Cooking Food

COOKING FOOD is an art and science. Cooking and baking require the use of heat energy. However, heat energy comes in numerous forms. The manner in which heat energy is transferred from the heat source to the food varies. Therefore, understanding the heat transfer methods will help you become a scientific cook. Do you know which type of pan is best for cooking and baking? Does it matter what metal are used to make the pan? Thermometers are used to measure temperature and to indicate if food is done. Have you used a thermometer while cooking? As the food is cooking, you must know when the food is ready to serve. No one wants to eat unsafely cooked or overcooked foods.

Objectives:

1. Compare and contrast how heat is transferred in cooking.
2. Identify dry and wet cooking methods.
3. Practice reading a thermometer.
4. Recognize when a food product is done.

Key Terms:

Heat Transfer Terms

clad	heat	infrared
conduction	heat transfer	molecules
convection	induction	radiation

Cooking Method Terms		
bake	fry	sauté
boil	grill	simmer
braise	moist heat cooking methods	steam
broil	pan-fry	stew
deep-fry	roast	stir-fry
dry heat cooking methods		

Thermometer Terms		
Celsius	instant read thermometer	thermometer
Fahrenheit	temperature	

Heat Transfer Methods

Heat is a combination of kinetic (movement) energy and temperature (a measurement of heat). **Heat transfer** is a form of energy that moves heat to food. In general, heat is transferred from one material to another in one of three ways: conduction, convection, or radiation.

CONDUCTION

Conduction is the transfer of heat directly from one source to another—direct physical contact of colliding **molecules** (the smallest unit of a molecular compound). Heat through

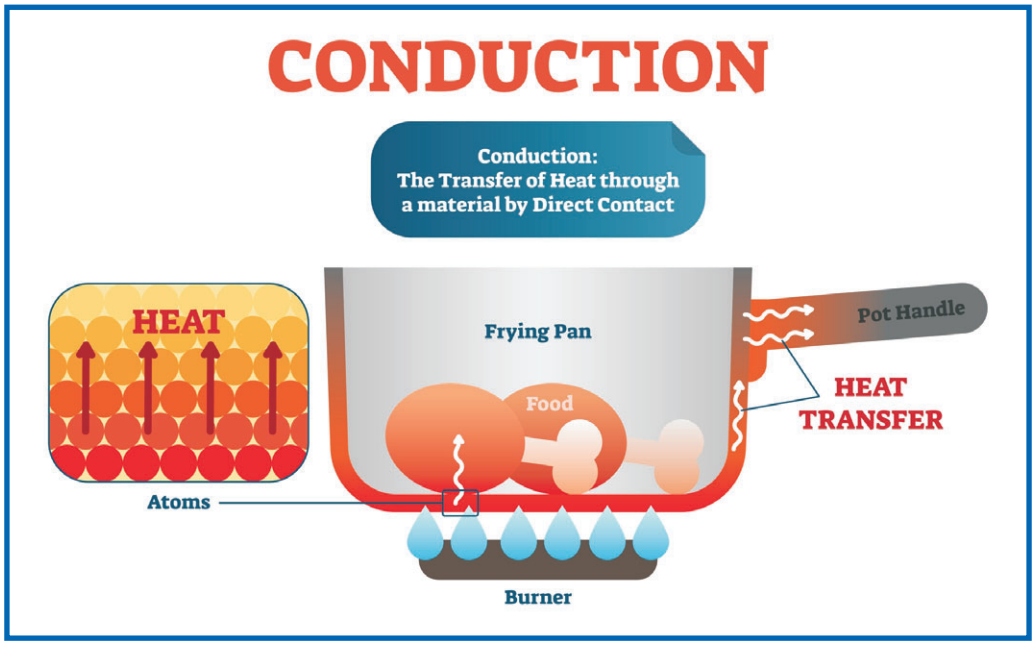

FIGURE 1. Conduction is the transfer of heat through a material with direct contact.

conduction is demonstrated as simply as putting a pan on a stove and turning on the flame (or coil). The heat (or energy) from the electric or gas range physically touches the pan. The heat moves from the bottom of the pan, through the pan, and into the food in the pan. Conduction is heat traveling through food.

CONVECTION

Convection is heat transfer involving natural and mechanical movements of a liquid or gas. Natural convection involves warm air (or liquid) rising and cool air (or liquid) falling. Mechanical convection involves fans or stirring to cause movements. Convection ovens have fans that move the heat and speed up the cooking time. These ovens cook 25 percent faster at a temperature 25 percent lower than a conventional oven. If a sauce is stirred while heating, the heat will transfer more rapidly throughout the food.

FIGURE 2. Convection is heat transfer involving natural and mechanical movements of a liquid or gas. Explain both pictures.

RADIATION

The heat transfer method, **radiation** is extremely different from conduction and convection. Radiation is a type of heat transfer that occurs by moving **infrared** rays or electromagnetic waves. Radiation uses heat or light to pass through molecules. Infrared waves are used in toasters and broilers. Microwaves use electromagnetic waves. No heat transfer medium is necessary.The food absorbs the raw radiant energy and is cooked by the vibration of water molecules in the food.

FIGURE 3. How do both pictures show radiation heat transfer?

INDUCTION

Induction ranges use the process of releasing magnetic currents (generated by a high-frequency induction coil) that react only with certain ferrous (containing iron) metals that allow the heat energy to pass into the metal and then into the food. No flame or red coil is visible, and the "burner" surface emanates no heat of any kind. This is a safe cooking surface for young children and older adults because the cooking surface is always cool. Cooking on an induction range requires special pans.

HEAT TRANSFER MEDIUMS

Heat transfer mediums are the actual "material" the heat is moving through: a pan, air, water, steam, or oil. The medium has a direct effect on how rapidly a food cooks.

Pans

Pans can be made of many types of material. All pans do not transfer heat the same. The gauge or thickness of the metal also affects the transfer of heat.

- Copper, aluminum, carbon steel, and cast iron are excellent conductors of heat (listed in order of best heat transfer). However, copper cannot be used alone in most cookware because it reacts with minerals and acid in foods causing a yellow color and bitter taste. Cast iron takes a long time to heat and cool. Cast iron retains the heat well and is the preferred material for Dutch ovens, fry pans, griddles, and grill pans.
- Stainless steel does not heat food as evenly as these other metals and is often **clad** with copper or another metal (covered with a layer of copper on the bottom of the pan).

- Clay and stoneware are the oldest cookware. They heat very evenly and hold heat well without hot spots. Clay and stoneware are used in the oven.

FIGURE 4. Clay cookware is still used today.

Heating Media Transfers Heat at Different Rates

Each heating media (air, water, steam, and fat) transfers heat at different rates.

- Steam is hotter than any temperature of water.
- Fat can be heated to a much higher temperature than water.
- When you roast, bake, broil, or grill you are primarily cooking with air as the heat medium.
- Food cooks quicker in a hotter heating media (e.g., chicken takes longer to cook in the oven than chicken that is fried).

Heat Conduction in Bakeware

Should you choose glass, dark metal, shiny metal, or silicone?

- Glass is not a good conductor of heat compared to metal. Glass retains heat well, so the food cooks faster. Baked goods baked in glass may become overbrown before getting done. The oven temperature is often reduced 25 degrees when baking in a glass pan.
- Dark metal absorbs more heat than shiny metal. This means foods cook faster and brown more. If you do not want a very brown cookie bottom, cover the dark metal pan with foil, parchment paper, or lower the oven temperature 25 degrees.
- Shiny metal pans (e.g., aluminum) are an excellent heat conductor. Foods bake quickly and become golden brown.

FIGURE 5. Notice some of the bakeware is dark and some is shinny. What is the advantage of each?

- Silicone is lightweight, flexible, and nonstick. Silicone is not a good heat conductor, so foods baked in silicone pans do not brown well. If you want a delicate cookie or cakes, silicone is the best choice. Because silicone is so flexible, the silicone bakeware is often placed on a tray before placing in the oven.

FIGURE 6. The silicone bakeware comes in many shapes. The nonstick feature is helpful with scalloped decorated sides or tops.

Cooking Methods and Terms

Cooking methods can be categorized as dry or moist. Heat makes food palatable and easier to digest. When food is heated:

- Fats melt
- Water evaporates
- Starches gelatinize (swell or thicken)
- Proteins coagulate (harden).
- Sugars caramelize (brown).

DRY COOKING METHODS

Dry heat cooking methods involve cooking with air.

Dry Heat Cooking Terms

- Baking—To **bake** is to cook food in an oven with hot, dry heat all around the food.
- Broiling—To **broil** the food is placed under a hot coil unit in an oven—as opposed to roasting and baking, which cook by means of heated air.

FIGURE 7. What is the dry heat cooking method shown in this picture? What foods are being cooked by dry heat cooking?

- Grilling—To **grill** is to cook on a hot grid, grate, or solid surface.
- Roasting—To **roast** is to cook food under dry heat—often in an oven.

MOIST HEAT COOKING METHODS

Moist heat cooking methods involve cooking with water, moisture, or steam.

Moist Heat Cooking Terms

- Boiling—To **boil** is to cook food in 212°F liquid that is bubbling vigorously and steaming.
- Braising—To **braise** is to use a combination cooking method of baking and steaming tough cuts of meat.
- Simmering—To **simmer** is to cooking foods in liquid or sauces just below the boiling point (195°F) so the surface barely ripples.
- Stewing—To **stew** food is cooked in liquid or sauce with vegetables.

FIGURE 8. Which moist heat cooking method is used to cook the Swiss steak?

STEAMING

Steaming is a variation of moist heat. To **steam** is to cook food on a perforated rack or pan over boiling water in a covered pan.

FIGURE 9. Notice the broccoli is placed in a steamer basket over boiling water in a pan with a lid.

FRYING

Frying food in fat is also a variation of moist heat. To **fry** is to cook food in hot oil or fat until a crisp brown crust forms.

Types of Frying

- Deep fat frying—To **deep-fry** is to cook food by completely submerging it in hot fat or oil.

- Pan frying—To **pan-fry** is to cook food in a hot pan with a small amount of hot oil, butter, or some other fat.
- Sautéing—To **sauté** is to cook food quickly over very high heat in a small amount of fat.
- Stir-frying—To **stir-fry** is to sauté small pieces of meat and vegetables quickly over very high heat while stirring continuously and rapidly.

FIGURE 10. These vegetables are being stir-fried in a wok. You can use a skillet to do the same thing.

RELATIONSHIP OF HEAT TRANSFER METHODS TO DRY AND MOIST HEAT COOKING

Many cooking tasks (e.g., braising) require more than one form of heat transfer.

- Steaming, boiling, deep frying, and sautéing cause effective heat transfer by conduction.
- Steaming, baking, and roasting cause effective heat transfer by convection.
- Broiling, grilling, and microwaving all use heat transfer by radiation.

Even when removed from the heat, food continues to cook using heat transfer methods for a few minutes. This is called "carryover cooking" or "rest time".

Using a Thermometer

A **thermometer** is an instrument for determining temperature of the surface or the internal temperature of foods.

EXPLORING OUR WORLD...

SCIENCE CONNECTION: Check Your Thermometer for Accuracy

Check your thermometers using two simple methods. Place the thermometer in ice water or boiling water. See the two tests at https://www.foodrepublic.com/2011/04/04/how-to-calibrate-your-food-thermometer/.

FIGURE 11. Compare the two types of candy thermometers.

TYPES OF THERMOMETERS

A common thermometer consisting typically of a glass bulb attached to a fine tube of glass with a numbered scale and containing a liquid (mercury or colored alcohol) that is sealed in and rises and falls with changes of temperature (e.g., candy thermometer).

An **instant read thermometer** provides quick and accurate internal temperature readings. The most common type used is a bimetallic stem thermometer. When a thermometer is used to test the doneness of meat, it is placed in the thickest part without touching bone. Instant read thermometers are often digital read, unlike glass tube thermometers.

FIGURE 12. This instant read digital thermometer is used to check the temperature of white chocolate.

Temperature Scales

The **temperature** (hotness or coldness of something) is calculated by degrees (°) on a scale. Thermometers temperature range should be considered. Thermometers for deep fat frying and candy making can calculate higher temperatures than room thermometers. The temperature scales are Fahrenheit and Celsius.

- **Fahrenheit** is a thermometric system in which waters freezing point is 32 degrees and its boiling point is 212 degrees. Fahrenheit is the customary measurement system used by

EXPLORING OUR WORLD...

SCIENCE CONNECTION: Reading a Thermometer

Accuracy is very important when reading a thermometer. See YouTube video for tips on reading a thermometer. On your device with internet, search "reading a thermometer" or see https://www.youtube.com/watch?v=saSah6kLGOc.

the United States and a few other small countries. Recipes in the U.S. use Fahrenheit temperature scale.

- **Celsius** is a thermometric system in which O degrees is the freezing point and 100 degrees is the boiling point of water. Celsius is used to measure temperature in the metric measurement system. Celsius is used in science experiments and recipes from most parts of the world.
- Some thermometers show both scales.

Reading a Glass Bulb and Tube Thermometer

Most thermometer scales are divided in two-degree increments. When you read the temperature on a thermometer, it should be vertical and your eyes should be level with the top of the liquid in the glass tube. Avoid holding the thermometer when reading. The heat from your hands will transfer to the glass causing the temperature to rise or fall. Use a clip to attach the thermometer to the pan. Adjust the thermometer to prevent the bulb from touching the bottom of the pan.

FIGURE 13. This thermometer is used to check the temperature of candy or oil for frying.

When Is Food Done?

Knowing when a food product is done is a correlation between time, temperature, touch, smell, visual, sound, and other unique techniques. Some examples include:

DIGGING DEEPER...

UNCOVERING ADDITIONAL FACTS: How to Know When Food Is Done

Each food has different techniques to determine doneness. Online Cooks Illustrated has pictures showing placement of the thermometer to check the temperature of meat and poultry. You can even temp baked potatoes between 205–212°F for perfect fluffiness. If you are baking cookies or cakes, this article has full proof pictures to identify the correct doneness. See all the information at https://www.cooksillustrated.com/articles/1390-how-to-know-when-food-is-done?extcode=NSCIL01FB&utm_source=facebook&utm_medium=photo&utm_content=fooddoneness&utm_campaign=cioarticles.

TIME AND TEMPERATURE

Time and temperature are used to determine if a food is done.

Time

When setting a timer to indicate the finish time of baking, use the shortest amount of time if the recipe indicates a range (e. g., 10–12 minutes). If only one time is listed, shorten the time and check for doneness early. You can always set the timer again.

Temperature

For food safety, follow the safe minimum cooking temperature charts. For information, see the "Safe Minimum Cooking Temperatures Charts" at https://www.foodsafety.gov/food-safety-charts/safe-minimum-cooking-temperature.

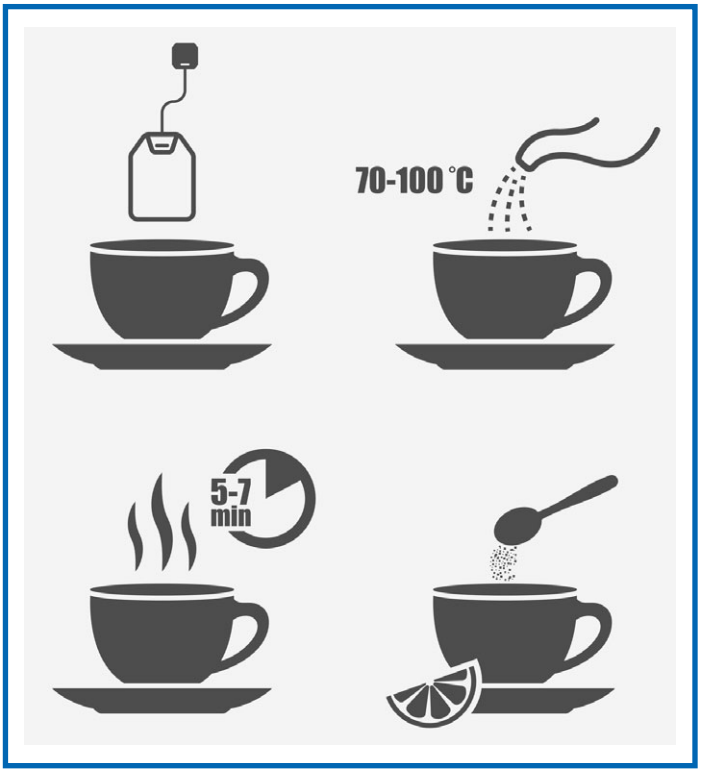

FIGURE 14. This is a time and temperature graphic for making tea. What do you notice about the temperature?

SENSES

Your senses are used to determine if food is done.

FURTHER EXPLORATION...

ONLINE CONNECTION: Touch Tests

Touch can be used to determine the doneness of a steak. The tests compare touching your hand or palm in different places and comparing the feeling when you touch the steak. See three touch tests for steak doneness at http://www.clovermeadowsbeef.com/touch-test-steak-doneness/. The last touch test is unusual. You can also see YouTube videos on meat touch tests.

Touch

Touch is used for many food items to determine if they are done.

- Custard based pies or cheese cake—outside should be firm when touched but the inside slightly wobbly.
- Cakes and sweet dessert breads (e. g., banana nut bread)—softly touch the center and it feels springy and leaves no indentation.

FIGURE 15. Does this cheesecake look over cooked?

Smell

Most food will have a pleasant roasting or caramelizing aroma when done.

Visual or Sight

This is the most used sense when determining if a food is done.

- Cakes should pull away from the sides. Cakes should not wiggle when moved. Insert a toothpick or cake tester in the center of the cake and it should come out clean.

FIGURE 16. Notice the red velvet brownie cheesecake being tested with a toothpick.

- Lift a loaf of yeast bread and check for browning on the bottom.
- When bubbles appear on top of the pancakes, it is time to flip them.
- When liquids run clear in poultry, fish, well-done meat, and hamburgers.
- Vegetables are pierces through the center with a fork or sharp knife.
- Rice should have all the liquid absorbed.
- Casseroles and quiches should be brown on the top.

Sound

Listen for a hollow sound when you tap yeast bread to indicate doneness.

Mouthfeel

Mouthfeel is the sensation of the food in the mouth. Pasta should be "Al dente" or it should be cooked just long enough to still be firm, and not too soft.

FIGURE 17. Pasta should be "Al dente."

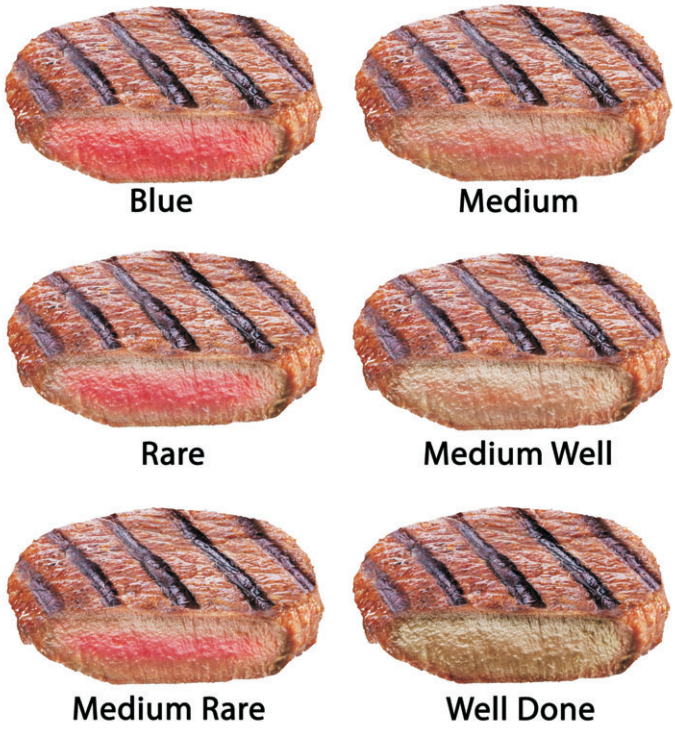

FIGURE 18. There are six ways to have your steak cooked. The newest is blue or blue rare. It is a steak that has been cooked momentarily at a very high temperature to char the outside with the inside having a bluish purple look.

Summary:

Heat is the amount of energy present in a given object or environment. It is transferred in one of three primary methods: conduction, convection, or radiation. Conduction is the process of heat or thermal energy moving from one molecule to the next, passing along from the source, through the medium (e.g., air, water, oil, or metal), and into the food. Convection uses motion or fans to move energy from place to place. Radiation uses energy waves to transfer heat in two forms: microwaves or infrared waves. Heat transfer mediums are the actual "material" the heat is moving through: a pan, air, water, steam, or oil. The types of materials pans effect the length of time needed to cook and quality of the cooked food or baked goods. Food is cooked using dry and moist cooking methods. Different cooking terms are used in each cooking method. It is important to know how to read a thermometer and the placement of the thermometer when it is inserted into food. Use time, temperature, and your senses to determine when a food is done.

Checking Your Knowledge:

1. How are the three common heat transfer methods different?
2. What are the five heat transfer mediums?
3. What is the difference in dry and moist cooking techniques and what are three names of cooking terms related to each?
4. How do you read a glass bulb thermometer?
5. What are eight methods of determining if food is done?

Expanding Your Knowledge:

Most homes have a microwave oven. Regardless of what is cooked or heated, the only real warning for microwave usage is: Do NOT use metal in any form inside the oven. Glass, china, paper, and plastic are all acceptable containers, but what most people don't know is that there is a problem with plastic. Some plastic containers are labeled as "microwave safe," but those that do not carry that label seem to work just fine. The problem has to do with food safety and chemical contamination. Do some research to determine the dangers of microwaving some types of plastic? What type of plastics should never be used to heat food in microwave? What are the dangers of eating foods heated in those containers? Should plastic wrap be used to heat food in a microwave oven? Share your findings with your family and friends. There is more than one opinion on the topic. For more information, see the web links below.

Web Links:

How to Safely Use Plastic Containers in Your Microwave

https://consumer.healthday.com/public-health-information-30/food-safety-news-589/how-to-safely-use-plastic-containers-in-your-microwave-741307.html

Microwaving Food in Plastic

http://www.health.harvard.edu/fhg/updates/update0706a.shtml

Mixing Plastic and Food: An Urban Legend?

https://www.webmd.com/food-recipes/features/mixing-plastic-food-urban-legend#1

That Plastic Container You Microwave In Could Be Super-Toxic

https://time.com/4229503/plastic-in-microwave-is-it-safe/