COMPETENCY 1.0 SCIENCE METHODOLOGY, TECHNIQUES, AND HISTORY

Skill 1.1 Nature of scientific knowledge, inquiry, and historical perspectives: scientific methods and processes; facts, models, theories and laws; historical roots of science, and contributions made by major historical figures

THE SCIENTIFIC METHOD

The scientific method is the basic process behind scientific experimentation. It involves several steps, beginning with formulating a hypothesis and working through the discovery process to make a conclusion based on observation and testing.

Posing a Question
Although many discoveries happen by chance, a scientist's standard thought process begins with forming a question to test by conducting research. The more limited the question, the more readily an experiment can be designed to answer that question.

Forming a Hypothesis
Once the question is formulated, a scientist makes an educated guess about the answer to the problem or question. This "best guess" is your hypothesis.

Doing the Test
Next, a series of steps known as an experiment are outlined to test this hypothesis. To make a test fair, data from an experiment must have a **variable** or any condition that can be changed, for example temperature or mass. A good test will try to manipulate as few variables as possible. This allows the researcher to more readily identify the variable or condition that produces a particular result. Experiments also require a second factor known as a **control**. A control is a factor that remains unchanged throughout the experiment, which allows the researcher to verify that the experiment worked correctly. When using a control, all the conditions are the same except for the variable being tested.

Observing and Recording the Data
Once the experiment is conducted, data must be gathered based on the results obtained. Data reporting should state specifics of how the measurements were made during the experiment. For example, a graduated cylinder needs to be read with proper procedures. For beginning students, technique must be part of the instructional process so as to give validity to the data.

Drawing a Conclusion
Careful analysis of the recorded data allows the experimenter to draw a conclusion based on the evidence. After recording data, compare your data with

that of other researchers that conducted similar experiments. A conclusion is the judgment derived from the data results.

Communicating Results

Scientific findings are usually documented in the form of a lab report. All lab reports should include a specific **title** and tell exactly what is being studied. The **abstract** is a summary of the report that is placed at the beginning of the paper. The **purpose** should always be defined, clearly stating the question the experiment was designed to answer. The purpose should include the **hypothesis** (educated guess) of the expected outcome of the experiment. The entire experiment should relate to this problem. It is important to accurately describe what was done to prove or disprove a hypothesis. A **control** is needed in every experiment; it is necessary to prove that the results obtained are a result of the manipulated variable. Only one variable should be manipulated at a time. **Observations** and **results** of an experiment should be recorded, including all results from data. Drawings, graphs, and illustrations should be included to support information. Observations are objective, whereas analysis and interpretation is subjective. A **conclusion** should explain why the results of the experiment either proved or disproved the hypothesis.

Scientific theory and experimentation must be repeatable. It is also possible that previously established theories can be disproved and may be changed on the basis of new scientific proof. Science depends on communication, agreement, and disagreement among scientists. It is built on theories, laws, and hypotheses.

- **Theory** - the formation of principles or relationships that have been verified and accepted, a proven hypothesis.
- **Law** - an explanation of events that occur with uniformity under the same conditions (laws of thermodynamics, law of gravitation).
- **Hypothesis** - an unproven theory or educated guess followed by research to best explain a phenomena.

Models

A **model** is a basic element of the scientific method. Many things in science are studied with models. A model is a simplification or representation of a problem that is being studied or predicted. A model is a substitute, but it is similar to what it represents. We encounter models at every step of our daily living. The periodic table of the elements is a model that chemists use for predicting the properties of the elements. Physicists use Newton’s laws to predict how objects will interact, such as planets and spaceships. In geology, the continental drift model estimates the past positions of continents. Samples, ideas, and methods are all examples of models. At every step of scientific study, models are extensively used. The primary activity of hundreds of thousands of U.S. scientists is to produce new models; these models are presented to the scientific community and the general public in tens of thousands of scientific papers published every year.

HISTORICAL PERSPECTIVE

Beginnings of Microbiology

Anton van Leeuwenhoek is known as the father of microscopy. In the 1650s, Leeuwenhoek made tiny lenses that produced magnifications up to 300x. He was the first scientist to see and describe bacteria, yeast, plants, and microscopic organisms found in water. Over the years, light microscopes have been refined to produce greater clarity and magnification. The scanning electron microscope (SEM) was developed in the 1950s. Instead of light, a beam of electrons is passed through the specimen. Scanning electron microscopes have a resolution about 1,000 times greater than that of light microscopes. The disadvantage of the SEM is that the chemical and physical methods used to prepare the samples result in the death of the specimen.

In the late 1800s, Louis Pasteur discovered that microorganisms play a causal role in the onset of disease. He also pioneered the pasteurization process, and the development of the rabies vaccine. Robert Koch took Pasteur's observation that microorganisms cause disease one step further by postulating that specific diseases were caused by specific pathogens. Koch's **postulates**, as his discoveries are called, are still used as guidelines in the field of microbiology.

The postulates state that:

- The same pathogen must be found in every person with the same disease.
- The pathogen must be isolated and grown in culture.
- When the organism is re-introduced into an experimental animal, that animal should develop the same disease originally seen.
- The same pathogen must be isolated from the re-infected, experimental animal.

Discovery of DNA

DNA structure was another key discovery in biological study. In the 1950s, James Watson and Francis Crick discovered that the DNA molecule was organized into a double helix. The discovery of this structure made it possible to explain DNA's ability to replicate and to control protein synthesis.

Experimental Models

The use of animals in biological research has expedited many scientific discoveries. Animal research has allowed scientists to learn more about biological systems, including the circulatory and reproductive systems. Animal models are used in a variety of applications including drug testing, vaccine creation, and the development of other products (such as perfumes and shampoos) before use or consumption by humans.

Skill 1.2 Mathematics, measurement, and data manipulation; measurement and notation systems; data presentation and interpretation, including error analysis

Science may be defined as a body of knowledge that is systematically derived from study, observations, and experimentation. Its goal is to identify and establish principles and theories, which may be applied to solve problems. **Pseudoscience**, on the other hand, is not based on scientific methodology or application. Some of the more classic examples of pseudoscience include witchcraft, alien encounters, or topics that are explained by hearsay rather than by reproducible experimentation.

THE METRIC SYSTEM

In science, the metric system is the worldwide standard of measurement; this allows for easier comparison among experiments done by scientists around the world. Learn the following basic metric units and prefixes:

Base units

- **Meter** - base unit of length.
- **Liter** - base unit of volume.
- **Gram** - base unit of mass.

Prefixes

- **Deca**-(meter, liter, gram) = 10X the base unit.
- **Hecto**-(meter, liter, gram) = 100X the base unit.
- **Kilo**-(meter, liter, gram) = 1000X the base unit.
- **Deci**-(meter, liter, gram) = 1/10 the base unit.
- **Centi**-(meter, liter, gram) = 1/100 the base unit.
- **Milli**-(meter, liter, gram) = 1/1000 the base unit.

GRAPHING

Graphing is an important way to visually display data for analysis. The two types of graphs most commonly used are the **line graph** and the **bar graph** (histogram).

Line Graphs

Line graphs are set up to show two variables, represented by one point on the graph. The *x*-axis is the horizontal axis; this is where the independent variable of the experiment is plotted. Independent variables are those that are not affected by any changes in the experimental conditions. A common example of an independent variable is time. Time proceeds regardless of any changes in experimental conditions. The *y*-axis is the vertical axis; the dependent variable is plotted here. Dependent variables are manipulated by the experimentor. Factors such as the amount of light or the height of a plant are examples of dependent variables. The axes of a graph should be labeled at equal intervals. If one interval represents one day, the next interval should not represent ten days. A “best fit” line is drawn to join the points on a graph though it may connect all the points of the data. Both axes should always be labeled for a graph to be accurately interpreted. Graphs must always include a descriptive title; a good title will describe both the dependent and the independent variables.

Bar Graphs
Bar graphs are set up with category labels along the horizontal axis. An appropriate scale is chosen for the vertical axis that will show the responding variable. A bar is drawn at each category with a height equal to the data along the vertical axis. Each bar represents a separate piece of data and is not joined by a continuous line. Bar graphs should also be given a descriptive title.

Uses for Graphs
The type of graph used to represent one’s data depends on the type of data collected. **Line graphs** are used to compare different sets of related data or to predict data that has not yet be measured. For example, a line graph would be used to compare the rate of activity of different enzymes at varying temperatures. A **bar graph** or **histogram** is used to compare different items and make comparisons based on this data. A bar graph would be used to compare the range of ages of children in a classroom. A **pie chart** is useful when organizing data as part of a whole. A pie chart would be used to display the percent of time students spend on various after-school activities.

EXPERIMENTAL ERROR

All experimental uncertainty is due to either random errors or systematic errors.

Random Errors
Random errors are statistical fluctuations in the measured data due to the precision limitations of the measurement device. Random errors usually result from the experimenter’s inability to take the same measurement in exactly the same way to get exactly the same number.

Systematic Errors
Systematic errors, by contrast, are reproducible inaccuracies that are consistently made during an experiment at the same point. Systematic errors are often due to a problem that persists throughout the entire experiment.

Systematic and random errors refer to problems associated with making measurements. Mistakes made in the calculations or in reading the instrument are not considered in error analysis.

Skill 1.3 Laboratory procedures and safety: techniques of safe preparation, storage, use, and disposal of laboratory and field materials; selection and use of appropriate laboratory equipment

CLASSROOM TECHNIQUES AND PROCEDURES

Dissections

Animals that are not obtained from recognized sources should not be used for laboratory experiments. Decaying animals or those of unknown origin may harbor pathogens and/or parasites that could be harmful to an experimenter's health. Specimens should be rinsed before handling. Non-latex gloves are desirable because some people have latex allergies. If gloves are not available, students with sores or scratches should be excused from the activity. Formaldehyde is a carcinogen and should be avoided or disposed of according to district regulations. Students objecting to dissections for moral reasons should be given alternative assignments.

Live specimens

Biological experiments may be done with all animals except mammalian vertebrates and birds. Lower-order life forms and invertebrates may be used for experimentation. No physiological harm should be inflicted upon the animal. All animals housed and cared for in the school must be handled in a safe and humane manner. Animals are not to remain on school premises during extended vacations unless adequate care is provided. Many state laws stipulate that any instructor who intentionally refuses to comply with the laws may be suspended or dismissed.

Microbiology

Pathogenic organisms must never be used for experimentation. Students should adhere to the following rules at all times when working with microorganisms to avoid accidental contamination:

1. Treat all microorganisms as if they were pathogenic.
2. Maintain sterile conditions at all times.

If you are taking a national level exam you should check the Department of Education for your state mandated safety procedures. You will want to know what your state expects of you not only for the test but also for performance in the classroom and for the welfare of your students.

LABORATORY EQUIPMENT

Bunsen Burners

Hot plates should be used whenever possible to avoid the risk of burns or fire. If Bunsen burners are used, the following precautions should be followed:

1. Know the location of fire extinguishers and safety blankets, and train students in their use. Long hair and long sleeves should be secured and out of the way.

2. Turn the gas on slowly to about a quarter of maximum on and make a spark with the striker. The preferred method to light burners is to use strikers, rather than matches.

3. Adjust the air valve at the bottom of the Bunsen burner until the flame shows an inner cone.

4. Adjust the flow of gas to the desired flame height by using the adjustment valve.

5. Do not touch the barrel of the burner (it is hot).

Graduated Cylinders
These are used for precise measurements. They should always be placed on a flat surface. The surface of the liquid will form a meniscus (lens-shaped curve). The measurement is read at eye level, reading the <u>bottom</u> of this curve.

Balances
Electronic balances are easier to use but are more expensive. An electronic balance should always be used on a flat surface and tared (returned to zero) before measuring. Substances should always be placed on a piece of weighing paper to avoid spills and/or damage to the instrument. Triple beam balances must be used on a level surface. There are screws located at the bottom of the balance to make any adjustments. Start with the largest counterweight first and proceed toward the last notch that does not tip the balance. Do the same with the next largest, and so on, until the pointer remains at zero. The total mass is the total of all the readings on the beams. Again, use weighing paper under the substance to protect the equipment.

Buret
A buret is used to dispense precisely measured volumes of liquid. A stopcock is used to control the volume of liquid being dispensed at a time.

Light Microscopes
These are commonly used in laboratory experiments. Several procedures should be followed to properly care for this equipment:

- Clean all lenses with lens paper only.
- Carry microscopes with two hands; one on the arm and one on the base.
- Always begin focusing on low power, then switch to high power.
- Store microscopes with the low power objective down.
- Always use a cover slip when viewing wet mount slides.

- Bring the objective down to its lowest position then adjust the fine focus, to avoid breaking the slide or scratching the lens.

Wet mount slides should be made by placing a drop of water on the specimen and then putting a glass cover slip on top of the drop of water. Placing the cover slip on the slide at a 45-degree angle will help avoid air bubbles. The total magnification is determined by multiplying the ocular (usually 10X) and the objective (usually 10X on low, 40X on high).

LABORATORY PROCEDURES

Chromatography uses the principles of capillary action to separate substances such as plant pigments. Molecules of a larger size will migrate up the paper more slowly, whereas smaller molecules will move more quickly and produce lines of pigments.

Spectrophotometry uses percent light absorbance to measure a color change, thus giving qualitative data a quantitative value.

Centrifugation is used to separate substances of varying densities, which is achieved by spinning substances at a high speed. The more dense part of a solution will sediment at the bottom of the test tube, while the lighter material will stay on top. For example, centrifugation is used to separate blood into blood cells and plasma, with the heavier blood cells settling to the bottom.

Electrophoresis uses electrical charges of molecules to separate them according to their size. The molecules, such as DNA or proteins, are pulled through a gel towards either the positive end of the gel box (if the material has a negative charge) or the negative end of the gel box (if the material has a positive charge).

TECHNOLOGY

Computer technology has greatly improved the collection and interpretation of scientific data. Molecular findings have been enhanced through the use of computer images. Technology has revolutionized access to data via the Internet and shared databases. The manipulation of data is enhanced by sophisticated software capabilities. Computer engineering advances have produced such products as MRIs and CT scans in medicine. Laser technology has numerous applications with refining precision.

Satellites have improved our ability to communicate and transmit radio and television signals. Navigational abilities have been greatly improved through the use of satellite signals.

Sonar technology uses sound waves to locate objects and is especially useful underwater. The sound waves bounce off the object and are used to assist in location.

Seismographs record vibrations in the Earth and allow us to measure earthquake activity.

USING LABORATORY CHEMICALS AND SOLUTIONS

All laboratory solutions should be prepared as directed in the lab manual. Care should be taken to avoid contamination of solutions and samples. All glassware should be rinsed thoroughly with distilled water before use and cleaned well after use. Safety goggles should be worn while working with glassware, to protect the eyes. All solutions should be made with distilled water, since tap water contains dissolved particles that may affect the results of an experiment. Chemicals should be stored in a secured, dry area. Chemicals should be stored in accordance with the material safety data sheet (MSDS). Acids are to be locked in a separate area. Used solutions should be disposed of according to local disposal procedures. Any questions regarding safe disposal or chemical safety may be directed to the local fire department.

COMPTENCY 2.0 THE PHYSICAL SCIENCES

Skill 2.1 Matter and energy: structure and properties of matter, occurrence and abundance of elements, physical and chemical changes, forms and transformations of energy, conservation of mass and energy

MATTER AND ITS PROPERTIES

Everything in our world is made up of **matter;** rocks, mushrooms, animals, and people are all made up of matter. Matter has two characteristics:

1. It takes up space.
2. It has mass.

Mass

Mass is a measure of the amount of matter in an object. Two objects of equal mass will balance each other on a simple balance scale no matter where the scale is located. For instance, two rocks with the same mass that are in balance on Earth will also be in balance on the moon. They will feel heavier on Earth than on the moon because of the gravitational pull of the Earth.

Weight

Weight is the measure of the Earth's pull of gravity on an object. It can also be defined as the pull of gravity between two bodies. The units of weight measurement most commonly used are the pound (English measure) and the kilogram (metric measure). So, based on the previous example about mass, although the two rocks have the same mass, depending on where they are in the universe their weight may vary because of differences in gravitational pull.

Volume and Density

In addition to mass, matter also has the property of volume. **Volume** is the amount of cubic space that an object occupies. Volume and mass together give a more exact description of an object. Two objects may have the same volume, but different masses, or the same mass but different volumes, etc. For instance, consider two cubes that are each one cubic centimeter, one made from plastic, one from lead. They have the same volume, but the lead cube has more mass. The measure that we use to describe the cubes takes into consideration both the mass and the volume. **Density** is the mass of a substance per unit of volume. If the density of an object is less than the density of a liquid, the object will float in the liquid. If the object is denser than the liquid, then the object will sink.

To find an object's density, you must measure its mass and its volume. Then divide the mass by the volume ($D = m/V$). Density is stated in grams per cubic centimeter (g/cm^3) where the gram is the standard unit of mass.

If the object is a regular shape, you can find the volume by multiplying the length, width, and height. However, if it is an irregular shape, the volume can be found by seeing how much water it displaces. Measure the volume of the water in the container before and after the object is submerged. The difference between the two volumes will be the volume of the object.

Specific gravity is the ratio of the density of a substance to the density of water. For instance, the specific density of one liter of turpentine is calculated by comparing its mass (0.81 kg) to the mass of one liter of water (1 kg):

$$\frac{\text{mass of 1 L turpentine}}{\text{mass of 1 L water}} = \frac{0.81\text{ kg}}{1.00\text{ kg}} = 0.81$$

Physical and Chemical Properties

Physical properties and chemical properties of matter describe the appearance and behavior of a substance respectively. A **physical property** can be observed without changing the identity of a substance. For instance, you can describe the color, mass, shape, and volume of a book. **Chemical properties** are properties of a substance that become apparent after a chemical reaction has occurred. The original substances change, or new substances are formed, as these chemical properties become apparent. Baking powder goes through a chemical change as it changes into carbon dioxide gas during the baking process.

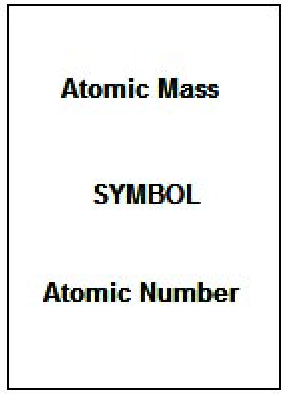
Matter can exist in different physical states. A **physical change** is a change that does not produce a new substance but changes the appearance of the substance. The freezing and melting of water is an example of a physical change. A **chemical change** (or chemical reaction) is any change of a substance into one or more different substances. When wood is burnt, it becomes ash; the chemical composition of ash and wood are different, therefore this represents a chemical change.

THE PERIODIC TABLE

The periodic table tells us a lot about the various elements and their atomic structures. The periodic table was invented in the late 1800s by Dmitri Mendeleev, and he grouped all of the known elements according to the similarities of their characteristics. He wrote the law of chemical periodicity, which states that the properties of the various elements are functions of the atomic number of the element. Elements are arranged according to different groups and “periods” and are listed in order of their atomic number. The **atomic number** is equal to the number of protons in each atom. Usually, the number of protons is the same as the number of electrons.

In a typical periodic table, the atomic number is located below the symbol of the element. The atomic mass is located above the symbol. The atomic mass is listed in units called atomic mass units, where one AMU equals 1/12 times the mass of carbon in grams. This takes into account both the neutrons and protons in the element. Elements that share the same atomic number but have a different atomic mass are called **isotopes** of one another.

The figure below represents the basic unit of the periodic table:



The periodic table is divided into “groups” and “periods”. Groups represent the vertical columns that include elements that are similar with respect to their chemical and physical properties. The columns start with metals and progress to nonmetals. The groups are shown as below:

- **Group 1A:** Alkali metals; very reactive; never found free in nature; react readily with water; e.g., sodium.
- **Group 2A:** Alkaline Earth elements; all are metals; occur only in compounds; react with oxygen in the general formula XO (where O is oxygen and X is Group 2A element); e.g., magnesium.
- **Group 3A:** Metalloids; includes aluminum (the most abundant metal on Earth); react with oxygen in the general formula X_2O_3.
- **Group 4A:** Includes metals and nonmetals; nonmetals are at the top of the column and metals are at the bottom; react with oxygen in the general formula XO_2; e.g., carbon.
- **Group 5A:** All elements form an oxygen or sulfur compound with X_2O_3 or X_2S_3 formulas; e.g., nitrogen.
- **Group 6A:** Includes oxygen.
- **Group 7A:** Elements combine violently with alkali metals to form salts; all are highly reactive; includes fluorine and chlorine.
- **Group 8A:** Nobel gasses; not abundant on the Earth; not reactive with other elements; e.g., neon and argon.

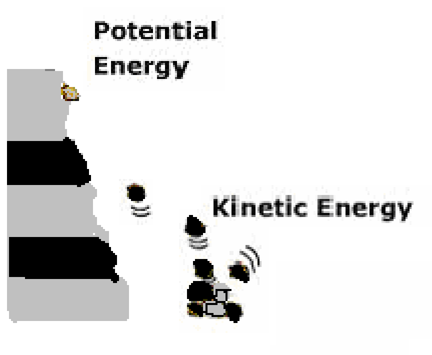
Periods are horizontal rows in the periodic table. The elements within a period have very different properties, however the patterns that are displayed across a period are repeated as one moves to the next period.

WORK AND ENERGY

Energy is the ability to do work or supply heat. Work is the transfer of energy to move an object a certain distance. It is motion against an opposing force. Lifting a chair into the air is work; the opposing force is gravity. Pushing a chair across the floor is work; the opposing force is friction.

According to the **First Law of Thermodynamics, energy** is neither created nor destroyed; rather it is converted from one form of energy to another. This also means that energy is neither created nor destroyed in ordinary physical and chemical processes (non-nuclear). Energy, in all of its forms, must be conserved. The following equation reflects the aforementioned statement: In any system, $\Delta E = q + w$ (Δ = change, E = energy, q = heat and w = work). This means that the change in energy is always equal to the energy used plus the work done.

Kinetic and Potential Energy



The two most commonly encountered forms of energy are potential and kinetic energy. **Kinetic energy** is the energy of a moving object. **Potential energy** is the energy stored in matter due to its position relative to other objects.

In any object, solid, liquid, or gas, the atoms and molecules that make up the object are constantly moving and colliding with each other. They are not stationary.

Due to this motion, the object's particles have varying amounts of kinetic energy. A fast moving atom can push a slower moving atom during a collision, so it has energy. All moving objects have energy, and that energy depends on the object's mass and velocity. Kinetic energy is calculated as: $KE = \frac{1}{2} mv^2$.

An object's temperature is proportional to the average kinetic energy of the particles in the substance. When the temperature of a substance is increased its particles move faster, so their average kinetic energies increase as well. Temperature is *not* energy, it is not conserved.

The energy an object has due to its position or arrangement of its parts is called potential energy. Potential energy due to position is equal to the mass of the object times the gravitational pull on the object times the height of the object, or: $PE = mgh$. Where PE = potential energy, m = mass of object, g = gravity, and h = height.

Heat
Heat is energy that is transferred between objects caused by differences in their temperatures. Heat is transferred from an object of higher temperature to one of lower temperature. This transfer continues until both objects reach the same temperature. Both kinetic energy and potential energy can be transformed into heat energy. When you step on the brakes in your car, the kinetic energy of the car is changed to heat energy by friction between the brake and the wheels. Other transformations can occur from kinetic to potential as well. Since most of the energy in our world is in a form that is not easily used, both man and nature have developed some clever ways of changing one form of energy into another form that may be more readily used

Skill 2.2 Heat and thermodynamics: thermal energy, measurement, transfer and effects on matter, first and second laws of thermodynamics

Heat and temperature are different physical quantities. **Heat** is a measure of energy. **Temperature** is a measure of the heat of an object.

Two concepts that are important in the discussion of temperature changes are thermal contact and thermal equilibrium. Objects are in **thermal contact** if they can affect each other's temperatures. Set a hot cup of coffee on a desktop. The two objects are in thermal contact with each other and will begin affecting each other's temperatures. The coffee will become cooler and the desktop warmer. Eventually, they will have the same temperature. When this happens, they are in **thermal equilibrium.**

TEMPERATURE

We cannot rely on our sense of touch to determine an object's temperature, because it is not an accurate measurement. **Thermometers** are used to measure temperature. When a thermometer is used, a small amount of mercury, or colored alcohol as is more commonly used today, in a capillary tube will expand when heated. The metal end of the thermometer and the object whose temperature it is measuring are put in contact long enough for them to reach thermal equilibrium. Then the temperature can be read from the thermometer scale.

Different Scales of Temperature
Three temperature units are used:

1. **Celsius:** The freezing point of water is set at 0 and the boiling point is 100 degrees. The interval between the two is divided into 100 equal parts called degrees Celsius.

2. **Fahrenheit:** The freezing point of water is 32 degrees and the boiling point is 212. The interval between is divided into 180 equal parts called degrees Fahrenheit.

3. **Kelvin:** This scale has degrees the same size as the Celsius scale, but the zero point is moved to down to a hypothetical absolute zero. This is determined by the triple point of water. Water inside a closed vessel is in thermal equilibrium in all three states (ice, water, and vapor) at 273.15 Kelvin. This temperature is equivalent to .01 degrees Celsius. Because the degrees are the same in the two scales, temperature changes are the same in Celsius and Kelvin.

Temperature readings can be converted from one to the other as follows.

- **Fahrenheit to Celsius -** C = 5/9 (F - 32)
- **Celsius to Fahrenheit -** F = (9/5) C + 32

Temperature readings can be converted from Celsius to Kelvin:

- **Celsius to Kelvin -** K = C + 273.15
- **Kelvin to Celsius -** C = K - 273.15

Units of Heat Measure
The heat capacity of an object is the amount of heat energy that it takes to raise the temperature of the object by one degree.

Heat capacity (C) per unit mass (m) is called **specific heat** (c):

$$c = \frac{C}{m} = \frac{Q / \Delta}{m}$$

A **calorimeter** uses the transfer of heat from one substance to another to determine the specific heat of the substance. Specific heats for many materials have been calculated and can be found in tables.

There are a number of ways that heat is measured. In each case, the measurement is dependent upon raising the temperature of a specific amount of water by a specific amount. These conversions of heat energy and work are called the **mechanical equivalent of heat**.

The **calorie** is the amount of energy that it takes to raise one gram of water one degree Celsius.

The **kilocalorie** is the amount of energy that it takes to raise one kilogram of water by one degree Celsius. Food “calories” are actually kilocalories.