skin that helps regulate body temperature by keeping heat in during exposure to cold. The same layer of fat cushions a person against minor bruises. Fats provide a source of stored energy because they can be converted to glucose when necessary.

Fat in foods plays a role in the pleasure acquired from eating, as fat carries flavor, odor, and mouth feel. Fat is also the last foodstuff to empty from the stomach. Since it stays in the gut longer, it creates a feeling of fullness that signals a person to stop eating and indicates that one is satisfied with the meal.

Lipids are not soluble in water and do not mix with water or blood. In the blood, lipids must have a protein wrap to be transported through the bloodstream. They are then called lipoproteins. In food, lipids gravitate to the top of any mixture containing water. To mix lipids and water, one must use an emulsifier that suspends small particles of lipid throughout the solution. Within the digestive system, bile acts as an emulsifier. It suspends small particles of fat throughout the digestive contents and allows the fat particles to be absorbed. Without bile, fat particles would clump together and most fat would not be absorbed.

Two of the polyunsaturated fatty acids are essential nutrients. These are alpha-linolenic acid (an omega-3 fatty acid) and linoleic acid (an omega-6 fatty acid). Alpha-linolenic acid is used by the body to make eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Linolenic acid is used by the body to make arachidonic acid (AA). EPA, DHA, and AA are then used to make prostaglandins that promote a response to inflammation, control blood pressure, cause uterine contractions, and more. Essential fatty acids are necessary for growth. Infants with too low an intake of essential fatty acids can have multiple physical problems.

Although there is no RDA for fats, studies suggest an amount labeled *Adequate Intake* (AI) for the essential fatty acids. The AI for alpha-linolenic acid is 1.6 g/day for men and

1.1 g/day for women. The AI for linoleic acid is 17 g/day for men and 12 g/day for women. The recommendation for cholesterol is to limit intake to 300 mg or less per day regardless of gender or caloric intake.³

PRACTICE POINT

The U.S. government requires that trans fat be shown on a food label when a single serving of food contains at least one gram of trans fat. Some manufacturers use partially hydrogenated oils (which are forms of trans fat) in their products but keep the serving size small enough that they are not required to report trans fat on the food label. However, any trans fat has negative health effects. For this reason, it's important to read the ingredient list on your food label as well as the Nutrition Facts.

Protein

Protein provides 4 kcal/g. Compared to carbohydrates and fats, proteins are unique. Like carbohydrates and fats, they are composed of carbon, hydrogen, and oxygen; however, protein adds nitrogen, which is an element that all cells need to make key biological compounds and structural components. Proteins are formed from groups of amino acids. (*Amino* means nitrogen containing.) There are 20 basic amino acids that the body uses to build structure, and of those nine are essential, meaning they must be obtained from food sources. The nine essential amino acids are tryptophan, threonine, valine, histidine, isoleucine, leucine, lysine, methionine, and phenylalanine. Proteins containing all nine of the essential amino acids are known as *complete* or *high quality*. Animal products (meat, fish, milk, eggs, cheese, yogurt, and some fortified food products) are complete proteins. Incomplete (*low quality*) proteins are those lacking one or more essential amino acids. Incomplete proteins are found in plant products (vegetables, grains, legumes, seeds, and nuts).

Proteins are the building blocks of the body (the brick and mortar of the structure) and the substance in enzymes, hormones, and antibodies. Proteins are the transport vehicles for nutrients, oxygen, waste, and more throughout the body. It is the basis for bones, skin, muscles, connective tissue, and more.

Vegetarians exclude some or all forms of animal protein. Vegetarians are classified by the protein sources they choose to eat. Those who avoid meat, fish, and poultry but will eat eggs and dairy are lacto-ovo vegetarians. They will get all their essential amino acids. Vegans take in no animal products (including foods produced by an animal, such as milk or eggs). A vegan must be careful to consume grains with legumes or legumes as well as seeds or nuts to obtain all of the essential amino acids required by the body. Just as an omnivore (person who eats both plant and animal products) must eat a balanced diet to get all of the nutrients, so must a vegan balance intake to take in the proper amount of nutrients. Both omnivores and vegans can have very healthy diets, and both can choose unwisely and have diets that are not health enhancing.

The RDA for protein is 0.8 g/kg of body weight. This translates to 360 mg per pound of body weight. A 156-pound (70-kg) person would need 56 g of protein per day. Because the protein recommendation is based on body weight, it cannot be included in the Nutrition Facts Panel on food labels. The energy nutrients are summarized in Table 24-1.

CASE?

What vitamins may Mrs. Broskie be losing by eliminating carbohydrate-rich foods from her meals?

TABLE 24-1. Energy Nutrients

Nutrient	Energy Factor	Type	Dietary Sources	Notes
Carbohydrates	4 kcal/g (3.4 kcal/g for IV dextrose)	Simple	Table sugar, honey, syrups, sweets, candy, soda, and other sweetened beverages	
		Complex		
		Starch	Breads and cereals from wheat, rice, oats, and barley; starchy vegetables like corn, peas, legumes (kidney beans, navy beans, black beans, etc.), and potatoes	
		Fiber	Whole grains, seeds, nuts, vegetables, and fruits	
Fat	9 kcal/g	Saturated fat	Animal sources (milk, butter, cheese, beef fat, pork fat, lard) and tropical oils (coconut and palm oil)	Except for the tropical oils, saturated fats are solid at room temperature
		Unsaturated fat	Monounsaturated fats: olive oil, canola oil, peanut oil Polyunsaturated fats: sunflower oil, safflower oil, soybean oil, corn oil	Liquid at room temperature
		Trans fat	Processed foods	These are not necessary to the diet and should be avoided
		Triglycerides	Processed foods	
		Phospholipids	Eggs, liver, peanuts, wheat germ, dairy products	Lecithin is a common phospholipid often added to processed foods as a stabilizer; there is no health benefit to supplementing the diet with lecithin powder
Protein	4 kcal/g		Meat, fish, milk, eggs, cheese, yogurt, legumes, seeds, nuts	The legumes (beans) have more protein than other plant foods; a combination of grains and legumes can be used as a meat substitute

Vitamins

Vitamins are essential nutrients needed in small amounts that are necessary to achieve a healthy, productive life. Vitamins are necessary for a variety of biological processes, including growth, digestion, and nerve function. There are 13 vitamins that the body absolutely needs from external sources: vitamins A, C, D, E, K, and the B vitamins (thiamine, riboflavin, niacin, pantothenic acid, biotin, vitamin B6, vitamin B12, and folate). Although most people get all the vitamins they need from the foods they eat, some cannot obtain optimal nutritional intake for a variety of reasons (such as intestinal malabsorption syndromes) and must rely on supplemental vitamins to achieve a good nutritional intake.

Fat-Soluble Vitamins

Fat-soluble vitamins include vitamins A, D, E, and K. They are absorbed into the body with the help of bile acids, which are made in the liver, and in the presence of dietary fat. People who have impaired digestive systems or who have too low an intake of fat may have deficiencies of these vitamins and require supplementation. Vitamins A and D work together in calcium metabolism and bone health, so they are often administered together in combination products. The fat-soluble vitamins, with their characteristics, uses, food sources, and drug interactions are listed in **Medication Table 24-1** (Medication Tables are located at the end of the chapter).

ALERT!

The body stores fat-soluble vitamins for use as needed, but if people take in too much of these nutrients, they can accumulate and cause toxicity in the long term.

Water-Soluble Vitamins and Nutrients: B Vitamins, Vitamin C, and Choline

Although water-soluble vitamins are easily absorbed by the body, they are not stored in significant amounts the way the fat-soluble vitamins are. The kidneys can usually remove the excess water-soluble vitamins from dietary or supplemental sources. The B vitamins have a wide and varied range of functions in the human body, but their primary function is to facilitate the process of converting blood sugar into energy.

B-vitamin deficiencies are uncommon in the United States, but when they occur, they usually involve several B vitamins, since many of them come from the same food groups. Alcohol interferes with the absorption of these vitamins, and some of the physical and mental problems that alcoholics experience may be attributed to a deficiency of B vitamins. Elderly people are also at risk for deficiencies because of inadequate diets and the possible interference with B-vitamin absorption by medications. Deficiencies can occur in severely malnourished people or in those receiving long-term dialysis or IV feeding. The water-soluble vitamins, with their characteristics, uses, and food sources are listed in Medication Table 24-1.

PRACTICE POINT

Because the B vitamins are water soluble and eliminated in the urine, toxic reactions from oral administration of most B vitamins are extremely rare (exceptions are niacin and vitamin B6.)

CASE?

When the Broskies moved to the country and started using well water, Helen's pediatrician wrote a prescription for a vitamin supplement drop to replace the over-the-counter product recommended when she was born. What is in this new supplement that Helen didn't need when she lived in the city?

Minerals

Minerals are inorganic elements that come from the earth, soil, and water and are absorbed by plants. Humans obtain minerals from the plants and the animal products they eat. Minerals are not destroyed by food processing or food storage methods. Minerals are categorized according to the amounts present in the normal human body. Major minerals (macrominerals) are present in amounts greater than 5 g. Trace minerals (minor minerals, trace elements) are present in quantities less than 5 g. The mineral nutrients, with their characteristics, uses, and food sources are listed in **Table 24-2**.

TABLE 24-2. Minerals³

Mineral	Functions	Food Sources	Adult Dietary Reference Intake (DRI) (male/female aged 31-50 years)	Deficiency	Toxicity	Notes
Major Minerals						
Calcium	Maintain and grow healthy bones and teeth, nerve conduction, muscle contraction, blood clotting, production of energy, immunity to disease	Dairy products, seafood, green leafy vegetables, meat, eggs	1,000 mg/day (TUI) 2,500 mg/day	Muscle weakness, bone pain, osteoporosis	Calcification of soft tissue (frequently the kidneys)	Most abundant mineral in the body
Phosphorus	Maintain strong bones, all cell functions, cell membranes	Dairy products, fish, meats, poultry, soda	700 mg/day (TUI) 4,000 mg/day	Inability to utilize calcium	Electrolyte imbalances	
Magnesium	Part of every major biologic process, use of glucose in the body, synthesis of nucleic acids and protein, cellular energy	Green leafy vegetables, fish, nuts	420 mg/day male 320 mg/day female (TUI 350 mg/day)	Electrolyte imbalances, heart failure, neuro-muscular symptoms	Flushing, sweating, CNS depression, cardiac abnormalities	Toxicity can occur with excess supplementation or from magnesium in laxatives and antacids; magnesium is used in pregnant women suffering from eclampsia
Sodium	Maintaining body's fluid and electrolyte balance, muscle contraction	Table salt, processed foods, canned foods, cured meats, fast food	1,500 mg/day	Fatigue, nausea/vomiting, muscle weakness, mental status changes (confusion, hallucination, coma)	Edema, high blood pressure	It is generally recommended that sodium intake be limited to 2,000 mg per day but no TUI has been determined
Chloride	Maintaining body's fluid and electrolyte balances, part of hydrochloric acid in the stomach	Table salt, processed foods, meat, dairy, eggs	2,300 mg/day (TUI) 3,600 mg/day	Dehydration or fluid loss may be noted, but many patients will have no symptoms	Vomiting	
Potassium	Part of many major biologic processes, muscle contraction, nerve impulses, synthesis of nucleic acids and protein, energy production	Fresh vegetables, fresh fruits	3,400 mg/day male 2,600 mg/day female	Irregular heartbeat, glucose intolerance	Vomiting, weakness, cardiac arrhythmia	TUI not determined
Trace Minerals						
Chromium	Insulin utilization and glucose tolerance	Whole grains, meats, brewer's yeast	35 mcg/day male 25 mcg/day female	Glucose intolerance	Kidney impairment	TUI not determined

Continued next page

TABLE 24-2. Minerals³ (Continued)

Mineral	Functions	Food Sources	Adult Dietary Reference Intake (DRI) (male/female aged 31-50 years)	Deficiency	Toxicity	Notes
Trace Minerals						
Copper	Part of iron absorption and incorporation into hemoglobin, necessary for melanin formation and maintaining myelin sheaths	Seafood, nuts, whole grains	900 mcg/day (TUI 10 mg/day)	Anemia also causes neutropenia	Liver damage, psychoses	
Fluoride	Binding calcium in bones and teeth	Fluoridated water	4 mg/day male 3 mg/day female (TUI 10 mg/day)	Dental decay	Changes in teeth and bone, CNS abnormalities, heart failure	Fluoride supplements and multi-vitamins with fluoride are used to provide adequate amounts of this nutrient for children who drink primarily well water or in areas where water is not fluoridated
Iodine	Part of thyroid hormones that help regulate energy metabolism, growth, and development	Seafood, iodized salt, plants grown in iodine-rich soil	150 mcg/day (TUI 1,100 mcg/day)	Goiter, cretinism (mental retardation and poor physical growth in infants)	Zinc hyper- or hypothyroidism, GI irritation	
Iron	Hemoglobin synthesis and function; production of collagen, elastin, neurotransmitters; melanin formation	Meats, fish, poultry, eggs, dried fruit	8 mg/day male 18 mg/day female (TUI 45 mg/day)	Iron deficiency anemia, fatigue, weakness	GI impairment, organ damage	Absorbed better in the presence of vitamin C; poorly absorbed in the presence of calcium
Manganese	Part of several enzymes, bone development	Whole grains, leafy green vegetables, nuts	2.3 mg/day male 1.8 mg/day female (TUI 11 mg)	Enzyme malfunction	CNS abnormalities	
Molybdenum	Part of several enzymes	Liver, cereals, nuts, legumes	45 mcg/day (TUI 2,000 mcg/day)	Enzyme malfunction	Liver damage	
Selenium	Antioxidant, thyroid hormone regulator	Seafood, meat, whole grains, eggs	55 mcg/day (TUI 400 mcg/day)	Heart disease	Brittle nails, hair loss, rash, fatigue, garlic breath odor	
Zinc	Immunity and healing, good eyesight, involved with numerous enzymes	Whole grains, brewer's yeast, fish, meats, enriched cereals	11 mg/day male 8 mg/day female (TUI 40 mg/day)	Impaired growth and maturation, diminished immune response, loss of appetite	Low HDL, decreased taste and smell, hair loss	Zinc supplements have been used to treat colds and promote wound healing but are not FDA approved for these indications

CNS = central nervous system; FDA = U.S. Food and Drug Administration; GI = gastrointestinal; HDL = high density lipoprotein; TUI = Tolerable Upper Intake Level.

Supplements

Supplements are only useful when they fill a specific identified nutrient gap that cannot be or is not otherwise being met by the individual's intake of food. Nutrient supplements cannot replace a healthy diet. Individuals who are already consuming the recommended amount of a nutrient in food will not gain any health benefit if they also take the nutrient as a supplement. It is important to note that supplements and fortified foods may cause intakes to exceed the safe levels of nutrients. Nutrients taken in as supplements are actually drugs and no longer considered nutrition.

PRACTICE POINT

Dietary studies have shown that the following nutrients are most likely to be deficient in the American diet for adults: calcium, choline, potassium, fiber, magnesium, and vitamins A (as carotenoids), C, D, and E. Iron also is under-consumed by many adolescent girls and women aged 19 to 50 years.

Individual vitamins and minerals are sometimes prescribed by physicians to treat specific patient problems or issues. Alcoholics, for example, often receive thiamin to relieve deficiencies; folic acid supplements are recommended to all women of childbearing age to prevent birth defects; and some patients with anemia may need iron. Pediatricians may prescribe fluoride-enhanced vitamins for children who drink primarily well water or live in areas where the water is not fluoridated. Some ophthalmologists recommend a multivitamin high in antioxidant vitamins and zinc to prevent age-related eye issues. Those who are on restricted diets or otherwise unable to fulfill their nutritional needs through normal food sources may also be candidates for supplementation. Sometimes medication therapies deplete vitamins and minerals, making supplements necessary or advisable in combination with those medications. Examples of these are listed in the drug/nutrient interactions column in Medication Table 24-1.

CASE?

Mr. Broskie has an artificial heart valve and takes warfarin to prevent a blood clot. What vitamin in some supplements might interfere with his therapy?

Many patients choose to take a nonprescription vitamin supplement for a variety of reasons, some better than others. These include those who take a multivitamin product for insurance against nonspecific vitamin deficiencies or hoping to prevent disease. Others select specific vitamins to supplement, based on claims in popular literature or Internet sources. The National Institutes of Health's position is that people who might benefit from multiple vitamin and mineral supplementation include postmenopausal women (calcium with vitamin D), women of childbearing age (folic acid), people over the age of 50 (vitamin B12), pregnant women (iron), and breastfed infants (vitamin D), as well as those with poor dietary nutrient intake, patients on restricted (eg, vegan) or low-calorie diets, and those with medical conditions that interfere with the absorption or use of nutrients.⁴ The American Academy of Pediatrics recommends a supplement of 400 IU of vitamin D daily for all partially and exclusively breastfed infants, as well as infants who consume less than 1 L of fortified infant formula per day.⁵

Since many multiple vitamin supplements contain the full recommended dietary allowance of several ingredients, it is possible that people who take them regularly could exceed the recommended maximum levels for those nutrients. Additionally, some vitamin supplements can interfere with medication therapy. (Examples of these are listed in the drug/nutrient interactions column in Medication Table 24-1.) Many patients, thinking that vitamins are natural and, therefore, harmless, are not aware of this issue and should be directed to seek the advice of the physician or pharmacist before choosing a supplement.

PRACTICE POINT

Patient profiles should list not only prescription preparations the patients are taking, but also over-the-counter products, including vitamins, dietary supplements, and herbals as well. As many people do not consider these to be medications, they will not mention that they take these products, so they should be specifically asked about them at the same time they are asked about their medications, and they should be advised to mention supplements to their physicians.

CASE?

Hugh Broskie is on the track team at his high school and wants to be sure he is getting enough vitamins. Mrs. Broskie has a leftover supply of her prenatal vitamins and thinks Hugh should use those up before spending a lot of money on the stress-formula tablets his teammates are taking. Should they talk to the pharmacist about this? What issues do you think are involved?

There are so many supplements and combinations available, both brand and generic, on pharmacy shelves, in grocery and convenience stores, and on the Internet that listing all would be impractical. A representative sampling is included in **Table 24-3**. The Academy of Nutrition and Dietetics and the National Institutes of Health recommend that consumers take care in choosing over-the-counter (OTC) vitamin supplements. Many available supplements have ingredients that could interact with patients' conditions or other therapies. More is not necessarily better; often supplements can be harmful when taken in high amounts, for a long time, or in combination with certain other substances. Consumers should evaluate whether the product is worth the cost.

Many supplements are quite expensive and may not offer the expected effect. This is especially true of water-soluble vitamins (B vitamins and vitamin C) that the body does not store and excretes the excess. The medical team should be made aware of any and all supplements being taken as some can cause inaccurate medical test results or alter the effect of medications.

CASE STUDY

Henry Broskie is 7 years old and weighs 21 kg (46 lb). He was normal at birth, but at 2 years of age he started to experience problems with swallowing food so a gastrostomy tube (GT) was placed and he was started on PediaSure feedings. When he was 4, he had bowel surgery and received parenteral nutrition until tube feedings could be restarted. The PediaSure was restarted slowly and while the volume was advancing, he showed signs of formula intolerance (intestinal pain and diarrhea). The formula was changed to Peptamen Junior, which he seemed to tolerate.

TABLE 24-3. Representative Multiple Vitamin Supplements⁸

Category	Brand Name	Nutrients	Target/Purpose
Daily multivitamin	Flintstones, One A Day	All or most of the recognized vitamins, generally at levels close to the Recommended Dietary Allowances (RDAs)	Formulations for children, adults, men, women, pregnant women, and seniors typically provide different amounts of the same vitamins and minerals based on the reported specific needs of these groups
Multivitamins with minerals	Centrum, Theragran-M	All or most of the recognized vitamins and minerals, generally at levels close to the RDAs	
Multivitamins with fluoride	Poly-Vi-Flor, Floriva, Tri-Vi-Flor	Similar to daily multivitamins, with 0.25-1 mg fluoride per dose	Supplement for children living in areas where drinking water is not fluoridated (prescription only)
Stress-formula vitamins	StressTabs, BioStress, Super B-complex	Water-soluble vitamins (B and C) in doses 2-10 times the RDA, sometimes with minerals, fish oil, or other additives	Marketed to people with stressful or active lives; could cause overdoses
Renal formula vitamins	Nephro-Vite RX, Nephroplex	B and C vitamins at RDA levels with additional B6, folate, and biotin	Patients with chronic kidney disease
Prenatal vitamins	Foltabs, CitraNatal Rx	Multiple vitamins with higher doses of folate and calcium and often zinc, copper, and/or iodine	Pregnant women; high folate products are RX only

NUTRITION SUPPORT

Nutrition is the provision of nutrients to the body and is necessary to sustain life. While it is recommended that people get their nutrition from consuming a healthy diet of nutrient-rich foods, sometimes illness and disease make this an unrealistic or impossible goal. When a person cannot eat at all or is unable to consume an adequate quantity of food due to an adverse physical condition, additional nutrition must be supplied in a different way. Nutrition support is the provision of oral, enteral, or parenteral nutrients to treat or prevent malnutrition in patients who are unable to fulfill their nutritional needs by consuming food for reasons including, but not limited to, illness, decreased appetite, difficulty swallowing, or surgery that interferes with eating. Nutrition support can enhance the rate of recovery from certain conditions and enable sustained life in others. Nutrition support includes, among other means, the provision of total enteral or parenteral nutrition support and therapeutic nutrients to maintain or restore optimal nutrition status and health. The amount, type, and route of nutrition support are tailored specifically to each patient, with the goal being to improve patient outcomes, minimize infections, and allow patients to live their lives as normally as possible.

Enteral Nutrition

Enteral nutrition (EN) provides nutrition via tube feedings or by mouth into the digestive tract. In most healthcare settings, however, the terms enteral nutrition and tube feeding are used synonymously. EN can be administered through different types of tubes. Feeding tubes can be placed in many ways, for example, through the nose into the stomach (nasogastric, NG) or intestines (nasoenteral), or may be placed via incision into the stomach (gastrostomy, GT or PEG) or intestine (jejunostomy). EN or tube feeding is a mixture of the energy nutrients (carbohydrate, fat, and protein), vitamins, and minerals in liquid form. Usually a commercial liquid nutrient product is used.

ALERT!

Tube feedings can also be homemade, but that is not recommended for sanitary reasons, as well as the potential for tube clogging of homemade feedings.

Supplemental nutrition refers to the use of liquid nutrient mixtures in addition to a person's diet. The person may be able to eat but not enough to provide adequate nutrition. This could be due to poor appetite (anorexia), extreme weakness due to illness, or an increased need for calories and nutrients beyond what a normal diet can provide. When increasing the nutritional intake is necessary, the first step should always be to add additional foods at or between meals if tolerated. Supplemental nutrition is generally given by mouth rather than via tube. Many people can tolerate liquids better than solids and for many the liquid nutrition can be milk, milkshakes, or instant breakfast drinks. Sometimes it is necessary to use commercial liquid nutrient products. When clinicians select an EN product, they consider the osmolarity of the product. Osmolarity is defined as the number of particles in solution. Different parts of the gastrointestinal tract have different tolerances to the osmolar load that is associated with the various enteral products. For example, a product that is intended strictly for gastric feeding may not be tolerated when administered directly into the jejunum.

In addition to supplemental products primarily administered by mouth to patients who are eating but unable to consume enough to satisfy their nutritional needs, there are four types of commercial nutrient products: modular, intact or polymeric, elemental (predigested), and disease-specific formulas.

CASE?

Use Table 24-3 to compare nutrition formulations. Why might Peptamen Junior be working better for Henry than PediaSure?

Modular formulas consist of one nutrient and are used for people who only need supplementation of one or two of the energy nutrients. They are supplied in liquid form or as a powder to be added to foods, beverages, or other types of oral supplements. Polycose, for instance, has only carbohydrates, while ProMod is considered a protein product with added carbohydrate. Pro-Phree, by contrast, contains no protein, supplying all of its calories from carbohydrate and fat. Examples of lipid products are Microlipid and medium chain triglyceride (MCT) oil.

Intact (polymeric) formulas are used when the person has a functioning gastrointestinal tract, but nutritional intake is limited to a specific volume. These liquid nutrient products must contain all of the nutrients the person needs. They

may be used orally or as a tube feeding. These products vary widely. Some products are in the form of pudding, some are lactose free or contain fiber, and some are strictly for use as tube feedings and are not flavored for oral use. The common goal of all of them is to provide a source of complete nutrition.

Elemental (predigested) feedings are formulated for persons with impaired gastrointestinal function or with metabolic disorders. These are intended as tube feedings and are seldom used for oral feedings because of taste issues. Elemental formulas vary, but most have had one or more energy nutrient treated with enzymes to compensate for insufficient amounts of digestive enzymes in the gut. In some products, some portions of an energy nutrient may be absent. Lactose (milk sugar) is frequently kept out of an elemental product. Protein may be pretreated partially or totally to allow absorption of amino acids. Fats that are used may be either those that are easier to absorb or partially digested.

ALERT!

Because of their ingredients and osmolarity considerations, tube feeding products are not uniformly interchangeable, in spite of having similar names. Technicians involved in dispensing these products must be conscious of the differences and be sure to select the correct one ordered for the patient.

Disease-specific formulas are most often used for diseases of the liver, respiratory system, and kidneys. Examples of disease-specific products are Hepatic Aid (liver), Pulmocare (respiratory), and Nepro (kidney). Representative formulations of each type mentioned are listed in **Table 24-4**, with their caloric density, energy nutrient composition, and osmolarity for comparison.

Adverse effects of EN can occur because of incorrect ordering, administration, or monitoring. The liquid nutrient solution should be selected by a clinician and quantified based on the person's individual nutrition needs. One size fits all is not appropriate. Dietitians should carefully monitor each patient's nutrition and electrolyte status.

Parenteral Nutrition

Parenteral nutrition (PN) supplies nutrients to the body when the stomach and intestines are not working or no longer present, or the patient is unable to meet nutritional

demands enterally. PN consists of a sterile nutrient liquid that is administered intravenously, directly into the bloodstream. Consisting of protein and energy nutrients, vitamins, and minerals and adequate fluid, PN has also historically been referred to as total parenteral nutrition (TPN) or total nutrient admixture (TNA).

CASE?

A case of Peptamen Junior costs the Broskies more than \$150, and Henry's medical bills are really stretching their budget. There is currently a deal on Peptamen 1.5 for about 10% less. Should Mrs. Broskie get that for Henry this month instead? Why or why not?

PRACTICE POINT

When parenteral nutrition was first developed it was called hyperalimentation, but this term is no longer used.

An IV nutrition solution can be administered through a peripheral vein or a central vein. The back of the hand or in the forearm area is the location where an IV catheter is placed for peripheral administration. It is easy to insert and requires minimal skill; the catheter doesn't travel too far from the insertion site. This type of insertion is used mainly for short-term access. Since the veins are small and the rate of blood flow past the catheter is relatively slow, they are prone to failing when high dextrose concentrations are infused. The veins also do not tolerate high concentrations of electrolytes. Dextrose concentrations greater than 10% are often not tolerated peripherally, and veins can become irritated or damaged when concentrations are too high. In these cases, a central catheter must be used for PN administration. There are several types, but they share one important feature. The tip of the catheter usually rests directly above the right atrium in the superior vena cava. This is a large vein that enjoys a high blood flow rate, which produces a dilution effect on the concentrated solutions. When a physician orders a PN, there is usually a place on the order form where peripheral or central access is indicated.

TABLE 24-4. Representative Enteral Nutrition Products¹³

Product	Type	Caloric Density (kcal/mL)	Osmolarity (mOsm/mL)	Protein (% of Total)	Carbohydrate (% of Total)	Fat (% of Total)
Polyose	Modular	3.8 kcal/g used	1.6/g used	0	100	0
Pro-Phree	Modular	5.1 kcal/g used	205	0	50.8	49.2
MCT oil	Modular	7.7 kcal/mL	NA	0	0	100
Tolorex	Elemental	1	550	8.2	90.5	1.3
Vivonex TEN	Elemental	1	630	15	82	3
Jevity	Standard	1.06	300	17	54	29
Nutren	Standard	1	300	16	51	33
Jevity 1.2, Fibersource HN	Standard	1.2	450	19	53	29
Nutren 2, TwoCal HN	Standard	2	746	16	39	45
Peptamen, Vital HN	Semi-elemental	1	270	16	51	33
Peptamen 1.5, Vital 1.5	Semi-elemental	1.5	550	18	49	33
Nutren Pulmonary, Pulmocare	Pulmonary	1.5	330	18	27	55
Nutrihep, Hepatic Aid II	Hepatic	1.5	790	11	77	12
Abbott, Nepro	Renal	1.8	960	17	35	48
Glucerna 1.0	Diabetic	1	355	17	34	49
Glucerna 1.5	Diabetic	1.5	875	22	33	48
Oxepa	Immune	1.5	535	17	28	55
Kindercal TF	Pediatric	1.06	290	11	51	38
PediaSure	Pediatric	1	278	12	44	44
Peptamen Junior	Pediatric	1.06	255	12	54	34
Carnation Instant Breakfast	Supplement	1	480	14	51	35
Boost	Supplement	1	625	17	67	16

MCT = medium chain triglyceride; NA = not available.

CASE?

Henry's bowel is diseased, and he must have surgery to remove a large portion of it. He will no longer be able to absorb nutrients from enteral feedings. What can be done to keep him alive and growing?

PN must meet each patient's individual nutritional, electrolyte, and fluid needs. The main components are the energy nutrients: carbohydrate, protein, and fat. These are also known as macronutrients. Additionally, PN usually

includes electrolytes (minerals such as sodium, potassium, and chloride) and vitamins, as well as trace elements. These are known as micronutrients. Finally, sterile water is usually added to the nutrition admixture to adjust the volume and ensure that the patient's fluid requirements are being met.

PRACTICE POINT

Most adults require an intake of fluid of 25–35 mL per day for every kg (2.2 lb) of body weight. This means that a 150-lb patient would be expected to require 1,700–2,400 mL of fluid daily.

ALERT!

Whenever dextrose concentrations exceed 10% or there is an otherwise high concentration of nutrients (including protein and electrolytes), PN cannot be administered through a peripheral vein; a central line is required. These high concentrations increase the osmolarity of the solution.

The process of ordering and compounding PN solutions is complex and involves numerous steps before the final product can be dispensed and administered to the patient. Someone knowledgeable about nutrition and authorized to do so must first initiate the order, based on the patient's size, medical condition, and nutritional needs (including the results of lab work). PN orders are usually written by a physician, dietitian, or pharmacist, and in some settings, a nutrition support team involves all three disciplines in the process. Once the order has been transmitted to the pharmacy, an overall evaluation of the order is performed to ensure that the formulation ordered is practical and can be compounded safely.

CASE?

Henry's PN formula includes 300 g of carbohydrate, delivered as dextrose. His daily fluid needs are 1,500 mL. Can his nutrition be administered through a peripheral vein?

Non-nutrients commonly added to PN admixtures include heparin, insulin, and histamine₂ antagonists. Heparin is frequently added to the PN to keep clots from forming in the vein used for administration. Insulin is sometimes included to ensure patients metabolize the dextrose being infused. Histamine₂-receptor antagonists such as famotidine (discussed in Chapter 20) can prevent stress ulcers in patients whose stomachs may still be producing digestive acids (which are not being utilized when the patient is being fed intravenously).

ALERT!

At least two pharmacy personnel should double check all calculations for PN. Errors in math could result in patient harm.

Since the IV route has already been established for the patient on PN, physicians may want to have as many medications as possible added to the PN for convenience. The issue with this is that the stability of the medications may not have been adequately studied under these conditions, and interactions between them and the components of the PN solution have not been evaluated. For instance, the pH (acidity) of the PN solution may be very different from a regular IV fluid and this could affect stability.

PRACTICE POINT

Compatibility between PN and an IV medication, which is administered through a common IV tubing as listed in a basic reference, does not mean that the medication can be placed in the PN solution and be in contact with it for 24 hours or more.

Some common additives in the PN have limited stability, especially when mixed with one another, and that must be considered when compounding. The multivitamins that are a routine component of the PN can lose their potency over time. For this reason, the vitamins should be one of the last items added. These vitamins are also sensitive to light and many pharmacies place a brown plastic wrap over the finished product to minimize the light exposure. Some institutions wrap the IV tubing for light protection once the PN is hung on the patient. Insulin is a medication that is commonly added to PN solutions. Insulin can react or adhere to the plastic from the bag or tubing, decreasing its potency or effectiveness. If it is to be added to the PN bag, this should also be one of the last steps. This is a more stable additive less likely to cause incompatibilities than those previously mentioned.

ALERT!

Only short-acting insulin solutions such as regular human insulin are added to PN. Long-acting products (such as insulin glargine) or suspensions (including NPH insulin) are never included in PN, although they may be administered separately to patients who are receiving IV nutrition.

Another issue that merits consideration when compounding is the order of mixing of the ingredients. Most electrolytes are compatible with each other. Calcium and phosphorus, however, are only conditionally compatible. In fact, if you were to mix calcium and phosphorus in a plain dextrose bag, it is likely that they would precipitate almost immediately. Fortunately, in a PN solution, calcium and phosphorus are protected, to some extent, from interacting with each other by the presence of the protein component. This protection is limited by how much calcium and phosphorus are added, how much protein is in the mixture, the pH of the mixture, and the temperature of the final product. Colder solutions, a lower pH, and sufficient amount of protein make the solution more stable.

ALERT!

Precipitates are not acceptable in PN solutions, as particles should not be administered intravenously.

PRACTICE POINT

When compounding PN, add the phosphorus to the PN before adding calcium to dilute it to a lower concentration. Reactive electrolytes such as phosphorus are usually added near the end of the compounding process to maximize the total volume of solution to which they are added (thereby minimizing their concentrations). In general, it is inadvisable to have a ratio of more than 10 mEq/L of calcium in solutions with 30 mM or more of phosphates.

Some PN formulations include carbohydrate (dextrose), protein (amino acids), and fat (intravenous lipid emulsion) in the same bag, often called a *three-in-one* or *all-in-one* (AIO), while others (*two-in-one*) require the fat component to be administered separately from the carbohydrate/protein admixture that carries the electrolytes and vitamins. The obvious advantage of the three-in-one admixture is the requirement for a single bag at a single rate to deliver all of the patient's nutrient needs. The disadvantage is that addition of the lipid component makes the admixture milky and precipitation may not be visually detected.

Standardized commercial PN products are available. These products are designed to meet the nutrition requirements of general population groups (specific for age, stress, or disease) and come in a range of protein (amino acid) and carbohydrate (dextrose) concentration combinations. (See [Table 24-5](#).) These standardized commercial PN products require fewer additions or compound adjustments before they are administered. The standard products are complex but preferred over pharmacy-compounded products for a multitude of reasons that include sterility, stability, and nutritional balance. Challenges occur when the person's formula must be individualized.

Adverse events are often related to the ordering process consisting of creating the correct order and communicating the order. For these reasons, many institutions require special forms or utilize an automated compounding device tied to their institution's computer system when ordering PN. Labels should provide information that matches the order in a manner that allows the person administering the PN to verify its accuracy.

PN support is administered using a variety of protocols. The most common method is through continuous infusion over a 24-hour period. This is especially helpful when initiating PN, advancing calorie content (especially dextrose calories), or administering it in a metabolically unstable patient. Glucose is the component of the PN solution that causes the greatest amount of intolerance if the administration rate is not regulated correctly. Infusing glucose at a high rate can produce hyperglycemia in the patient receiving it, and this can cause a variety of metabolic complications. Once the patient is at goal nutrition or is stable, it is possible to infuse the PN over a shorter period. This is known as cycling the PN and offers several benefits. First, the patient is free of all the tubing and pumps for several hours each day and can move freely about the environment. This is especially advantageous in long-term outpatient settings. It is difficult to attempt to lead a relatively normal life when receiving PN 24 hours a day. People who work or attend school usually prefer not to be hooked to the PN solution while out of the house. Another benefit is that it gives the liver a rest from metabolizing the components. Long-term infusion of PN can often damage the liver, and cycling allows the liver a period of recovery that may minimize potential damage. The component most related to liver damage is the intravenous fat emulsion, especially the omega-6 fatty acid content. Lipid emulsions contain varying amounts of omega-6 fatty acid, depending on the brand used. Minimizing the amount of lipids or

TABLE 24-5. Representative Parenteral Nutrition Products⁷

Product	Amino Acid %	Dextrose %	Fat	Electrolytes	Notes
Aminosyn II	10, 15	—	—	—	Sulfite free; 15% used in bulk compounding
Aminosyn PF	7, 10	—	—	—	Infants/children; sulfite free
Premasol	6, 10	—	—	—	Infants/children; sulfite free
Travasol	10	—	—	—	
Prosol	20	—	—	—	Used in bulk compounding
Clinisol	15	—	—	—	Used in bulk compounding
FreAmine III	10	—	—	—	Contains phosphate
Freamine HBC	6.9	—	—	—	Can be used via peripheral vein or central vein with appropriate dextrose; used for patients in metabolic stress
Plenamaine	15	—	—	—	Designed for bulk compounding
Procalamine	3	3	—	—	Contains 3% glycerol; can be used via peripheral catheter
Trophamine	6, 10	—	—	—	Infants/children; sulfite free
Clinimix	4.25, 5, 6, 8	5, 10, 15, 20, 14	—	—	Sulfite free, comes in a variety of combinations; comes in a 2-chambered bag, unclamp before dispensing
Clinimix E	2.75, 4.25, 5, 8	5, 10, 15, 20, 14	—	Varies	Sulfite free, comes in a variety of combinations; comes in a 2-chambered bag, unclamp before dispensing
Kabiven	3.3	9.8	3.9%	Yes	3-chambered bag, unclamp before dispensing; lipid is soy based
Peri-Kabiven	2.4	6.8	3.5%	Yes	3-chambered bag, unclamp before dispensing; can be used via peripheral catheter; lipid is soy based
Hepatamine	8	—	—	—	Hepatic formula
NephrAmine	5.4	—	—	—	Renal formula
Intravenous Lipids^{7,8}					
Intralipid	20, 30	—	2 kcal/mL, 3 kcal/mL	—	100% soy oil; 30% used in compounding
Nutrilipid	20	—	2 kcal/mL	—	
SMOFlipid	20	—	2 kcal/mL	—	30% soy, 30% medium chain triglyceride, 25% olive, 10% fish oils
Omegaven	10	—	1.1 kcal/mL	—	100% fish oil
Clinolipid	20	—	2 kcal/mL	—	20% soy, 80% olive oil

the omega-6 component can lessen the chance of developing liver disease. Reducing the number of days the lipid is administered may also prevent or slow the progression of liver damage associated with lipid infusion. For some patients, it may be possible to administer lipids only one

to three times per week. The periods without lipids allow the liver to clear the fats so they don't build up in the liver and cause damage. For those patients who do not depend on PN for 100% of their nutrition, the PN can also be given fewer than 7 days per week.¹⁴

OBESITY

Overweight and obesity refer to body weights above those generally considered healthy. Because total weight includes total body composition (bone, muscle, water, fat), a healthy weight varies with height, gender, and age. Weights that fall into the ranges of overweight and obesity have been shown to increase the likelihood of certain diseases and other health problems.³ While in the past, weight status was based on charts of population averages for gender and height, it is now defined on the basis of body mass index (BMI), a measure of total body weight relative to height. A BMI of 18.5–24.9 is termed *normal* weight, while a BMI of 25–29.9 is considered overweight, a BMI of above 30 indicates obesity, and a BMI above 40 defines severe obesity.⁹

CASE?

Mrs. Broskie has been spending a lot of time in the hospital with Henry and relying on the vending machines there for snacks. Her weight is increasing and she wants to try an OTC product to help her lose weight. What might the pharmacist recommend?

PRACTICE POINT

An individual who is 5'9" tall and weighs 125–168 lb would have a BMI in the healthy range but would be considered obese with a weight above 203 lb. The Centers for Disease Control and Prevention provide online BMI calculators for adults at https://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/english_bmi_calculator/bmi_calculator.html and for children and teens at <https://www.cdc.gov/healthyweight/bmi/calculator.html>.

Weight loss can contribute to improved health. Modest weight loss (5% to 10% of total weight) can decrease risk factors for weight-related health problems and reduce blood pressure, blood sugar, and cholesterol.⁶ Most dietitians and other medical professionals recommend gradual weight loss

programs emphasizing reduced calorie intake and increased exercise, but some patients request or require pharmaceutical assistance to accomplish their weight goals. Medications approved for use in weight loss programs work either by decreasing nutrient absorption or suppressing appetite. Prescription weight loss medications are generally individualized based on patient goals and health issues.

Because calories are absorbed through the gastrointestinal tract, reducing energy-nutrient absorption can cause weight loss. While various products have been marketed as *blockers* of carbohydrate absorption, the only weight loss medication approved by the U.S. Food and Drug Administration (FDA) to decrease calorie absorption is a lipase inhibitor, orlistat, which reduces the ability of the gastrointestinal tract to process dietary fats. Orlistat prevents absorption of about 30% of dietary fat, which then passes through the bowel for evacuation. Because excess unabsorbed fat can cause uncomfortable side effects, including fecal incontinence, urgency, and intestinal gas, patients who reduce their fat consumption find the drug more tolerable, thus losing even more weight from additional caloric restriction. It is recommended that patients begin a reduced-fat diet 3 or more days before beginning to take orlistat. Doses are taken only with meals containing fat and skipped when meals are skipped or are without fat. Because orlistat interferes with fat absorption, it can also reduce absorption of fat-soluble vitamins (A, D, E, and K), so it is recommended that patients also take a multivitamin, timed at least 2 hours before or after the orlistat dose.

Orlistat is available as an OTC product, Alli, which is packaged with extensive instructions and access to an online diet plan. Patients purchasing Alli should be reminded to read all of the accompanying literature. A higher-strength capsule, Xenical, is available only by prescription, but it is the same drug with the same actions. Alli is approved for use in weight-loss plans of up to 6 months, but Xenical also carries an indication for maintenance of weight loss.

CASE?

Mrs. Broskie purchased Alli at the pharmacy but was too busy to read the directions. She complains that she has an upset stomach, especially when she eats her favorite fried eggs and bacon breakfast in the hospital cafeteria. Should she stop taking Alli? What do you think the pharmacist might advise?

Appetite suppressants, called anorexiant, can assist patients in following a calorie-restricted diet. Anorexiant currently approved by the FDA are benzphetamine, diethylpropion, phentermine (also available as a combination product, with topiramate), and phendimetrazine. They work by stimulating the sympathetic (adrenergic) nervous system, increasing norepinephrine release and/or transmission in the central nervous system. (Refer to Chapters 4 and 5.) These drugs, related to amphetamines, are effective in suppression of appetite and are recommended only for short-term use as part of a weight-reduction plan based on caloric restriction. All are considered to have abuse potential, and extended use (longer than a few weeks) is contraindicated. While results are not dramatic, these drugs have been shown to cause increased weight loss in some patients. Common side effects of drugs in this category include cardiovascular issues (palpitations, increased heart rate, and blood pressure), central nervous system effects (stimulation, insomnia, restlessness), and gastrointestinal effects (nausea, constipation, stomach pain), along with mouth dryness and changes in urinary frequency and libido. Patients with diabetes may experience changes in their patterns of blood sugar and insulin needs that do not necessarily parallel their weight loss. Anorexiant are not currently recommended for patients with cardiovascular disease, severe chronic kidney disease or liver impairment, psychosis, or glaucoma.¹⁰

A combination product containing naltrexone, an opioid antagonist, and bupropion, also used in substance use disorders, has been shown to be effective for weight management in some patients, and is classified as an anorexiant combination. Its use is contraindicated in patients with uncontrolled hypertension, severe kidney or liver disease, glaucoma, seizure disorders, and most patients diagnosed with substance use disorders. It is also not recommended for patients with binge eating disorders, or for adolescents and young adults suffering from depression.¹⁰

ALERT!

The combination product naltrexone and bupropion (Contrave) used for weight management carries a boxed warning for suicidal thoughts or actions and a medication guide must be dispensed along with all prescriptions for it.

PRACTICE POINT

Currently all approved anorexiant except naltrexone/bupropion are considered by the Drug Enforcement Administration (DEA) as controlled substances in schedule III or IV, with prescribing restrictions and limited refills.

Glucagon-like peptide 1 (GLP-1), a substance normally produced in the body, has many actions related to glucose metabolism and insulin release (see Chapter 10). A group of agents known as GLP-1 receptor agonists that mimic the actions of naturally produced GLP-1 is used in the treatment of type 2 diabetes. GLP-1-receptor agonists are known to reduce appetite and/or increase feelings of fullness, so a logical extension is use in weight management. Although five different GLP-1-receptor agonists are available for diabetes therapy, only one of these, liraglutide, has FDA approval for use in weight management. The product with this approval, Saxenda, has the same generic name as one approved for diabetes, but only Saxenda is labeled for this indication (and *not* for diabetes mellitus). Unlike other pharmacotherapy for weight management, liraglutide must be administered not by mouth but by subcutaneous injection every day. It is a recommended weight management treatment for patients who suffer from or are at risk for type 2 diabetes, but should not be used for this purpose by patients who are already being treated with a GLP-1-receptor agonist.

PRACTICE POINT

In the pharmacy, liraglutide must be refrigerated (at 2°C–8°C), and discarded if freezing occurs. After initial use, patients may choose to keep it in the refrigerator or at room temperature (below 86°F). Each pen syringe must be discarded 30 days after first use regardless of storage conditions.¹¹

FDA-approved medications for use in weight loss are listed in **Medication Table 24-2**.

Numerous other therapies, some prescription and some OTC, have been and continue to be used to promote weight management. Some physicians favor off-label prescribing (for indications not approved by the FDA) of other drugs, including antidepressant agents, for weight loss. If enough

ALERT!

Liraglutide is currently classified as a hazardous drug, although the prefilled syringes may be excluded from some handling requirements. Gloves should be worn while receiving, unpacking, and placing the product in storage.¹²

ALERT!

Liraglutide has a black box warning for risk of thyroid tumors. Patients must receive the required medication guide when the product is dispensed.

data can be collected, some of these may, like bupropion, eventually be approved for use in weight management.

Finally, a wide variety of complementary and alternative therapies are available OTC and used by some patients hoping for assistance in weight management. These include bitter orange, guarana extract, and various diet teas, which appear to act in ways similar to the FDA-approved appetite suppressants, although recommended safe doses have not been documented (and they could be dangerous if added to prescription anorexiants therapy). Other “natural” supplements popularized on the Internet and in lay publications for weight loss include calcium pyruvate, chromium picolinate, chitosan, *Garcinia*, and *Hoodia*. These have not been studied scientifically, and most are unclear on even their mechanism of action, let alone a recommended safe dose, and should be avoided until further information is available. Products containing the herb *Ephedra* have been promoted for weight loss and may still be obtained from international sources, but the FDA has banned their legal sale in the United States.

SUMMARY

Adequate and proper nutrition is vital to the life and health of all human beings. Energy and nonenergy nutrients must be supplied in proper amounts to maintain body function and, while the best way to accomplish this is by consumption of a balanced diet, some patients require nonfood

supplementation. Overweight and obesity are conditions that can contribute to health problems, and medication therapy can be useful in weight management.

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REVIEW QUESTIONS

1. Name the energy nutrients and give the energy yield and common dietary sources of each.
2. List the fat-soluble vitamins and explain why it is dangerous for patients to over-supplement with them.
3. What are the components of enteral nutrition products? How can they be administered?
4. What are the components of PN? How is it administered?
5. How does orlistat work to promote weight loss?

MEDICATION TABLES

MEDICATION TABLE 24-1. Vitamins and Essential Nutrients^{2,3,7,8a}

Type	Vitamin	Chemical Name(s)	Functions	Food Sources	Adult Recommended Dietary Allowance or Daily Adequate Intake ages 31–50 (male/female)	Tolerable Upper Intake (TUI)	Deficiency May Result In	Toxicity	Drug/Nutrient Interactions ⁵	Brand Name
A		Retinol (REH tin ol), Beta carotene (bay tuh KAYR oh teen)	Vision, protein synthesis, skin, reproduction, growth	Fortified milk, egg yolks, and cheese; dark leafy green vegetables and broccoli; dark orange fruits and vegetables	Male/female 900/700 mcg	3,000 mcg/day	Skin disorders, diarrhea, eye damage, night blindness, total blindness, dry skin, poor growth, poor immune response	Liver damage, bone fractures, dry skin, intestinal disturbances	Statins and oral contraceptives can increase levels; cholestyramine, orlistat, and neomycin decrease absorption	Aquasol-A
D		Calcitriol (kal si TRYE ole), cholecalciferol (kol eh kal SIF er ol), ergocalciferol (ER goh kal SIF er ol), paricalcitol (payr ih KAL si tol)	Bone growth/maintenance through calcium and phosphorus absorption	Fish liver oils; fatty fish, liver; sunshine on skin; fortified milk and cereals	Male/female 15 mcg (600 IU)	100 mcg (4,000 IU)	Osteomalacia, rickets in children	Kidney damage, mineral deposits in soft tissue	Anticonvulsants, cimetidine, heparin, isoniazid, and neomycin may interfere with absorption and/or activity	Rocaltrol, Drisdol, Zemplar
E		Alpha-tocopherol (AL fa tuh KOF er ol)	Antioxidant	Wheat germ, nuts, seeds, vegetable oils, egg yolks, dark leafy green vegetables	Male/female 15 mg	1,000 mg alpha-tocopherol	None established	Bleeding due to interference with vitamin K	May increase effects of oral anticoagulants	E-400, Nutr-E-Sol, Solu-Vita E

Continued next page

Fat Soluble

MEDICATION TABLE 24-1. Vitamins and Essential Nutrients^{2,3,7,8a} (Continued)

Type	Vitamin	Chemical Name(s)	Functions	Food Sources	Adult Recommended Dietary Allowance or Daily Adequate Intake ages 31–50 (male/female)	Tolerable Upper Intake (TUI)	Deficiency May Result In	Toxicity	Drug/Nutrient Interactions ⁵	Brand Name
	K	Phytonadione (fytone)	Blood clotting, prevention of bleeding, bone health, fracture healing	Liver, cabbage, dark leafy vegetables, broccoli, citrus fruits	Male/female 120/90 mcg	TUI not determined	Easy bruising/bleeding	Rare	May interact with aspirin, antibiotics, anticoagulant/antiplatelet drugs, doxorubicin, laxatives, weight-loss medications, antiseizure medications, and warfarin; individuals should consult a physician before beginning a vitamin K regimen	Mephyton
Fat Soluble	B1	Thiamin, Thiamine (THYE amin)	Coenzyme in energy metabolism, nerve function	Pork, enriched breads/cereals, black beans, nuts	Male/female 1.2/1.1	TUI not determined	Beriberi (weak; poor muscle coordination, digestion, nerve function, cardiovascular function, and digestion)		Deficiencies have been associated in patients on phenytoin and some diuretics; people who consume a lot of carbohydrates or high-calorie diets need more thiamin	
Water Soluble	B2	Riboflavin (RYE bohin)	Coenzyme in energy metabolism	Milk, milk products, whole grains, enriched breads/cereals	Male/female 1.3/1.1 mg	TUI not determined	Skin, mucous membranes deficient, cracks on lips and corners of mouth	None known	Chlorpromazine, doxorubicin, and possibly oral contraceptives reduce the conversion of riboflavin to its active form	B-2-400

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MEDICATION TABLE 24-1. Vitamins and Essential Nutrients^{2,3,7,8a} (Continued)

Type	Vitamin	Chemical Name(s)	Functions	Food Sources	Adult Recommended Dietary Allowance or Daily Adequate Intake ages 31–50 (male/female)	Tolerable Upper Intake (TUI)	Deficiency May Result In	Toxicity	Drug/Nutrient Interactions ⁵	Brand Name
B3	Niacin (NVE a sin)	Coenzyme in energy metabolism, protein and fat metabolism; vasodilator	Protein-rich foods: meats, fish, poultry, dairy, eggs, enriched breads/cereals	Male/female 16/14 mg	35 mg/day	Pellagra (diarrhea, dementia, dermatitis, death)	Red skin flush, upset digestion	May interfere with diabetes medications and increase toxicity of statins and carbamazepine		
B5	Pantothenic acid (pan TOE then ik)	Coenzyme in energy metabolism, and protein metabolism, production of essential body compounds	Whole grains, legumes, nuts, seeds, animal protein	Male/female 5 mg	TUI not determined	None known			Panto-250	
B7 (also known as vitamin H or coenzyme R)	Biotin (BYE oh tin)	Coenzyme in carbohydrate metabolism, production of proteins and fats	Eggs, milk, liver, mushrooms, bananas, tomatoes, whole grains, nuts, brewer's yeast; also produced by bacteria in the intestines	Male/female 30 mcg	TUI not determined	Rare: skin rash, hair loss, damage to nerves			Meribin	

Water Soluble

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MEDICATION TABLE 24-1. Vitamins and Essential Nutrients^{2,3,7,8a} (Continued)

Type	Vitamin	Chemical Name(s)	Functions	Food Sources	Adult Recommended Dietary Allowance or Daily Adequate Intake ages 31–50 (male/female)	Tolerable Upper Intake (TUI)	Deficiency May Result In	Toxicity	Drug/Nutrient Interactions ⁵	Brand Name
	B6	Pyridoxine (per i DOX een)	Coenzyme in amino acid metabolism, especially for nervous system, red and white blood cell production, and heart disease	Meats, fish, poultry, whole grains, nuts and seeds, dried fortified cereals, soybeans, avocados, baked potatoes with skins, watermelon, plantains, bananas, peanuts, and brewer's yeast	Male/female 1.3 mg/day	100 mg/day	Associated with heart disease, skin problems and nervous system disorders, mouth sores, small-cell type anemia, insulin sensitivity; increased risk for kidney stones	Nerve damage to the limbs, which may cause numbness, trouble walking, and pain; very high doses can cause symptoms of instability and numbness in the feet and hands, which may be permanent in some cases; of specific concern are possible adverse effects on nerve development in the offspring of pregnant women who take large doses, such as for morning sickness	The following drugs interfere with vitamin B6 status: isoniazid, hydralazine, phenelzine, cycloserine, estrogens, theophylline, corticosteroids, erythromycin, gentamicin, neomycin, sulfonamides, alcohol, and caffeine	Pyri-500

Water Soluble

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MEDICATION TABLE 24-1. Vitamins and Essential Nutrients^{2,3,7,8a} (Continued)

Type	Vitamin	Chemical Name(s)	Functions	Food Sources	Adult Recommended Dietary Allowance or Daily Adequate Intake ages 31–50 (male/female)	Tolerable Upper Intake (TUI)	Deficiency May Result In	Toxicity	Drug/Nutrient Interactions ⁵	Brand Name
	B9 (this name is seldom used)	Folic acid, folate (FOE lik) (FOE late)	Important for the formation of RNA and DNA as well as new cell formation, protein metabolism, and growth; it is used in the manufacturing of neurotransmitters (chemical messengers in the brain), in protecting the heart via its influence on homocysteine	Liver, legumes, avocado, bananas, orange juice, cold cereal, asparagus, green leafy vegetables, and yeast; folic acid is now added to commercial breads and cereals	Male/female 400 mcg/day (600 mcg/day in pregnancy, 500 mcg/day in lactation)	1,000 mcg/day	Megaloblastic anemia, depression, poor growth, nerve and impairments in concentration, memory, and hearing	High levels may, especially in older adults, hide signs of B12 deficiency, a condition that can cause nerve damage	May interfere with anticonvulsants and methotrexate; absorption and activity can be decreased by including oral contraceptives, aspirin, indomethacin, famotidine, some antibiotics (tetracycline, isoniazid, cycloserine, erythromycin, sulfonamides), and cholestyramine; may reduce blood levels of levodopa and some anticonvulsants	FA-8

Water Soluble

Continued next page

MEDICATION TABLE 24-1. Vitamins and Essential Nutrients^{2,3,7,8a} (Continued)

Type	Vitamin	Chemical Name(s)	Functions	Food Sources	Adult Recommended Dietary Allowance or Daily Adequate Intake ages 31–50 (male/female)	Tolerable Upper Intake (TUI)	Deficiency May Result In	Toxicity	Drug/Nutrient Interactions ⁵	Brand Name
B12	Cyanocobalamin (cyanocobalamin), hydroxycobalamin, and methylcobalamin	Production of red blood cells, manufacturing genetic material (DNA and RNA), and healthy functioning of the nervous system; B12 works closely with folate	Animal products only (not in vegetables), including meats, dairy products, eggs, and fish (clams and oily fish are very high in B12); B12 is added to commercial dried cereals	Male/female 2.4 mcg/day	TUI not determined	Low levels of folate during pregnancy increase risk of birth defects in newborns	B12 requires an intrinsic factor that is produced in the stomach for absorption; without the intrinsic factor dietary B12 is useless	Folic acid supplementation may mask B12 deficiencies; vitamin C and iron supplements may interfere with its bioavailability; blood levels may be reduced by zidovudine, antacids, metformin, oral contraceptives, and some antibiotics	Nascobal	
C	Ascorbic acid (vitamin C)	Acts as an antioxidant (reduces harm from damaging chemical processes in the body) and as such plays a role in the immune system;	Citrus fruits and juices, strawberries, papayas, hot chili peppers, bell peppers, broccoli, potatoes, dark leafy greens, kale, red cabbage, and brussels sprouts	Male/female 90/75 mg/day	2,000 mg/day	Scurvy is the primary deficiency disease; it affects most body tissues, particularly bones, teeth, and blood vessels; symptoms include bleeding gums, wounds that won't heal, rough skin, and wasting away of the muscles; deficiencies may contribute to periodontal disease and gallstones;	High doses may cause nausea and diarrhea, may increase risk of kidney stones; ascorbic acid increases iron absorption so people with blood disorders, such as hemochromatosis, thalassemia, or sideroblastic anemia, should avoid high doses;	Increases absorption of iron; may interfere with absorption of copper and chromium and reduce efficacy of some chemotherapy	Acerola-C, Fruit C	

Continued next page

Water Soluble

MEDICATION TABLE 24-1. Vitamins and Essential Nutrients^{2,3,7,8a} (Continued)

Type	Vitamin	Chemical Name(s)	Functions	Food Sources	Adult Recommended Dietary Allowance or Daily Adequate Intake ages 31–50 (male/female)	Tolerable Upper Intake (TUI)	Deficiency May Result In	Toxicity	Drug/Nutrient Interactions ⁵	Brand Name
	Choline (KOE leen)	Essential for fetal brain development and for learning and memory; it aids with the movement of fat into cells and decreases fat content in the liver; choline is a precursor of acetylcholine, a neurotransmitter, and it plays a role in phospholipid and homocysteine synthesis	essential for the production of collagen, the basic protein in bones, cartilage, tendons, and ligaments	Liver, peanuts, eggs, and milk	Male/female 550/425 mg/day	Liver damage	uncommon in the U.S., usually occurring in the elderly, alcoholics, cancer patients, and some people on severely limited diets low in fresh fruits and vegetables	large doses may also thin blood and interfere with anticoagulant medications, blood tests used in diabetes, and stool tests		
Water Soluble					3,500 mg/day		Fishy body odor, vomiting, sweating, low blood pressure, and gastrointestinal problems			

^a Pronunciations have been adapted with permission from USP Dictionary of USAN and International Drug Names (USP Dictionary) © 2022.

MEDICATION TABLE 24-2. Agents Used for Weight Loss^{7,8}

Category	Generic Name	Brand Name	Dosage Form	Usual Dose	Length of Therapy	Regulatory Status
Lipase inhibitor	Orlistat (OR listat)	Alli	Capsule	60 mg 1-3 times daily	Up to 6 months	OTC
		Xenical	Capsule	Up to 120 mg 3 times daily	Up to 2 yr	Rx
Anorexiant	Benzphetamine (benz FET ameen)	Various generics	Tablet	25-50 mg 1-3 times daily	2-4 wk	aRx (C-III)
	Diethylpropion (dye eth il PROE pee on)	Various generics	Tablet, IR	25 mg 3-4 times daily	2-4 wk	Rx (C-IV)
			Tablet, CR	75 mg daily	2-4 wk	Rx (C-IV)
	Phendimetrazine (fen dye ME tra zeen)	Various generics	Capsule, ER	105 mg every morning before breakfast	Up to 12 weeks	Rx (C-III)
			Tablet, IR	17.5-35 mg 2-3 times daily one hour before meals		
Phentermine (FEN ter meen)	Adipex-P and generics	Tablet	15-37.5 mg total per day in 1 or 2 doses	2-4 wk	Rx (C-IV)	
		Capsule				
	Lomaira	Tablet	8 mg 3 times daily			
Glucagon-like Peptide-1 antagonist	Liraglutide (lir a GLOO tide)	Saxenda	Solution (pen injector)	0.6-3 mg SUBQ once daily	Indefinite	Rx
Combination products	Naltrexone and Bupropion (nal TREKS one, byoo PROE pee on)	Contrave	Tablet, ER (naltrexone 8 mg and bupropion 90 mg)	2 tablets twice daily	Indefinite; discontinue after 12 weeks if 5% weight loss not achieved	Rx
	Phentermine and topiramate (FEN ter meen, toe PYRE a mate)	Qsymia	Capsule, ER (phentermine/topiramate 3.75 mg/23 mg, 7.5 mg/46 mg, 11.25 mg/69 mg, 15 mg/92 mg)	1 capsule of prescribed strength once daily	Indefinite; gradually discontinue after 12 weeks if 5% weight loss not achieved on maximum dose	Rx (C-IV)

CR = controlled release; ER = extended release; IR = immediate release; OTC = over the counter; SUBQ = subcutaneous.

