## Skills for Success Curriculum Resource Cover Page

**Organization**

College Sector Committee for Adult Upgrading (CSC)

**Curriculum Resource**

***Food Services Preparation Module 4 - Basic Kitchen Science***

This module is the fourth in a five-part series. It can be used to support learners in LBS and/or pre-apprenticeship who are interested in food service/cooking. This module covers science fundamentals as they apply to cooking, specifically nutrition, basic digestion, and heat. Although learners do not need background in basic science, there are terms and concepts that may require some additional explanation. A multiple-choice assessment (including the answer key) is included at the end of the module.

**OALCF Alignment**

| Competency | Task Group | Level |
|---|---|---|
| Competency A -Find and Use Information | A1. Read continuous text | 3 |
| Competency B - Communicate Ideas and Information | A2. Interpret documents | 3 |

**Goal Paths (check all that apply)**

☒ Employment
☒ Apprenticeship
☐ Secondary School Credit
☒ Postsecondary
☒ Independence

**Embedded Skills for Success (check all that apply)**

☒ Adaptability
☒ Collaboration
☒ Communication
☒ Creativity and innovation
☒ Digital
☒ Numeracy
☒ Problem Solving
☒ Reading
☒ Writing

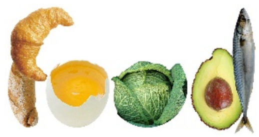
**Notes:**

This resource can be used in a teacher-led or self-directed format.
Note that fonts used in the equation editor differ from the rest of the text.
The opinions expressed in this document are the opinions of the College Sector Committee for Adult Upgrading. The Government of Ontario and its agencies are in no way bound by any recommendations contained in this document

**Table of Contents**

## Introduction

This resource is the fourth in a five-part series pertaining to the basic theory used in the kitchens of food service establishments, such as restaurants, cafeterias, and food trucks. The previous three modules focused on the basic mathematics practiced in kitchens. This module focuses on basic kitchen science. All employees, including managers and owners, who prepare food should have a basic understanding of the fundamental principles pertaining to kitchen science.



This module introduces the fundamentals of kitchen science in the following sequence: nutrition, digestion, and heat.

- The first chapter covers the basics of nutrition in the following order: essential nutrients, energy, Canada's Food Guide, and nutrition labels.
- The second chapter covers the basics of digestion.
- The third chapter will cover the concept of heat, as well as its effects on macronutrients.
- The end of each chapter contains a discussion question section to assist learners in consolidating the content of each chapter.
- The module concludes with a multiple-choice test.

This resource partly follows the theoretical outline found in the textbook of Labensky et al. (2006), *On Cooking: A Textbook of Culinary Fundamentals.*

If at any time a learner encounters difficulties with the content of this resource, the instructor can provide assistance.

## Acknowledgement

The *College Sector Committee for Adult Upgrading* would like to thank Professor Christopher Prechotko (Cambrian College) for researching and authoring this resource for use by Literacy and Basic Skills/Academic Upgrading programs across Ontario.

## Chapter 1 – Nutrition

Nutrition is a process that entails consuming an appropriate quantity, quality, and diversity of food for the growth and health of an organism. Nutritional science is the study of nutrients contained in food and the effects of these nutrients on organisms in different environments. For example, sports nutrition is a field concerned with optimizing athletic performance.

In addition, nutritionists are professionals who help individuals develop a personalized diet, based on numerous factors, such as age, activity level, income, and health. Nutritionists also educate and counsel individuals, groups, and communities on their food choices while considering local food availability and environment.

Cooks are professionals who should also concern themselves with nutrition. First, cooks should consider their personal nutrition needs, so they are properly nourished to maintain their activity inside and outside the kitchen. Cooking is a rewarding career. However, it also involves long hours of continuous standing, lifting, carrying, moving, and sweating in hot, at times humid, environments.

Additionally, cooks should concern themselves with the nutritional needs of their customers. This can be done by creating menus with a wide variety of food options and/or some healthy food options. Skillfully applying various cooking methods and techniques can also help to preserve the nutritional quality of food during the cooking process. In addition, cooks may work closely with nutritionists to provide nutritious food to specialized populations. For instance, nutritionists and cooks could collaborate to build an appropriate menu for the residents of a long-term care facility.

This chapter covers the following topics: essential nutrients, Canada's Food Guide, and nutrition labels.

## Essential Nutrients

All humans require *essential nutrients* for survival because the human body cannot grow and maintain health without balanced nutrients. Essential nutrients fall under two main categories: *macronutrients* and *micronutrients*.

### *a) Macronutrients*

The three energy providing *macronutrients* are carbohydrates, lipids, and proteins. These essential nutrients are required to provide the body with energy and the necessities for growth, development, and health. We can also classify water as a macronutrient although it does not provide the body with energy, like the previous three macronutrients do.

#### i. Carbohydrates

*Carbohydrates* are the main source from which the human body acquires energy. Many foods contain carbohydrates, even animal protein, but the primary sources of carbohydrates in our diets are from plant-based foods and dairy products.

Carbohydrates are composed of carbon, oxygen, and hydrogen atoms in various structural arrangements. There are two main categories of carbohydrates to know: *simple* and *complex*.

There are two forms of *simple* carbohydrates (simple sugars): *monosaccharides* and *disaccharides*. (You may have heard of these before.)

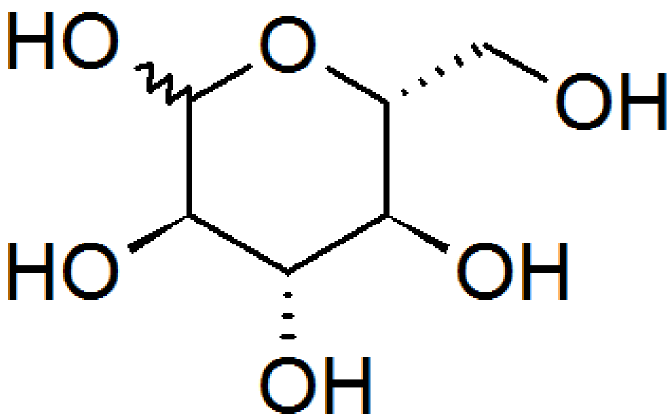
*Monosaccharides* contain one sugar unit, and they are the simplest of sugars; the digestive system does not break monosaccharides into smaller pieces because the human body readily absorbs them from the digestive system into the blood stream.

Three important single sugars found in food are *glucose* (main source of fuel for human cells, see Figure 1), *fructose* (fruit sugar, see Figure 2), and *galactose* (part of milk sugar, see Figure 3).

(Note that in all the figures in this resource that show the structure of a molecule, the letters represent the different atoms (small particles) that comprise the molecule (larger particle). Some of the most common atoms you'll see in these figures are carbon (C), hydrogen (H), and oxygen (O). The lines connecting the different parts of the molecule are called "bonds". The bonds hold all of the atoms in place within the molecule.)

**Figure 1.**

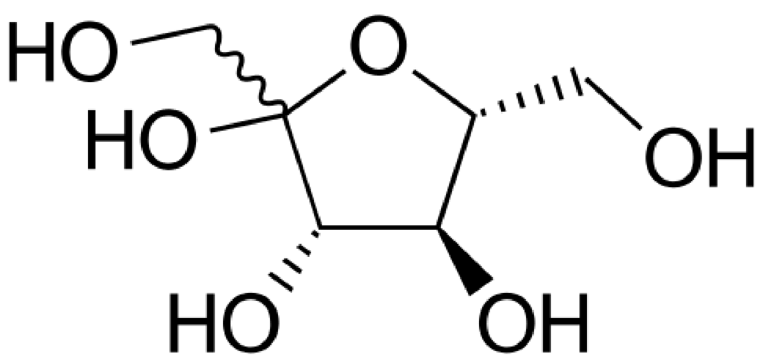
Glucose Molecule




*Note.* Cyclic Form (Source: Physchim62, 2009).

**Figure 2.**

*Fructose Molecule*

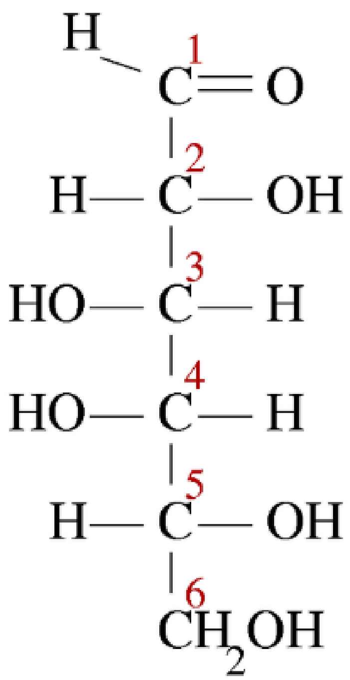



*Note.* Cyclic Form (Source: Darkness3560, 2012).

You can see that both the **glucose** and **fructose** molecules shown above are made of oxygen and hydrogen atoms, but those atoms are connected in a different pattern in each molecule. The different shape and structure of these two molecules gives them different characteristics.

**Figure 3.**

*Galactose Molecule*




*Note.* Fischer Projection (Source: Hooft, 2004).

Unlike monosaccharides like glucose and fructose, *disaccharides* are made of two monosaccharides. They are composed of two of the same or two different monosaccharides, linked together with a bond.

The digestive system (in the human body) must break disaccharides into two single sugar units (monosaccharides) before the sugars can be absorbed into the blood stream and used by the body.

Three commonly known disaccharides are

- *lactose* (also known as milk sugar, see Figure 4);
- *sucrose* (also known as table sugar, see Figure 5); and
- *maltose* (also known as malt sugar, see Figure 6).

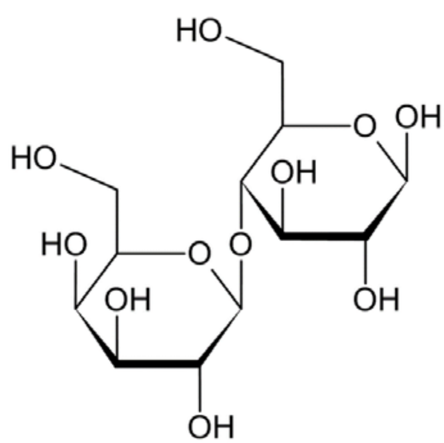
*Lactose* is composed of one glucose unit and one galactose unit. *Sucrose* is composed of one glucose unit and one fructose unit, and *maltose* is composed of two glucose units.

If someone doesn't have enough sugar in their blood ('low blood sugar'), the quickest way to replenish blood sugar is to eat foods that contain simple sugars, like fruit juice which contains the monosaccharide fructose. As a rule, the simpler the sugar, the quicker it is for the body to digest, absorb into the blood stream and, consequently, raise blood sugar levels.

Below are diagrams of **lactose, sucrose**, and **galactose** molecules. Notice that their structure is more complex (more atoms and bonds) than in the monosaccharides (glucose and fructose).

**Figure 4.**

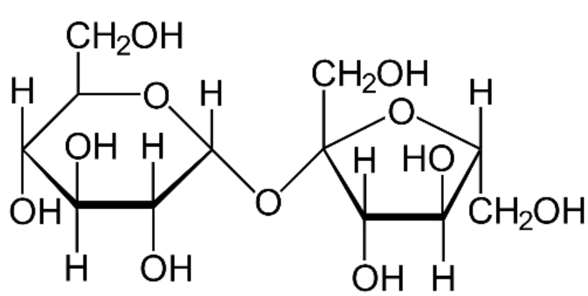
*Lactose Molecule*




*Note.* Haworth Projection (Source: Assaiki, 2009).

**Figure 5.**

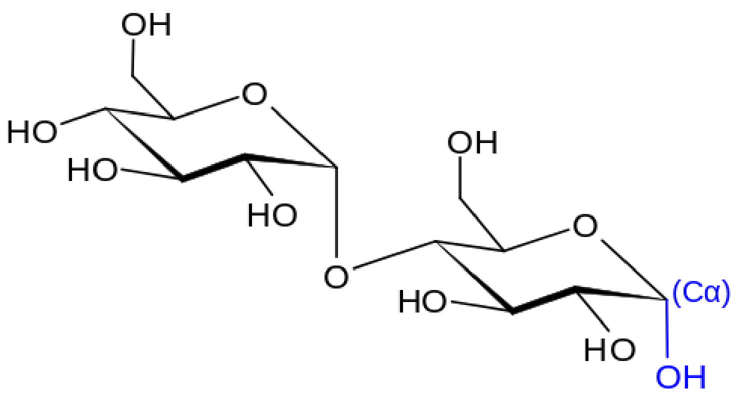
*Sucrose Molecule*




*Note.* Sucrose structure formula (Source: Carlson, 2007).

**Figure 6.**

*Maltose Molecule*




*Note.* Adapted Image from Maltose Epimerase (Source: J3D3, 2014).

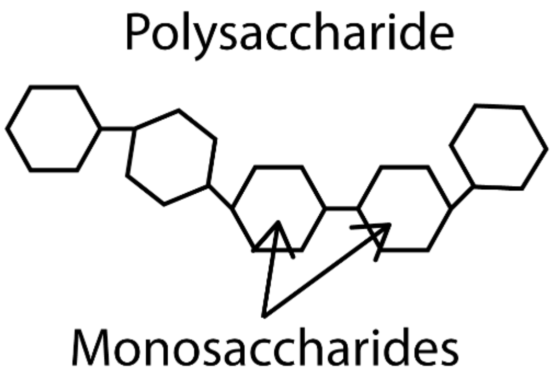
*Complex* carbohydrates, also known as *polysaccharides* (see Figure 7), are long chains of sugar units (monosaccharides) linked together with bonds. For example, an important polysaccharide found in plant-based food is *starch*, and an important polysaccharide found in animal and human muscle is *glycogen*.

Complex carbohydrates are found in foods such as pasta and bread. Since these carbohydrates are composed of long chains of monosaccharides, digestion of these macromolecules requires more energy and time than either monosaccharides or disaccharides do. As a result, the digestion of complex carbohydrates raises blood sugar levels at a slower rate than the digestion of simple sugars.

Eating complex carbohydrates is a great way to store “reserve energy” for endurance events, like marathon running. Endurance athletes will “carb load” for a few days leading up to an event, so their bodies have an energy surplus to access during the event. These athletes may also consume food with simple sugars during the event, for a quick boost of sugar in the blood stream when it is needed, e.g., sports drinks or gels.

**Figure 7.**

*Polysaccharide Molecule*




You can see that the *polysaccharide* molecule is made up of many smaller *monosaccharides*

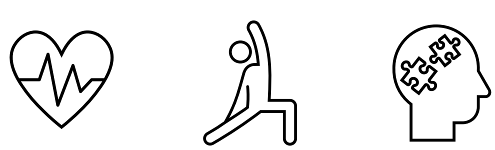
*Note.* Adapted image of polysaccharide hydrolysis (Source: Greenwood, 2018).

Finally, *fibre* is also a complex carbohydrate found in the plant-based foods we eat. One type of fibre is *cellulose*. For example, cellulose is ingested when wholegrain foods, like wheatberries or brown rice, are eaten. The human body cannot digest fibre because it cannot be broken down into single sugar units by the human digestive system, so fibre enters and leaves the digestive tract undigested.

Eating fibre is an important tool in the maintenance of health because fibre helps with the digestion of other macronutrients and prevents constipation. Typically, healthy, active persons do not require additional fibre in their diet if they eat enough whole grain foods.

### ii. Lipids

*Lipids* are substances that contain carbon, hydrogen, and oxygen in different numbers and molecular arrangements (shapes) than carbohydrates do. Lipids are another source of energy for the human body. Also, lipids provide the human body with the building blocks for cell membranes, hormones, and many other anatomical and physiological needs to support good health.

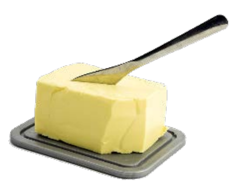


Lipids found in food are *saturated fatty acids*, *unsaturated fatty acids*, *glycerol*, *saturated fats*, *trans-saturated fats*, *unsaturated fats*, and *cholesterol*. Most foods contain some quantity of lipid. Many foods contain a mix of these lipids, not just one.

For instance, high concentrations of saturated fats and cholesterol are mostly found in animal-based food products like meat, cheese, and butter while some plant-based foods, like coconut, can also contain a high concentration of saturated fat.

High concentrations of unsaturated fats are typically found in plant-based foods like nuts, seeds, and vegetable oils. However, some animal-based foods can also be high in unsaturated fats. As an example, fish and fish oils, like salmon and cod, contain mostly unsaturated fats and a small amount of saturated fats and cholesterol.

In the kitchen, it can be relatively easy to identify forms of saturated fat and unsaturated fat. Saturated fats, such as butter and lard, are solid at room temperature while unsaturated fats, such as olive oil and canola oil, are liquid at room temperature. Also, unsaturated fats can be chemically converted into saturated fats.



A process that converts unsaturated fat into saturated fat is called *hydrogenation* (see Figure 8). Hydrogenation is a chemical reaction where unsaturated fats are reacted with hydrogen gas and a nickel catalyst. (A catalyst is a substance that makes a chemical reaction go faster.) Margarine is an example of a food product created by hydrogenation. In the process of making margarine, some of the unsaturated fats in vegetables oils are saturated. Consequently, margarine is solid at room temperature because it is composed of enough saturated fats to be solid at that temperature.

Hydrogenation does have drawbacks. Earlier forms of hydrogenation produced artificial *trans-saturated fats*, which are unhealthier to humans than saturated fats. Research has found that the ingestion of *trans-fats* increases the chance of acquiring cardiovascular (heart) diseases, so artificial trans-fats have been banned from food products in Canada.

Hydrogenation is still used in the process of making some margarines, but the process is now better controlled to ensure there is a negligible amount of trans-fat in the final product. However, it is still recommended to avoid hydrogenated foods as much as possible because saturated fats have been found to negatively affect cardiovascular health.

**Figure 8.**

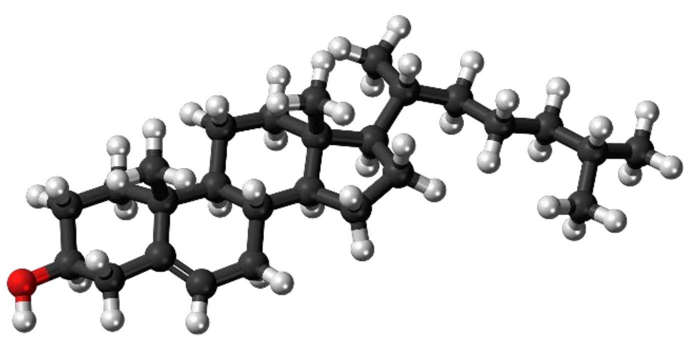
*Hydrogenation of an Unsaturated Fat (simplified)*

Unsaturated Fat + Hydrogen + Nickel → Saturated Fat

Researchers have concluded that *unsaturated fats* are typically healthier than saturated fats. It is recommended that humans ingest mostly unsaturated fats while limiting saturated fats to maintain cardiovascular and overall health. Also, the human body can make its own *cholesterol* (see Figure 9), so cholesterol is not an essential nutrient. In fact, it is recommended to limit the intake of cholesterol to reduce the chances of cardiovascular disease with age.

**Figure 9.**

*Cholesterol*



*Note.* Ball and stick model of cholesterol (Source: Jynto, 2011).

### iii. Proteins

*Proteins* are compounds that contain mostly carbon, oxygen, hydrogen, nitrogen, and sulfur atoms in different molecular arrangements. In fact, the human body acquires most of the nitrogen and sulfur it needs to function from proteins.

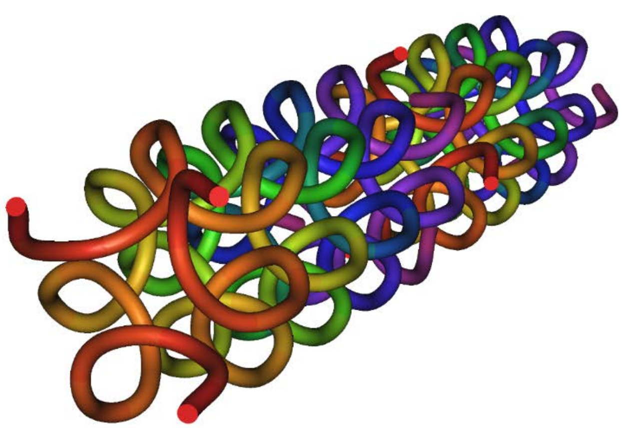
Additionally, proteins are made up of long and folded chains of building blocks called *amino acids* (see Figure 11). Some proteins are composed of multiple chains arranged in helical and/or sheet-like structure (see Figure 10).

There are twenty amino acids found in animal and plant protein. Eleven amino acids can be produced by the body, known as *non-essential* amino acids, while the other nine amino acids cannot be made by the body. Those are known as *essential* amino-acids, and they must be obtained from food.

Proteins provide the body with some energy, but more importantly, proteins provide the body with the building blocks needed to grow and repair itself.

**Figure 10.**

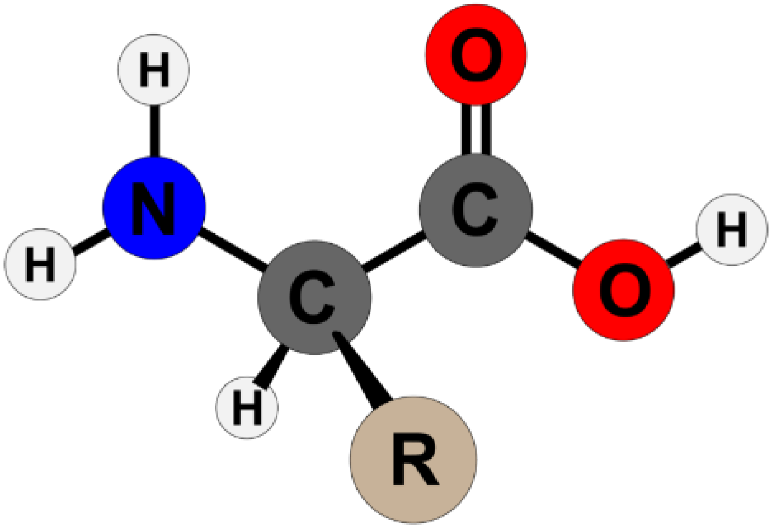
*Protein Molecule*



*Note.* Collagen molecule with triple helical structure (Source: Dilmen, 2002).

**Figure 11.**

*Basic Amino Acid Structure*




In this figure we see atoms of hydrogen, carbon, oxygen, and nitrogen (N). The "R" is a placeholder for other atoms, depending on the type of amino acid.

*Note.* *(Source: Techguy78, 2020).*

The highest concentrations of protein are found in animal products, like meat and dairy. Animal products contain all the essential amino acids, so they are referred to as complete proteins.

Grains and legumes also contain proteins, but they contain lower quantities of protein than animal products do. On their own, grains and legumes are not complete proteins because neither group contains all the essential amino acids, except for plant-based foods such as quinoa, buckwheat, and soy. Quinoa, buckwheat, and soy contain all the essential amino acids required for a healthy body.

As previously mentioned, grains and legumes do not contain all the essential amino acids needed. However, if both legumes and grains are eaten, the body will be nourished with all the essential amino acids required to comprise a complete protein diet. It is recommended to include both grains (e.g., rice) and legumes (e.g., beans) in a diet that is low in (or free of) animal food products.

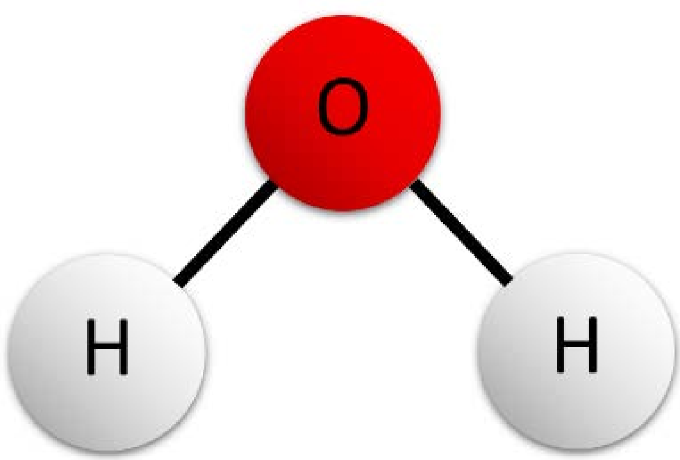
### iv. Water

A *water* molecule is composed of one oxygen and two hydrogen atoms (see Figure 12). It can be considered an essential macronutrient, but unlike the other macronutrients it does not provide the body with energy. The human body is 60% water, so ingesting water is critical for the survival of the human organism.

The human body uses water for various purposes. On of the primary purposes is to create blood. Blood transports nutrients to areas of the body that need them, and it also transports waste products away from cells for excretion. Other purposes of water are to maintain cell structure and regulate heat. For example, the body sweats to regulate heat.

**Figure 12.**

*Water Molecule*




*Note.* (Source: MsKDinh, 2020).

## *b. Micronutrients*

*Micronutrients* are essential to human life. Without them, health complications and even death can result. While they are essential, micronutrients are required in much smaller amounts than macronutrients. The two categories of micronutrients are *vitamins* and *minerals*.

### i. Vitamins

*Vitamins* are important compounds that are essential to the proper functioning of the human body. They are *organic compounds*. In simple terms, an organic compound is a substance whose molecules contain carbon atoms that are usually joined with hydrogen atoms. Plants and animals produce these organic compounds. Consequently, the human body can produce some of its own vitamins, like vitamin D and K.

However, humans must obtain many vitamins from food consumption because humans cannot produce all the vitamins required for survival. Alternatively, vitamin supplements can be taken to remedy a vitamin deficiency. For example, people who live in northern climates do not usually produce enough vitamin D to maintain optimum health, so they may be advised to take a vitamin D supplement, especially as they age.

Vitamins can be categorized as either *water soluble* or *fat soluble*. Water soluble means the vitamin can be dissolved in water while fat soluble means the vitamin can be dissolved in fat. Vitamins B (all eight B vitamins) and C are water soluble. Vitamins A, D, E, and K are fat soluble.

It is important for cooks to know the solubility of vitamins. This information can affect how cooks prepare and serve certain foods as some cooking methods can help retain more nutrients during the cooking process than others. For example, it’s better to steam kale than boil it. Kale is a food rich in vitamin C, which is water soluble, so when kale is boiled, vitamin C leaches out of the kale and into the boiling water.

As another example, it is better to serve carrots with a small quantity of fat. Carrots are rich in beta-carotene, which is converted into vitamin K in the digestive system. Since vitamin K is fat soluble, a fat (e.g., olive oil) will help the body absorb the vitamin better.

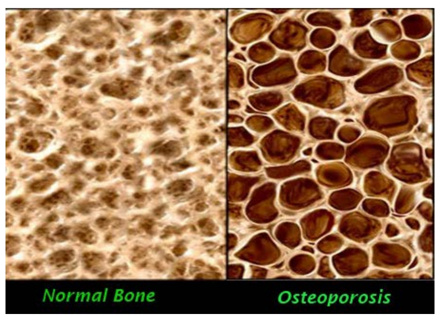
It is important for cooks to be aware of the vitamin content of prepared food because overcooking or overheating vegetables can decrease their nutrient content.

### ii. Minerals

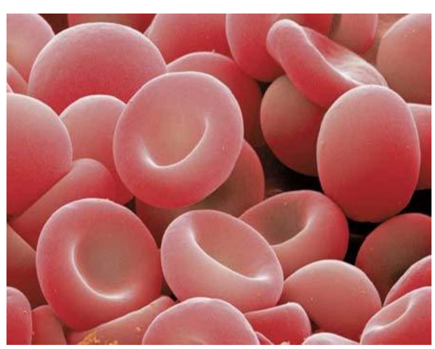
*Minerals* are also found in animal and plant-based foods, but they are *inorganic compounds*, which means they are not made by an organism. Instead, animals obtain minerals from their diets, and in turn, plants absorb minerals from soil and water.

Minerals are important for the proper functioning and structure of the human body. Calcium, phosphorous, magnesium, sulfur, sodium, potassium, chloride, and iron are some of the most important minerals for the human body, and they have the highest concentrations in contrast to other minerals not mentioned in this resource. For example, calcium and phosphorous are important for bone density and strength.

Over time, a diet deficient in calcium and phosphorous can result in osteoporosis, a disease characterized by low bone density and bone mass and, eventually, weak and brittle bones.




Iron is another important component of *hemoglobin* in red blood cells. It helps to transport oxygen from the lungs to the rest of the cells in the human body. Iron levels also affect the production of red blood cells in the body. A diet deficient in iron can result in anemia, where the body does not produce enough red blood cell. In turn, that affects that ability of the blood to transport oxygen to body cells and to remove carbon dioxide waste away from cells. Consequently, the anemic person often feels tired and weak. The picture below shows normal red blood cells as seen through a microscope.



### iii. Energy

As previously mentioned, carbohydrates, lipids, and proteins provide the body with energy. The energy unit provided by food is a *calorie*. Both carbohydrates and proteins contain 4 calories per gram while fats contain 9 calories per gram. Thus, fats are more energy dense than carbohydrates and proteins. Please note, cholesterol does not provide the body with energy because the body does not convert cholesterol into energy.

Knowing the caloric content of different foods is powerful information. The caloric content of the macronutrients is an important starting point to understand how much energy is stored in the foods we eat. However, the legally required listing of the caloric content on many of the packaged foods we eat is usually a more accurate measure.

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When the caloric content of different dishes can be calculated accurately, food can be prepared for customers or clients on restricted caloric diets. Also, if one knows how many calories they need per day to maintain weight (the average person requires 2000 calories per day), they can plan meals in a way that most people can effectively lose, maintain or gain weight.

## Canada's Food Guide

Since 1942, Canada has been developing food guides to help Canadians choose a healthy, balanced diet. In 2019, Canada developed and released a new Food Guide. There are many differences between the 2007 and 2019 Food Guides.

The older *Eating Well with Canada's Food Guide* (2007a) recommended daily servings of four different food groups: grain products, vegetables & fruit, milk products, as well as meat & alternatives (see Figure 13). The diet was to consist predominantly of grains, vegetables & fruit, followed by milk products, and then meat & meat alternatives.

**Figure 13.**

*Old Canada's Food Guide*


*Note.* Includes a dairy category (Source: Health Canada, 2007b)

The food guide typically recommended individuals to eat an equal number of servings from both the grain and vegetable and fruit groups, daily. Also, it was recommended to eat at least fifty percent whole grains from the grain products food group. Overall, the intake of fat, sugar, and salt was to be limited.

On the other hand, the original Food Guide recommended eating a smaller quantity of milk products and to eat milk alternatives if one had an allergy or aversion to milk products. Individuals were encouraged to choose low fat options.

Further, it was recommended to eat an even smaller amount of food from the meat and alternatives group. Plant-based meat alternatives were to be eaten often. Also, choices low in fat and salt were encouraged.

In 2007, a separate but closely related food guide for First Nations, Inuit and Métis persons and their communities was also published, “recognizing the importance of both traditional and store-bought foods in contemporary food patterns of Aboriginal people.” (Health Canada, 2007c, p. 12).

The new 2019 Food Guide is much easier to use, and it is different from the old Food Guide in many ways. Health Canada claims the new Food Guide is “relevant to all Canadians and is inclusive of Indigenous peoples” (Health Canada, 2021), so there currently isn’t a separate food guide for Indigenous Peoples as there was between 2007 and 2019.

Another major change in the new guide is that the milk products category has been removed, so four food groups have been collapsed into three, as listed below:

- vegetables and fruits
- protein foods
- wholegrain foods

(Dairy products are now included in the protein foods group.)

A third major change, the number of servings and serving sizes based on age and gender, is no longer prescribed. Instead, a plate of food or a diet is to be composed of half vegetables and fruits, a quarter of protein foods, and a quarter of wholegrain foods (see Figure 14).

There is a strong emphasis on eating unrefined plant-based foods rather than animal foods. Like the 2007 Food Guide, the 2019 Food Guide recommends limiting the consumption of salt, saturated fat (no trans-fat), and refined sugars.

**Figure 14.**

*New Canada Food Guide*

*Note.* Ideal plate composition (Source: Health Canada, 2019)

Cooks may not follow the Canada Food Guide in the daily preparation and cooking of food at the food service establishment where you work. However, the guide may be an important reference for you if you are required to prepare food for special populations (e.g., diabetics) in certain settings, for example hospitals, daycares, retirement homes, etc. More specifically, the Food Guide is a helpful resource to assist you in making healthier personal choices.

### Nutrition Labels

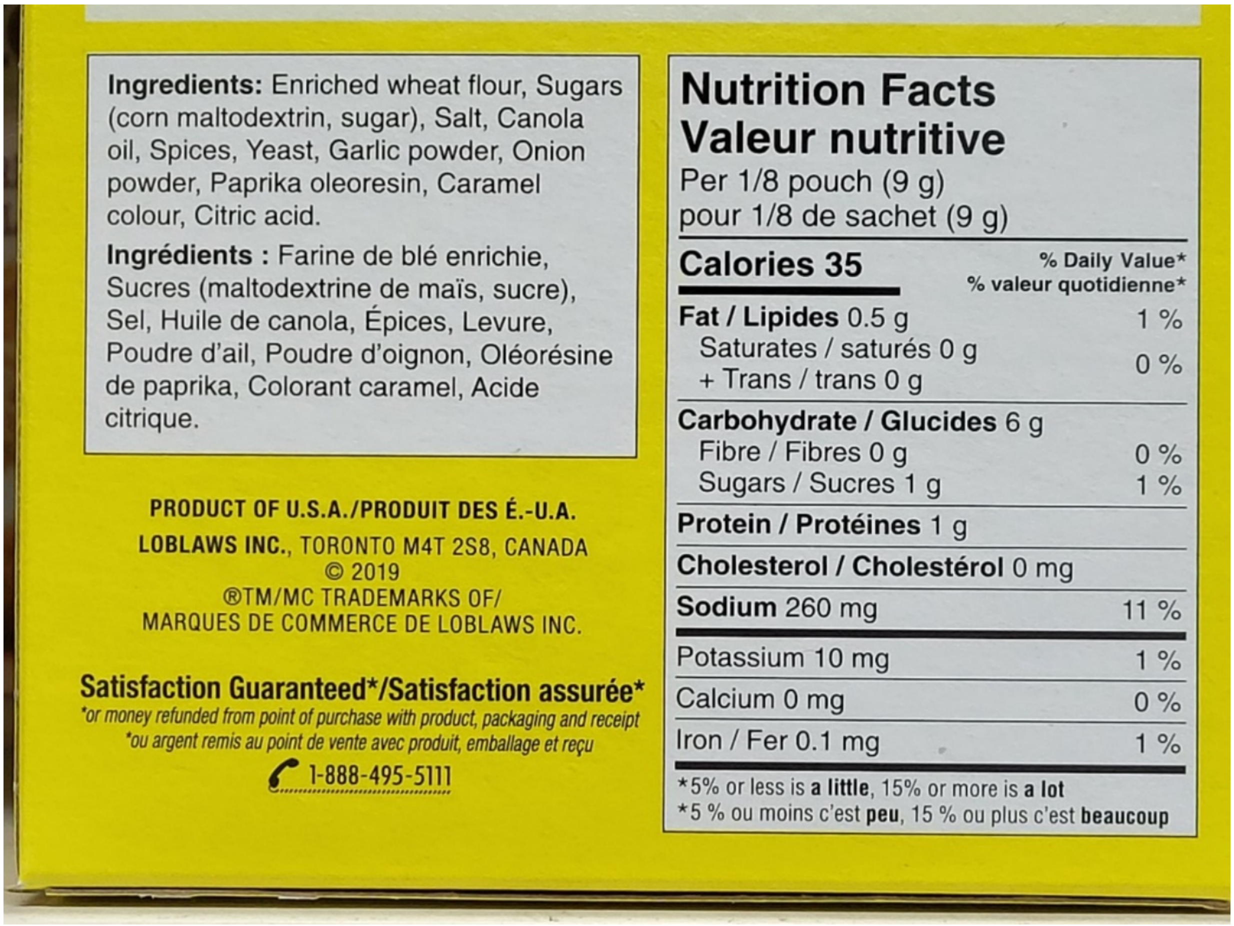
The Government of Canada develops and implements the policy for nutrition labelling in Canada. Since Canada has two official languages, the Government of Canada (2019) requires all nutrition labelling to be written in both English and French. Most food products in Canada are legally required to be labelled with specific nutritional information, and this information has a specific format that must be followed.

The intent of this law is to provide consumers with the information needed to make informed decisions about the foods they purchase and consume. Cooks use these labels to make personal diet decisions, but some cooks must also use these labels to prepare food for the diets of customers and clients. There are two important components of a nutrition label: the *nutrition facts table* and the *list of ingredients*.

The *nutrition facts table* must contain certain information (see Figure 15).

**Figure 15.**

*Canadian Nutrition Label*




*Note.* Nutrition label from a box of breadcrumbs.

First, it must contain the **number of calories** in a serving size of a food product.

Second, the facts table must contain the **weight and/or percent of daily value of 12 core nutrients** in this serving size (Government of Canada, n.d.). The percent of daily value represents the percentage of the daily requirement of a nutrient in a food product where a person should eat up to a total of a hundred percent of this nutrient or not exceed a total of a hundred percent of this nutrient per day.

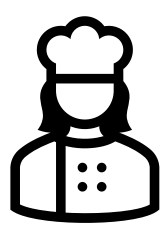
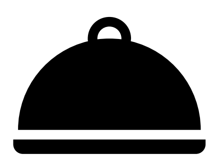
For example, iron, fibre, potassium, and calcium should be consumed up to 100% of their daily value and perhaps more for some individuals. The consumption of saturated fat, trans fat, and sodium should be under or not exceed the 100% daily value. This does not mean that an individual should consume the complete daily value of a nutrient from one food product. Instead, a variety of food products should be eaten to obtain the percentage daily value of healthy nutrients.

The 12 core nutrients are listed below and appear in the nutrition label:

- fat
- saturated fat
- trans fat
- cholesterol
- sodium
- carbohydrate
- fibre
- sugars
- protein
- potassium
- calcium
- iron

Of these 12 nutrients, the percentage (%) of daily value in a serving must be provided for each one, except carbohydrate, protein, and cholesterol. The percentage of daily value for saturated and trans fats is summed into one total percentage. Furthermore, there is a note on the nutrition facts table to inform consumers that 5% and under of percentage daily value is a small amount of nutrient obtained from a food product while 15% or more is a lot.

Next, the *list of ingredients* is written in order of the decreasing weight per ingredient found in the food product. In other words, the first ingredient in the list is present in the highest quantity by weight, and the last ingredient in the list is present in the least quantity by weight (see Figure 15).

On the next page, you will find a list of questions related to the information you've read in Chapter 1. You can write down answers to the questions, or you can discuss them with classmates in a group.

## Discussion Questions – Chapter 1

1. List three different foods that contain monosaccharides. Name the monosaccharides in each food.
2. List three different foods that contain disaccharides. Name the disaccharides in each food.
3. List two examples of polysaccharides.
4. In general, what foods contain a healthy amount of fibre? As well, give two specific examples.
5. Which lipid does not provide the body with energy?
6. Name a chemical process that converts unsaturated fats into trans-saturated and saturated fats.
7. What are the building blocks of proteins named? How many are essential, and how many are non-essential.
8. Define an organic compound. Provide a specific example of an organic micronutrient essential to the human body.
9. Define an inorganic compound. Provide a specific example of an inorganic micronutrient essential to the human body.
10. Which vitamins are water soluble? Which vitamins are fat soluble?
11. What is the energy content in a gram of each macronutrient?
12. Describe three differences between the 2007 and 2019 Food Guides.
13. In what ways do you have to change your current diet to better align with recommendations in the Food Guide?
14. Describe the nutrition facts table of a nutrient label.
15. Describe the list of ingredients of a nutrient label.
16. Give three reasons to utilize food labels when preparing meals.

## Chapter 2 – Basic Digestion

The digestive system processes the food we eat. It breaks food into smaller pieces, so nutrients from the food can be absorbed into the bloodstream. The simplest way to picture the digestive system is to think of it as a nine-metre-long tube with an opening for food entry at one end (the mouth) and an opening for the excretion (defecation) of waste at the other end (the anus).

Once food enters the mouth (also known as ingestion), food is moved through the tube and slowly broken down along the way. Nutrients are absorbed into the bloodstream as the food is digested, and then the final stage of digestion occurs when waste from the digested food exits the body (excretion).

The five main functions of the digestive system are *ingestion*, *digestion*, *propulsion*, *absorption*, and *excretion*.

### Organs of the Digestive System

The organs of the digestive system can be understood as two main groups:

- the *alimentary canal*, also known as the *digestive tract*, and
- the *accessory digestive organs*.

The *alimentary canal* (see Figure 16) consists of six organs: mouth, pharynx (the throat), esophagus, stomach, small intestine, and large intestine.
The alimentary canal performs the functions of ingestion, propulsion, digestion, absorption, and defecation.

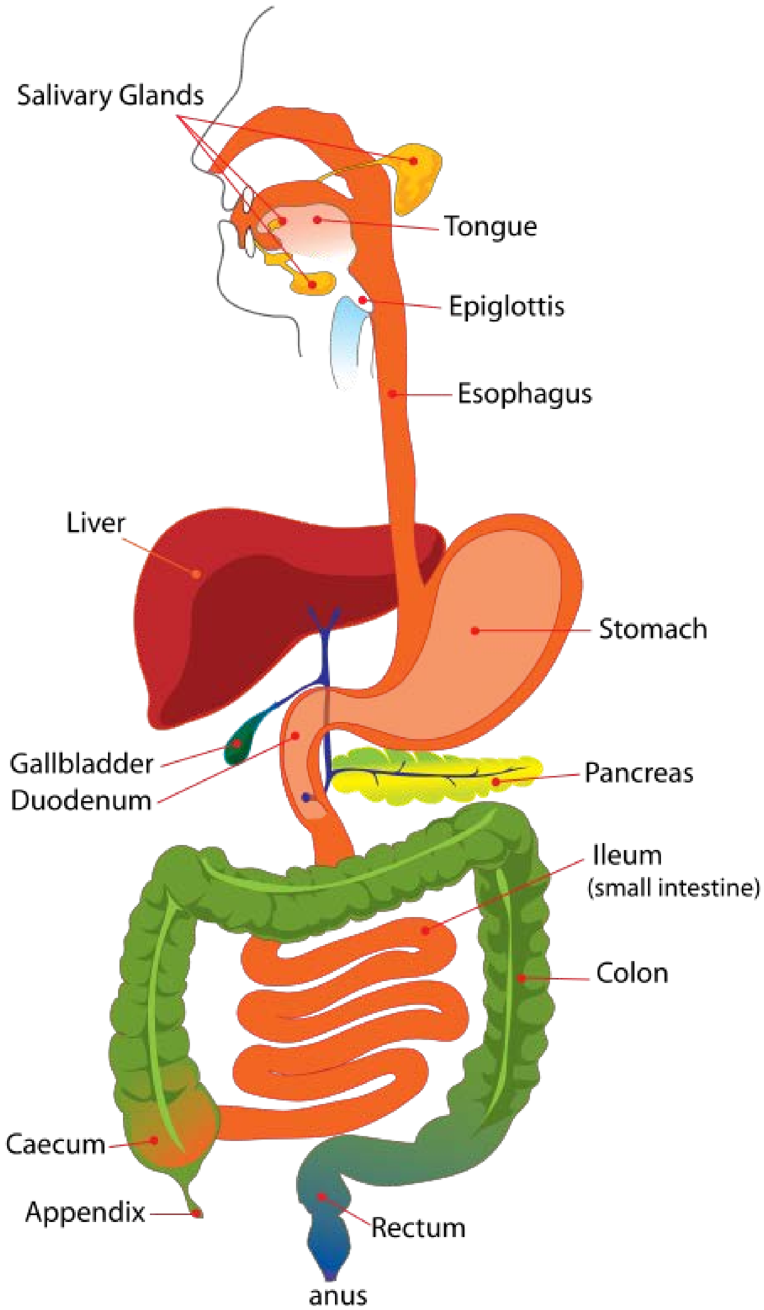
The *accessory digestive organs* (see Figure 16) are the teeth, tongue, salivary glands, stomach glands, pancreas, liver, and gallbladder, and they all contribute a specific function to the digestion of food.

- The teeth, tongue, stomach, and small intestine perform the mechanical functions of digestion, i.e. grinding and churning the food.
- The salivary glands, stomach glands, pancreas, and liver produce and secrete substances to break down food (chemical digestion).
- The gallbladder does not produce anything, but it does store and secrete a substance produced by the liver, known as bile.
- The small intestine also contributes to chemical digestion.

The distinction between mechanical and chemical digestion will be explained in the next section.

**Figure 16.**

*The Digestive System*




*Note.* (Source: 2140673sudeep, 2023).

## Digestion, Propulsion, and Absorption

The function of digestion involves breaking food into smaller pieces. Digestion occurs in two different ways: *mechanical digestion* and *chemical digestion*. Since digestion occurs in multiple steps along the alimentary canal, food must be propelled from one location to another. Also, food must be absorbed into the bloodstream once it is completely digested.

This section explains the functions of *digestion*, *propulsion,* and *absorption*. Although the functions of digestion, propulsion, and absorption can occur simultaneously in different areas of the alimentary canal and at different times, we will first learn the basic details of each function separately.

In the last section of this chapter, we will combine all the previously mentioned functions to explain the step-by-step digestion of food as it moves through the digestive system.

### *i. Mechanical Digestion*

*Mechanical digestion* involves breaking food down into smaller pieces. There are three methods of mechanical digestion in the human body: *chewing*, *churning*, and *segmentation*.

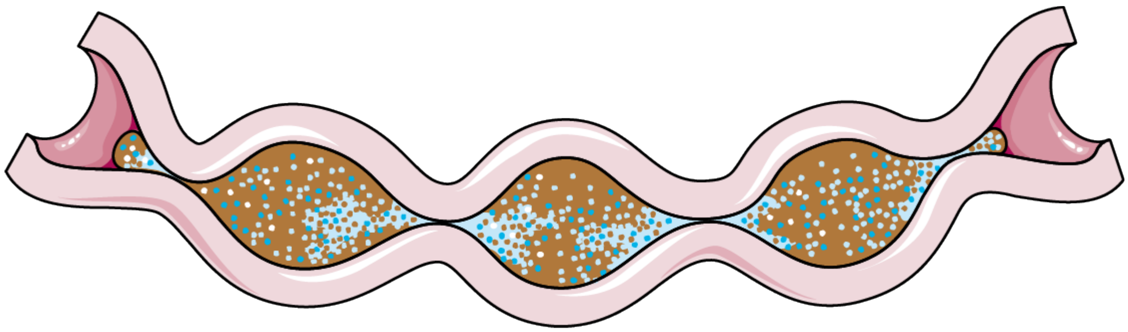
First, *chewing* occurs in the mouth. Food is mechanically digested when the teeth and tongue work together to chew food, so it breaks into smaller pieces. As food is chewed, it becomes a *bolus*.

Next, *churning* occurs in the stomach. After food is chewed, it is swallowed, and it moves to the stomach. Churning occurs when the stomach muscles mix and grind the food to further digest it.

Last, *segmentation* occurs in the small intestine. Partially digested food that moves from the stomach to the small intestine is called *chyme*. Segmentation occurs in the small intestine when muscles lining the small intestine move the chyme in a backward and forward movement, which mixes the chyme with secretions from some of the accessory digestive organs (see Figure 17).

**Figure 17.**

*Segmentation*



*Note.* (Source: Laboratoires Servier, 2016).

### *ii. Propulsion*

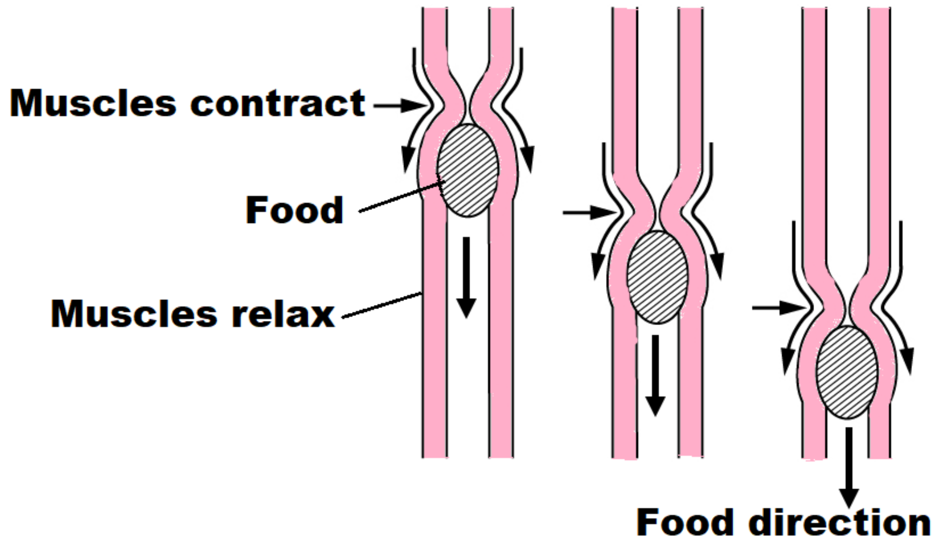
Food is propelled though the alimentary canal in a couple ways. The first is *swallowing*. Once food is sufficiently chewed to swallow safely, the bolus is pushed to the back of the mouth toward the pharynx. At this point, the swallowing reflex is activated, and the bolus is swallowed.

The second way food is propelled though the alimentary canal is called *peristalsis* (see Figure 18). Peristalsis is characterized as a wavelike series of contractions. After the bolus is swallowed, the muscles surrounding the alimentary canal move the partially digested food along the canal as the food is slowly digested along the way.

Peristalsis is *involuntary*, which means it happens automatically once food is swallowed. Peristalsis is so effective that movement of food along the alimentary canal will occur even if someone is lying or upside down.

**Figure 18a.**

*Peristalsis*




*Note.* (Source: OpenStax College, 2022).

### *iii. Chemical Digestion*

Like mechanical digestion, *chemical digestion* also involves breaking down food into smaller pieces, but chemical digestion breaks chemical bonds while mechanical digestion does not, which is the primary distinction between the two forms of digestion.

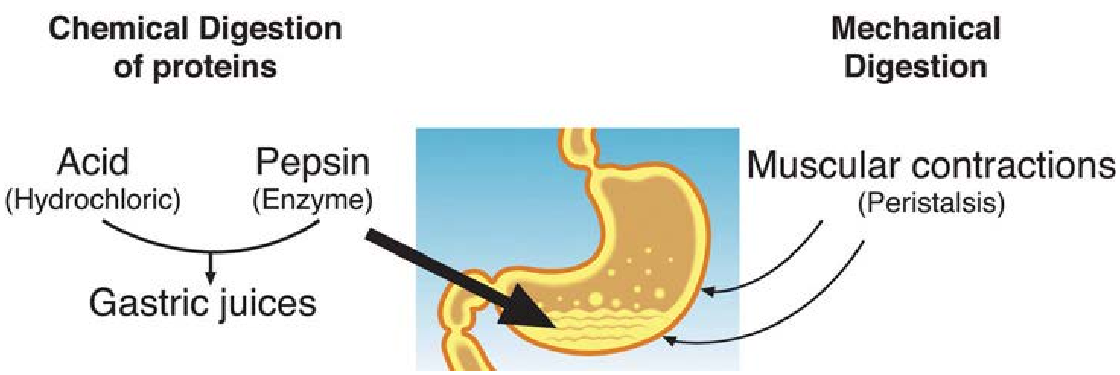
Chemical bonds are broken by proteins produced by some of the accessory digestive organs. These proteins are called *enzymes*. The salivary glands, stomach glands, pancreas, and small intestine all produce enzymes. Each enzyme acts upon a specific chemical bond; for example, enzymes responsible for chemically digesting carbohydrates cannot break bonds in proteins or lipids and vice versa.

The first location where chemical digestion takes place in the alimentary canal is the *mouth*. The salivary glands release salivary amylase into the mouth, which is an enzyme that begins to breakdown polysaccharides (complex carbohydrates) into smaller pieces.

The second location where chemical digestion takes place is in the *stomach*. The stomach glands release pepsin. Pepsin is an enzyme, and it starts the chemical digestion of proteins. The stomach glands also release gastric lipase, which begins the chemical digestion of lipids.

**Figure 18b**

*Chemical and Mechanical Digestion in the Stomach*






The third location where chemical digestion takes place is in the *small intestine*. The small intestine is the location where the final breakdown of carbohydrates, proteins, and lipids occur before they're absorbed into the bloodstream.

The digestion of carbohydrates is completed by *brush border enzymes*, which are produced by the small intestine. These enzymes are produced specifically for the breakdown of carbohydrates. After complete digestion, all carbohydrates have been broken down into single sugar units, also known as *monosaccharides.* These monosaccharides are glucose, fructose, and galactose. These simple sugars were introduced in the first chapter of this resource.

The digestion of proteins in the small intestine is completed by two types of enzymes. The first type is pancreatic enzymes. The pancreas produces p*ancreatic enzymes*, and the pancreas releases these enzymes into the small intestine. The pancreas produces these enzymes specifically for the chemical digestion of proteins.

*Brush border enzymes* are the second type of enzyme that digests proteins in the small intestine. These brush border enzymes are produced specifically for the breakdown of proteins, so they're different from the brush border enzymes produced to digest carbohydrates. Brush border enzymes complete the digestion process of proteins. After complete digestion, proteins have been broken into *single amino acids*.

The digestion of fats is completed in the small intestine. The *liver* produces *bile*, and the *gall bladder* stores it. Bile does not break the chemical bonds of fats. Bile is released into the small intestine from both the liver and the gallbladder to help *emulsify* dietary fats, so the fats can be chemically digested effectively.

The *pancreas* produces *pancreatic lipase*, an enzyme specifically for the chemical digestion of fats. The pancreas releases these enzymes into the small intestine to breakdown fats. When fats have been completely digested, they have been broken down into the following units of fat: monoglycerides, fatty acids, and glycerol.

### *iv. Absorption*

After foods have been digested, the nutrients are *absorbed* into the bloodstream. Nutrient absorption primarily occurs in the small intestine, as described below:

- Carbohydrates are absorbed into the bloodstream as glucose, fructose, and galactose.
- Proteins are absorbed into the bloodstream as amino acids.
- Lipids (fats) are absorbed into the bloodstream as monoglycerides, fatty acids, glycerol, and cholesterol.

## Putting It All Together: Following the Digestion of Bread

This section goes into more detail on the digestion of a morsel of bread from start to finish, as described in the bullet points on the next page.

- Bread is composed of carbohydrates, proteins, and lipids. When a bite is taken from a slice of bread, it has been *ingested*. *Mechanical digestion* begins as the piece of bread is *chewed*.
- Seeing and chewing the bread causes the *salivary glands* to release *salivary amylase* into the *mouth*, which begins the *chemical digestion* of the *starch* in the bread.
- Also, as the bread is chewed, a *bolus* forms.
- When the bolus is chewed enough, it is pushed to the back of the mouth toward the throat where the *swallowing reflex* is triggered, which causes the bolus to be swallowed into the *pharynx*.
- From the pharynx, the bolus moves through the *esophagus* into the *stomach* via *peristalsis*. Seeing and smelling food causes the stomach to release gastric juices.
- Also, the action of eating and the presence of the bolus in the stomach stimulates the release of more *gastric juice* (commonly known as stomach acid).
- Gastric juice stimulates the release of *pepsin* and *gastric lipase* from the *stomach glands*.
- When the bolus approaches the base of the stomach, the bolus is *churned* with enzymes and gastric juice.
- Churning *mechanically digests* the bolus while pepsin begins to *chemically digest* the *protein* in the bolus, and *lipase* begins to *chemically digest* the *lipids*.
- Eventually, as the bolus is mixed with stomach juices, it becomes *chyme*.
- A small amount of chyme (3-4 mL) is released at a time into the small intestine for further digestion until all the chyme has left the stomach.
- In the *small intestine*, the *pancreas* releases *enzymes* to *chemically digest* the *proteins* and *fats* in the chyme.
- At the same time, the *liver* and *gallbladder* release *bile* to *emulsify* the *fats* in the chyme to *assist* with digestion.
- The small intestine will undergo *segmentation* to chop the chyme and mix the enzymes and bile with the chyme.
- The chyme will also contact *brush border enzymes* to further *digest* the carbohydrates and proteins in the chyme.

- Once the digestion is complete, most of the nutrients are *absorbed* into the *bloodstream*.

- At this point food has been in the digestive system for approximately 2 to 8 hours, depending on what was eaten and how much was eaten as well as the activity level of the digester.

- The remaining chyme that is not absorbed into the blood moves to *the large intestine*.

- As the chyme moves through the large intestine, *water* is absorbed into the *bloodstream*, and the chyme is *concentrated*.

- Eventually the chyme is concentrated to the point where it becomes *feces*, and then it is *excreted* from the *anus*.

The time it takes to completely digest a meal, from mouth to anus, really depends on how much was eaten, what was eaten, the activity level of the digester, metabolism, health complications, and age. On average, it takes around 36 hours, but this is a rough approximation.

On the next page, you will find a list of questions related to the information you've read in Chapter 2. You can write down answers to the questions, or you can discuss them with classmates in a group.

## Discussion Questions – Chapter 2

1. List the five main functions of the digestive system.
2. List the organs of the alimentary canal.
3. List the accessory digestive organs.
4. List three methods of mechanical digestion and where they occur in the digestive system.
5. List two forms of propulsion in the digestive system.
6. Describe peristalsis.
7. What is the main difference between mechanical and chemical digestion? What is the general name for the type of protein responsible for chemical digestion?
8. What organ is the final location of chemical digestion in the digestive system?
9. Where does nutrient absorption mainly occur in the digestive system?
10. After carbohydrates, proteins, and lipids have been completely digested, what are the resulting names of the units in each digested macronutrient that are, finally, absorbed into the bloodstream from the digestive system.
11. Describe what happens to chyme in the large intestine?

## Chapter 3 – Heat

*Heat* is an essential ingredient for cooking. Heat is a form of energy that is used to transform plant and animal food products into so many appetizing dishes. Without heat, many foods would be unappetizing, inedible, or unsafe.

The discovery of fire, and the use of its heat to cook food was one of the most important and impactful technological advancements in history. Cooking can make food edible and more flavorsome. It can make nutrients more accessible for digestion. Another benefit of cooking is that it kills harmful pathogens, such as bacteria and worms, so our health is less likely to be compromised by the foods we eat. These are but a few of the benefits to cooking food.

Not only has heat allowed us to cook, coming to understand the concept of heat has also helped us to learn how to preserve the food we eat by removing heat. Substances become colder because heat leaves them. It is a *natural law* that heat passively moves from *hot* to *cold* environments.

Our ancestors learned that placing our food in cold environments can slow spoilage. Spoilage is delayed for a period of time because the microbial activity (spoiling) in food is slowed. Above 0°C and below 4°C, many foods are kept in a safe place where microbial activity is inhibited for a limited period, but above 4°C and below 60°C is known as the danger zone where microbes multiply exponentially and food spoils quickly. Refrigeration and freezing (below 0°C) are two common methods of preservation that remove some of the heat from food and delay spoilage.

This chapter discusses heat in more detail. To understand heat and its effects, we must first understand the particle theory of matter and the states of matter. Following this, it is necessary to explain the concept of heat transfer, including the different forms of heat transfer available to cooks in the kitchen. Lastly, the effects of heat on macronutrients are explained.

## Particle Theory of Matter

The *particle theory of matter* is a *scientific model* that helps us in better understanding our world. It can also help you to understand more about the effects of heat in the kitchen.

This theory has *six principles*.

1. The *first* principle is that all *substances* (also known as matter) are made up of *tiny particles*. The particles are so small that we cannot see them with the naked eye. These particles are called *atoms* and *molecules*. (You'll remember we briefly mentioned atoms and molecules in Chapter 1.)

2. The s*econd* principle is that each *element* that we know of here on earth has a single unit; an element cannot be broken down into smaller pieces and still be an element. We call this single unit an *atom*. Every element in its simplest form is a type of atom, which makes it unique to other atoms. For example, oxygen and hydrogen are elements whose atoms have similarities, but they are also distinctly different from each other.

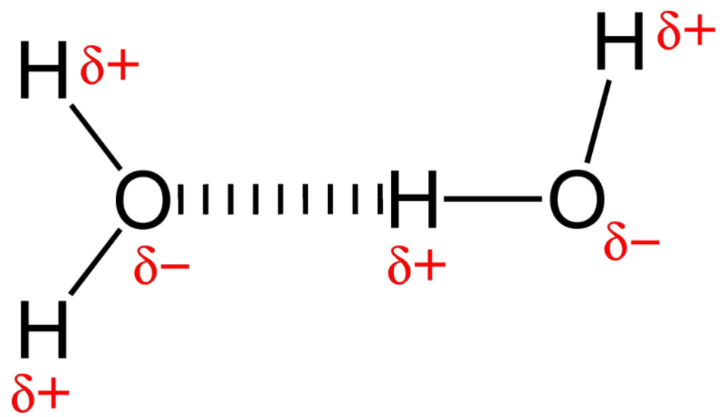
   On the other hand, *molecules* are made up of two or more atoms of different elements; molecules are groups of atoms from different elements. For example, water is composed of water molecules (see Figure 12 in Chapter 1 to review the structure of a water molecule). Each of these molecules is made-up of one oxygen atom and two hydrogen atoms. Thus, the water in a glass of water is made up of many water molecules in the glass.

3. The t*hird* principle is that particles in a substance are *attracted* to each other. *Attractive forces* tend to keep these particles close to each other so the substance they make up remains whole. For example, the particles that make-up an ice cube (water molecules in solid form) must have some attraction to each other, or the ice cube would melt and no longer exist. Similarly, water molecules in liquid form must be attracted to each other, so they are less likely to float off into the atmosphere as a vapour (see Figure 19).

These attractive forces cannot be seen with the naked eye just as we cannot see the forces between a magnet and a piece of metal. For example, as a magnet is slowly placed on a refrigerator, there is a distance from the fridge where an attraction between the magnet and the fridge can be felt. This force of attraction can be felt to increase in strength as the magnet moves closer to the fridge. The attraction between the magnet and the fridge is no longer felt when the magnet touches the fridge, but the attraction is evidently still there because the magnet remains attached to the fridge when one's fingers let go of the magnet. This is a useful analogy to help envision the force of attraction between two atoms.

**Figure 19.**

*Particle Attraction*



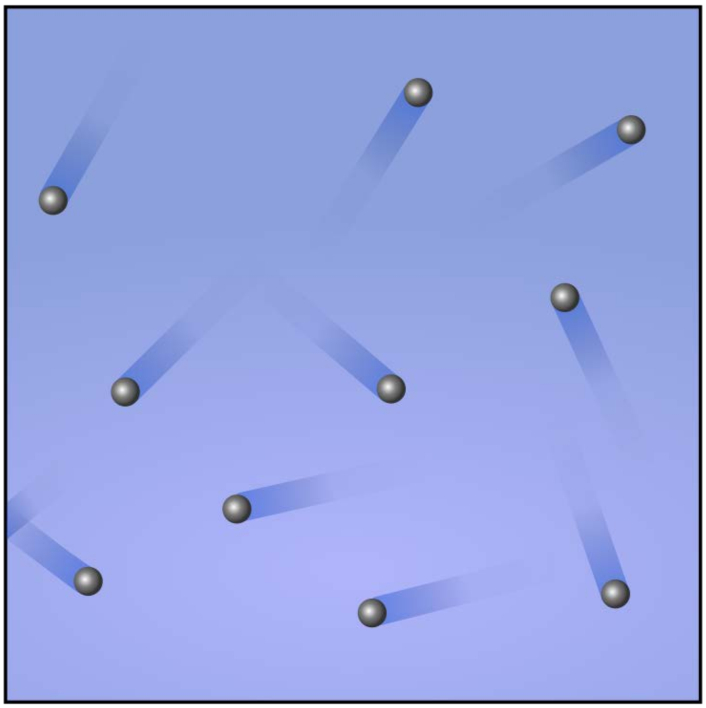

*Note.* Attractive force between two water molecules (Source: Benjah-bmm27, 2007).

4. The *fourth* principle is that particles in a substance are always in *constant motion* if the temperature is above *absolute zero* (-273°C). Motion can involve particle movement from one place to another within the substance (see Figure 20). Motion also means particles may have a speed. Even if particles are not moving from one place to another and therefore do not have a speed, particles can still be energized enough to vibrate in place.

   *Absolute zero* is the temperature at which there is no heat left in a substance. Therefore, if the temperature of a substance is above absolute zero, there is some heat left in it, and the particles of the substance are moving in some way even if this movement is primarily vibration.

**Figure 20.**

*Particle Motion*



*Note.* Energized particles in motion (Source: Sharayanan, 2007).

5. The f*ifth* principle is that adding heat to a substance will *increase the energy* of the particles in a substance. As heat is added, the particles will *move around more* and at *higher speeds*. However, if heat is removed from the substance, the particles will lose energy and slow down, perhaps to a point where they don't change location in the substance but instead vibrate.

   Therefore, the *particles* in a *substance* increase in *energy* and *motion* as the substance gets warmer, but the opposite occurs as the substance gets cooler. For example, the water molecules in a pot of boiling water have more energy and motion than the water molecules did when the water in the pot was cold or at room temperature.

6. The *sixth* (and final) principle is that there are *spaces* or *distances* between the particles that make-up a substance (see Figure 21, the particles are the blue spheres). For instance, molecules in a glass of water are attracted to each other, but these molecules have spaces between them. The attractive forces between the molecules (principle 3) are enough to keep the water molecules together so they exist in liquid state. Molecules of solids (e.g., ice) are closer together than molecules of liquid (e.g., water).

   This is because the water molecules (principles 1 and 2) in solid water form have little energy (principle 4), so their attractive forces (principle 3) draw the molecules closer together and reduce the space (principle 6) between them. Heat is removed from water to create ice (principle 5).

   In this way, water can exist as a solid when temperatures are below zero, the freezing point of ice. On the other hand, the molecules of boiling water (principles 1 and 2) have more space between them (principle 6), more energy and motion (principle 4) than the molecules of ice or room temperature water.

   In fact, the heat added to boiling water causes the energy of the water molecules (principle 5) to overcome the attraction they have for each other (principle 3). In this instance, the space between water molecules increases (principle 6), and some of them eventually escape from the boiling water as water vapour molecules.

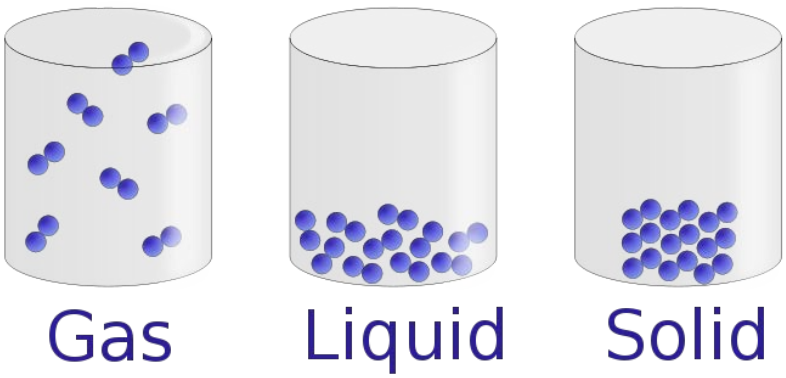
   Water vapour is a gas. When water molecules escape into a gaseous state, the space between liquid water molecules and gaseous water molecules increases (principle 6). In other words, the distance between the molecules increases.

### ***States of Matter***

As previously stated, there are *three states of matter*: *solid*, *liquid*, and *gas* (see Figure 21).

**Figure 21.**

*States of Matter*




*Note.* (Source: Yelod – Wikimedia Commons, 2009).

*Solids* are comprised of particles that have more attraction for each other than they have energy required to separate them. Think again of a magnet on a fridge. Energy must be used to separate the magnet from the fridge, but without this energy the magnet will remain in place on the fridge. This means that there is little space between the particles of a solid. These particles have little energy. They do not move around per say, but they do vibrate in place. The attraction that these particles have for each other keeps the substance a solid, for example ice. Consequently, a solid can maintain its shape.

The particles in a *liquid* have more energy than particles in a solid, so liquid particles move around rather than vibrate in place. These particles will move around more and faster when heat is added, and consequently, the temperature of the substance increases. Particles in a liquid are still attracted to each other, but the energy they have partly counteracts this attraction.

Again, think of the magnet on fridge. As energy is applied to slowly move the magnet away from the fridge, there is a distance at which the attraction between the magnet and the fridge can be felt until the magnet is moved far enough away from the fridge that this attractive force can no longer be felt. The space between the fridge and the distance where the attractive force can no longer be felt is similar to the space that contains the forces of attraction between liquid molecules. These molecules have an energy that keeps them just far enough apart that the attractive forces between them still have an effect. However, unlike a solid, the liquid cannot maintain its shape without being held in something, for example a glass of water.

The particles in *gases* have so much energy that they move very quickly, and they are quite far away from each other. The particles are so far away from each other that any attraction they have for each other is negligible. For example, when a magnet is slowly removed and distanced from a fridge, there is a point where the attractive force between the fridge and the magnet can no longer be felt. The attractive forces between gas molecules can be thought of in the same way. Gases do not have a shape, and if they are placed in an open vessel like a glass, they will escape into the atmosphere (like steam from boiling water).

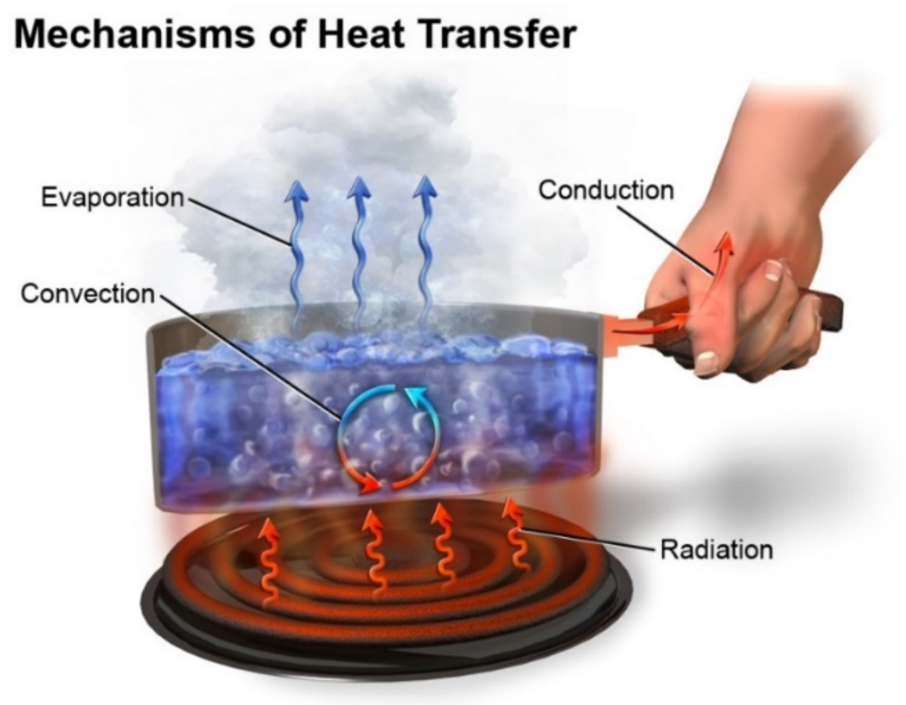
### Heat Transfer

As previously stated, *heat flows from hotter areas to colder areas*. This *movement of heat* is known as *heat transfer* because the heat moves from the warmer particles of a substance to colder particles of the same substance. Also, heat can move from one substance to another as the warmer particles of one substance add energy to and, as a result, warm the particles of another colder substance.

There are *three* mechanisms for heat transfer: *conduction*, *convection*, and *radiation* (see Figure 22). Many cooking methods use a combination of the three forms of heat transfer to cook.

**Figure 22.**

*Heat Transfer*




*Note.* (Source: BruceBlaus, 2017).

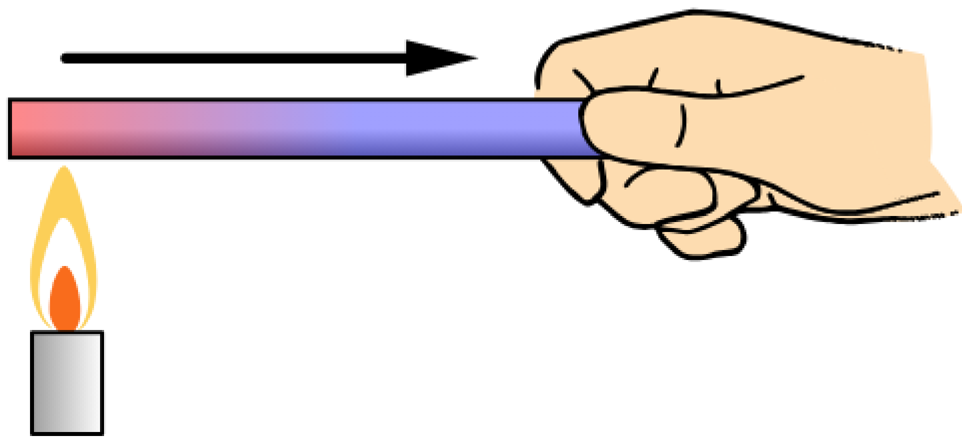
### *Conduction*

*Conduction* is the *transfer* (movement) of *heat* within a solid from a *hotter* area to a *colder* area. *Conduction* is also the *transfer* of *heat* from one solid to another *solid* when they touch each other. When heat is transferred via conduction, hotter particles contact colder particles. As a result, the colder particles become energized, which increases the movement of the particles, and the solid increases in temperature.

In Figure 23, a flame directly heats one end of a metal rod. As a result, this rod will increase in energy and, therefore, increase in temperature at the heated end. In turn, the particles in the rod will transfer heat along the length of the rod, from one end of the rod to the other and then to the hand holding it. The transfer of heat along the length of the rod as well as the transfer of heat from the rod to the hand are both examples of conduction.

**Figure 23.**

*Conduction*



*Note.* (Source: MikeRun, 2019).

Conduction is a mechanism which enables us to cook food. For example, a steak is a solid. When a steak is cooked over a grill, the solid grill conducts heat onto the areas where it contacts the steak. Also, the heat from the grill causes the steak to cook from the outside in. As the steak cooks, the heat from the grill transfers (moves) from the outside of the steak to the inside of the steak, via conduction between the particles of the steak, until the steak is cooked to the desired doneness.

### *Convection*

*Convection* is the *transfer* of *heat* within a *liquid* or *gas*. *Convection* is also the *transfer* of *heat* from a *liquid* or *gas* to something else. For example, when heat is placed under a pot of water, the water molecules will eventually increase in energy and motion. The hotter molecules will rise to the top of the pot of water, while the colder molecules will fall to the bottom. As the water molecules increase in energy, they also transfer some of this energy to water molecules of lower energy.

Steaming fish is an example of cooking with convection (see Figure 24). Steam rising from boiling water beneath the fish transfers heat to the outside of the fish. This heat then energizes the particles on the outside of the fish where the steam contacts them. However, the inside of the fish is cooked via conduction where the outside particles energize the inside particles until the fish is cooked to the desired doneness

**Figure 24.**

*Convection – Steamed Fish and Vegetables in a Bamboo Steamer*

*Note.* (Source: fifikins, n.d.)

***Radiation***

There are *two forms* of *radiation* used in the kitchen to cook: *infrared* and *microwave*. *Infrared* cooking is different from conduction and convection because energy in the form of *heat* is *transferred directly* from the *heat source* to the *object* being heated; a medium such as a solid, liquid, or gas is not required to accomplish the transfer of heat. Infrared heat travels as waves at the speed of light. Infrared radiation is used when cooking under a broiler, in a toaster, over coals (see Figure 25), and over fire.

**Figure 25.**

*Infrared Radiation – Cooking over Coals*

*Note.* Infrared Radiation (Source: Devika_Smile, 2013).

Another form of radiation commonly used to cook is *microwave* radiation. Microwave ovens use microwaves to cook food. Unlike other forms of heat transfer, microwaves penetrate food a few centimeters deep by *energizing water molecules* in the first few centimetres of the food. This energization causes *friction* between the water molecules to create *heat*. The *heat* is then *transferred* further inside of the food via *conduction* or *convection* which is dependent on whether the food is a *solid* or *liquid*.

This all means that food cooks quicker in a microwave. Most importantly, the food must have some water content for microwaves to cook food.

## Effects of Heat on Macronutrients

It is important to know the effects that heat has on macronutrients, such as carbohydrates, proteins, and fats. Knowing this information will enable you to predict the effects of heat on food, so you can be a better cook.

### *Carbohydrates*

There are *two important effects of heat* on *carbohydrates*. This *first* effect is *gelatinization*. This occurs when heat is added to starches mixed with some sort of fluid like water or broth. Starches come in many forms, for example corn, wheat, and rice. Pectin is also a starch. When any of these starches are mixed into a fluid and heated, the starch granules *absorb water*, which *thickens* the fluid. Therefore, starches are often used as thickeners to thicken sauces and soups. When bread cooks, the wheat starch gelatinizes as well, so gelatinization also occurs during baking.

The *other* important effect that occurs when adding heat to carbohydrates is *caramelization*. More specifically, simple sugars caramelize when enough heat is added to them for a long enough time and at a high enough intensity. The temperature of the sugar must increase to a specific temperature for caramelization to occur. Various sugars have different caramelization temperatures. Caramelization *changes* the taste, colour, and structure of simple sugars. For example, when table sugar is properly caramelized, it turns from colourless to amber or brown, and the flavour becomes nutty and more complex. If sugar is caramelized for too long, it will burn. Caramelized onion is a common ingredient in many dishes, similar to the picture below.

### *Proteins*

There are *two effects of heat* on *proteins*: *coagulation* and the *Maillard reaction*. First, when heat is added to protein, it coagulates. *Coagulation* is the *change in shape* of a protein as it cooks. This change in shape occurs simultaneously with a loss in size because water is pushed out of the protein. For example, an overcooked steak will be sensed as dry by most people because much of the water has been cooked out of the steak. Furthermore, different proteins coagulate at different temperatures. For example, egg white proteins coagulate between 62°C and 65°C while egg yolk proteins coagulate between 65°C and 70°C.

*Another* important effect of heat on proteins is the *Maillard reaction*. It is a common misconception that the browning of animal protein results from the caramelization of the sugars in the meat. However, this is incorrect. In fact, a different reaction occurs in the meat where at high enough temperatures, the sugars and amino acids from the protein react. This reaction *changes the structure of the meat as well as the colour and flavour*. “Maillard flavors are more complex and meatier than caramelized flavors, because the involvement of the amino acids adds nitrogen and sulfur atoms to the mix of carbon, hydrogen, and oxygen, and produces new families of molecules and new aromatic dimensions” (McGee, 2004, p. 778).

### *Fats*

*Fats melt* when heated. As they melt, they *transition* from a *solid* to a *liquid* form. For example, butter is fat. It is a solid when stored in the fridge. However, if butter is removed from the fridge and given time to come to room temperature, butter will soften. If the butter is exposed to additional heat, the butter will eventually melt into a liquid.

### *Water*

*Water* will slowly *evaporate* over time if left in an open container in the fridge or on the counter. Also, ice also slowly evaporates if left uncovered in the freezer. Look at a tray of ice cubes after they’ve been in the freezer for a few weeks. You’ll notice the ice cubes have reduced in size because water has evaporated from the ice.

Water evaporates at these temperatures because molecules at the surface of water or ice have enough energy to overcome both the atmospheric pressure and the attraction, they have for each other. As a result, over time, water molecules slowly escape and float off into the air. Of course, this will occur more rapidly at higher temperatures than lower temperatures.

The *rate* at which water evaporates *increases* as *energy is added* to the water in the form of *heat*. Imagine a pot of water over a flame. The heat eventually rises to the top of the vessel containing the water as energized molecules rise to the top of the pot where they are more likely to escape into the atmosphere, and less energized molecules sink to the bottom of the pot to become more energized as they are exposed to the heat source and energized particles.

As the temperature of the water increases to the boiling point (approximately 100°C), the water molecules evaporate into the atmosphere at increasing rates, and steam can, eventually, be seen leaving the pot.

On the next page you will find a list of questions related to the information you've read in Chapter 3. You can write down answers to the questions, or you can discuss them with classmates in a group.

## Discussion Questions – Chapter 3

1. What are the benefits of using heat to cook?
2. Name two methods that remove heat to preserve food.
3. List the six principles of the particle theory of matter.
4. Choose three principles of the particle theory of matter and describe them.
5. Name and describe the three states of matter.
6. Name and describe the three mechanisms of heat transfer.
7. Name a describe the effects of heat on carbohydrates.
8. Name and describe the effects of heat on proteins.
9. Name and describe the effect of heat on fats.
10. Name and describe the effect of heat on water.

## Multiple Choice Assessment Activity

## Instructions

- This is an **open book** activity, so you can refer to the information in this module to answer the questions.

- There is no time limit, so you can take your time and think about each question.

- There are three sections, each with a set of questions. You may want to do one section at a time, and take a break before going on to the next section.

- Each question is worth one mark out of a total of 64.

- When you have completed the assessment, please submit it to your instructor. *A successful outcome on the assessment is 45/64 (70%).*

- Since this is a multiple-choice assessment, there may be more than one appropriate answer per question. Choose the best answer for each question because one answer will always be the most correct.

**Hint:**

Keep in mind that there are some helpful strategies for completing multiple choice activities or tests..

One effective strategy is the process of elimination. Before you choose an answer to a question, ensure you first eliminate the answers that you **know** are not correct. This way, if you're left with two answers that could be correct and you're unsure of which answer to choose, you have a 50% chance of choosing the correct answer.

## Section I – Nutrition

1. Why should cooks concern themselves with nutrition?
    a. To support their personal health
    b. To support the health of their patrons or customers
    c. To promote the health benefits of fast food
    d. Both answers a and b are correct

2. Which professional can a cook work with to support the health of specialized populations in a long-term care facility?
    a. An actor
    b. A construction worker
    c. A nutritionist
    d. All of the above

3. The four essential macronutrients are _______________.
    a. bread, butter, proteins, and water
    b. carbohydrates, meat, fats, and water
    c. grains, legumes, unsaturated fat, and water
    d. carbohydrates, lipids, proteins, and water

4. Which macronutrient is the main source of energy for the human body?
    a. Lipids
    b. Proteins
    c. Carbohydrates
    d. Water

5. What are the two main forms of carbohydrates?
    a. Simple
    b. Fibre
    c. Complex
    d. Both answers a and c are correct

6. The two forms of simple sugars are
    a. carbohydrates and grains
    b. monosaccharides and disaccharides
    c. simple and complex
    d. all of the above

7. Which monosaccharides are readily absorbed into the bloodstream?
    a. Glucose
    b. Fructose
    c. Galactose
    d. All of the above

8. Select the answer that lists the three common disaccharides found in food.
    a. Sucrose, lactose, and maltose
    b. Honey, sugar, and molasses
    c. Glucose, fructose, and galactose
    d. All of the above

9. Complex carbohydrates are also known as
    a. polysaccharides
    b. monosaccharides
    c. disaccharides
    d. all of the above

10. Two common complex carbohydrates found in plant-based food are
    a. simple sugars and fibre
    b. starch and fibre
    c. starch and cellulose
    d. Both answers b and c are correct

11. The main categories of lipids found in food include _____________.
    a. Saturated fat, unsaturated fat, trans-saturated fat, and cholesterol
    b. Cholesterol and animal fat
    c. Cholesterol and plant fat
    d. Cholesterol, plant fat, and animal fat

12. Which lipid in food has been legally banned in Canada?
    a. Saturated fat
    b. Artificial trans-saturated fat
    c. Unsaturated fat
    d. Cholesterol

13. What's the name of the chemical process that converts unsaturated fats into saturated fats to make margarine?
    a. Mailardization
    b. Saturation
    c. Hydrogenation
    d. Unsaturation

14. Which lipid is made by the human body?
    a. Trans-saturated fat
    b. Saturated fat
    c. Unsaturated fat
    d. Cholesterol

15. What are the building blocks of proteins?
    a. Amino acids
    b. Amino bases
    c. Acids
    d. Bases

16. Animal proteins are complete proteins because they contain:
    a. iron
    b. both essential and non-essential amino acids
    c. all the essential amino acids
    d. all the non-essential amino acids

17. How many essential amino acids does the body require from the food it ingests?
    a. Eleven
    b. Twenty
    c. Nine
    d. Ten

18. The consumption of these two plant-based foods will ensure all essential amino acids are ingested to meet bodily requirements.
    a. Grains and fruits
    b. Bean and fruits
    c. Legumes and Beans
    d. Grains and legumes

19. On average, what is the water composition of the human body?
    a. 50%
    b. 65%
    c. 60%
    d. 40%

20. The two essential micronutrient categories are _________________.
    a. water and vitamins
    b. vitamins and minerals
    c. water and minerals
    d. Both answers a and c are correct

21. Which vitamins are water soluble?
    a. Vitamins B and C
    b. Vitamins A and D
    c. Vitamins B and K
    d. Vitamin A and calcium

22. Which cooking method reduces the leaching of water-soluble vitamins in vegetables in contrast to boiling?
    a. Poaching
    b. Simmering
    c. Steaming
    d. All of the above

23. For better absorption into the blood stream fat soluble vitamins should be eaten with ____________.
    a. A little fat
    b. A little water
    c. A little salt
    d. All the above

24. Vitamins are ________compounds; minerals are _________ compounds.
    a. big; small
    b. essential; non-essential
    c. inorganic; organic
    d. organic; inorganic

25. Plants and animals _____ make the minerals they require for a healthy life.
    a. can
    b. cannot
    c. can sometimes
    d. All the answers are incorrect.

26. Which macronutrient is the most energy dense?
    a. Proteins
    b. Carbohydrates
    c. Fats
    d. Water

27. Which food group in Canada's 2007 food guide is no longer a food group in the 2019 food guide?
    a. Grains
    b. Milk products
    c. Fats
    d. Vegetables and fruits

28. In the 2019 food guide, what portion of a plate should be composed of fruits and vegetables?
    a. One quarter
    b. One third
    c. One half
    d. One eighth

29. What are the two important components of a nutrition label?
    a. Caloric content and ingredients
    b. Nutrition facts table and list of ingredients
    c. Percent daily value and macronutrients
    d. Nutrition facts table and caloric content

30. How many nutrients are listed on the nutrition facts table?
    a. 11
    b. 20
    c. 9
    d. 12

31. How are ingredients listed on the nutrition labels of packaged food?
    a. By decreasing size
    b. By increasing weight
    c. By decreasing weight
    d. By increasing size

## Section II – Basic Digestion

32. What is/are the main group(s) of the digestive system?
    a. Alimentary canal and accessory digestive organs
    b. Digestive tract and accessory digestive organs
    c. Stomach and intestines
    d. Both answers a and b are correct

33. Digestion occurs in two main ways. What are these ways?
    a. Chemical and mechanical digestion
    b. Mechanical and propulsive digestion
    c. Chemical and propulsive digestion
    d. Both answers a and b are correct

34. What location of the digestive system does churning occur in?
    a. Mouth
    b. Small intestine
    c. Stomach
    d. All of the above

35. Where does chemical digestion of carbohydrates begin in the digestive system?
    a. Mouth
    b. Small intestine
    c. Stomach
    d. All of the above

36. What type of digestion is segmentation?
    a. Mechanical
    b. Chemical
    c. Propulsion
    d. Mechanical and chemical

37. What is the term for the automatic and involuntary way food is propelled through the alimentary canal?
    a. Segmentation
    b. Chewing
    c. Peristalsis
    d. Churning

38. Chemical digestion involves enzymes breaking ____________.
    a. physical bonds
    b. fraternal bonds
    c. adhesive bonds
    d. chemical bonds

39. _________ are the proteins used for chemical digestion.
    a. Collagens
    b. Amino acids
    c. Enzymes
    d. Essential amino acids

40. The accessory digestive organs include the salivary glands, stomach glands, pancreas, liver, and ____________.
    a. gall bladder
    b. small intestine
    c. large intestine
    d. pharynx

41. Where does the chemical digestion of fats and proteins begin in the alimentary canal?
    a. Mouth
    b. Stomach
    c. Small intestine
    d. Large intestine

42. As food is chewed, it becomes a _________ before it is swallowed.
    a. chyme
    b. bolus
    c. feces
    d. esophagus

43. Where does carbohydrate, lipid, and protein absorption into the bloodstream occur in the alimentary canal?
    a. Mouth
    b. Stomach
    c. Small intestine
    d. Large intestine

44. Another word for pharynx is the __________.
    a. esophagus
    b. throat
    c. small intestine
    d. large intestine

45. The enzyme responsible for chemical digestion in the mouth is called ________.
    a. pancreatic amylase
    b. bile
    c. brush border enzyme
    d. salivary amylase

46. The five main functions of the digestive system are ingestion, digestion, propulsion, absorption, and __________.
    a. excretion
    b. segmentation
    c. peristalsis
    d. churning

47. Where is water absorbed from chyme into the bloodstream?
    a. Mouth
    b. Stomach
    c. Small intestine
    d. Large intestine

**Section III – Heat**

48. Heat naturally flows from __________ to __________ areas.
    a. cold; hot
    b. cold; warm
    c. hot; cold
    d. warm; hot

49. How many principles does the particle theory of matter have?
    a. 3
    b. 4
    c. 5
    d. 6

50. Which answer is a principle of the particle theory of matter?
    a. All substances are made up of tiny particles.
    b. Particles in a particular substance are attracted to each other.
    c. Adding heat to a substance will increase the energy of the particles in the substance.
    d. All the above

51. Particles of a substance are named ________________.
    a. molecules
    b. neutrinos
    c. atoms
    d. Both answers a and c are correct

52. At what temperature is there no heat left in a substance?
    a. 0°C
    b. Absolute Zero
    c. -273.15°C
    d. Both answers b and c are correct

53. Adding heat to a substance will ______________.
    a. increase the motion of and distance between particles of a substance.
    b. decrease the motion of and distance between particles of a substance.
    c. change the size of particles of a substance.
    d. None of the above answers is correct

54. Particles of an ice cube are _______________________.
    a. further from each other in contrast to particles of water
    b. closer to each other in contrast to particles of water
    c. at the same distance from each other as particles of water
    d. None of the above answers is correct

55. The states of matter are ________________.
    a. solid
    b. liquid
    c. gas
    d. All the above

56. The transfer of heat in a solid, like a steak, is called __________.
    a. conduction
    b. convection
    c. radiation
    d. energizing

57. The microwaves transfer heat to food via ____________.
    a. conduction
    b. convection
    c. radiation
    d. energizing

58. The transfer of heat in a liquid, like water, or a gas, like steam, is called _______.
    a. conduction
    b. convection
    c. radiation
    d. energizing

59. An important effect of heat on carbohydrates is ______________.
    a. melting
    b. gelatinization
    c. caramelization
    d. Both answers b and c are correct

60. An important effect of heat on fats is _______________.
    a. melting
    b. gelatinization
    c. caramelization
    d. coagulation

61. An important effect of heat on protein is ______________.
    a. coagulation
    b. melting
    c. maillardization
    d. Both answers a and c are correct

62. The colour and flavour changes of carbohydrates exposed to enough heat is called _____________.
    a. caramelization
    b. maillardization
    c. gelatinization
    d. Both a and b are correct

63. The effect of heat on water is ______________.
    a. Vaporization
    b. Gelatinization
    c. Evaporation
    d. Incineration

64. What is the boiling point of water at sea level?
    a. 0°C
    b. 38°C
    c. 100°C
    d. 150°C

## Answer Key

1. d
2. c
3. d
4. c
5. d
6. b
7. d
8. a
9. a
10. d
11. a
12. b
13. c
14. d
15. a
16. c
17. c
18. d
19. c
20. b
21. a
22. c
23. a
24. d
25. b
26. c
27. b
28. c
29. b
30. d
31. c
32. d
33. a
34. c
35. a
36. a
37. c
38. d
39. c
40. a
41. b
42. b
43. c
44. b
45. d
46. a
47. d
48. c
49. d
50. d
51. d
52. d
53. a
54. b
55. d
56. a
57. c
58. b
59. d
60. a
61. a
62. b
63. c
64. c

## Summary

This module is the fourth module in a five-part series meant to provide those interested in cooking and/or restaurant operations with basic theoretical knowledge pertaining to kitchen math and science. In this module, you learned nutrition in the first chapter, the basics of digestion in the second chapter, and heat and its effects in the third chapter.

The final module in this series is a short project where you will apply the theory you learned in the last four modules. All four modules can be used as references to complete the project tasks. Please see the project module for further information.

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