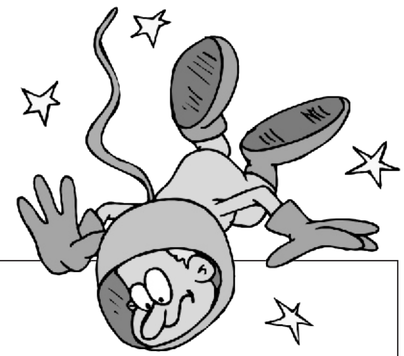
Laboratory Equipment and Procedures

Section 1.4
Mass and Weight Measurements



Pre-View 1.4

- **Gram** – the metric unit for mass
- **Mass** – the measure of how much matter is in an object
- **Newton** – the metric unit for force (and weight)
- **Spring scale** – equipment used to find force or weight
- **Triple beam balance** – a type of balance scale commonly used in high school laboratories
- **Weight** – the measurement of *force* exerted by gravity on an object

Measuring Mass

Mass is the measurement of how much matter is in an object, and it is measured in grams using a balance scale. The most common types of scale balances are the **triple beam balance** (figure 1-17) and the electronic balance (figure 1-18). Both types of balances measure mass in grams. The triple beam balance is commonly found in high school laboratories, but you may also have an electronic balance.

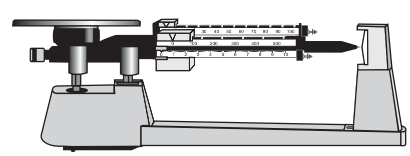


Fig. 1-17 Triple Beam Balance

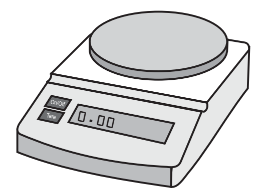


Fig. 1-18 Electronic Balance

Accuracy in Mass Measurements

To get an accurate mass using a triple beam balance, be sure the balance is calibrated correctly. As a quick check, the mass should be exactly zero when there is nothing in the pan.

Example: A laboratory technician tests the accuracy and precision of the two balances in her lab, a triple beam balance and an electronic balance. She uses a 5.0 gram mass to test each balance. In the chart below, she records the measurements of four trials for each balance.

	Trial 1	Trial 2	Trial 3	Trial 4
Triple beam balance:	4.9 g	4.8 g	5.1 g	5.0 g
Electronic balance:	4.4 g	4.3 g	4.4 g	4.4 g

Which balance is more accurate? Which is more precise? Which balance should be used for measuring small masses?

The actual mass is 5.0 grams, so the triple beam balance is more accurate than the electronic balance. The electronic balance is more precise because it consistently gives the same measurement, but its measurement is not as close to being correct. The technician should use the triple beam balance if she wants to accurately measure small masses. Remember, precision is only important once you know a measurement is accurate. Consistency (as indicated by precision) doesn't matter if the measurement is consistently wrong!

Scientific Investigations

Section 2.5
Determining Validity of Experiments

Pre-View 2.5

- **Conclusion** – the analysis of data in a scientific investigation that either supports or refutes the hypothesis
- **Scientifically valid** – a description of a scientific experiment, data, or conclusion that is relevant or meaningful
- **Technology** – new procedures or devices that use scientific advances or discoveries for practical purposes

In order for an experiment to be **scientifically valid**, it must give meaningful results. To get meaningful results, the experiment must be carefully designed, controlled, and performed. A **conclusion** is then made based on analyzing the data, which should either support or refute the hypothesis. Many things can affect the validity of an experiment and can make any conclusions drawn less valid. Look at some examples below.

Examples of Factors that Make an Experiment Less Scientifically Valid

- Using equipment that isn't calibrated; it gives inaccurate readings
- Using only one member in a test group instead of using multiple members per group
- Failing to have a control group
- Not controlling factors in an experiment that can affect the results and conclusions
- Making assumptions without sufficient data or failing to recognize alternative explanations
- Being unable to repeat an experiment to obtain the same results

Scientists make new discoveries every day. When these new discoveries are used for practical purposes, the new procedures or devices are called **technology**. New technologies often target specific audiences. For example, a new pharmaceutical drug for arthritis targets people who suffer from arthritis. The group of people who suffer from arthritis is the specific audience that this drug is designed to help. When scientists are designing experimental procedures to test new technologies, they are always mindful of the target audience, and the experiment must be designed so that it measures meaningful data. New technologies should also be carefully tested before they are made available to their intended audience.

Example 1: Fleas are often prevented from biting dogs by using a topical medication that is applied between the shoulder blades of the dog once a month. A pharmaceutical company develops an injection to prevent flea bites that can be given by a veterinarian once every six months. The scientists believe that the injection will be just as effective as preventing flea bites as the topical medication and will result in fewer side effects. What step should the scientists take next?

The next step is to test. The injection needs to be tested against the topical medication, so the scientists should design an experiment to perform such a test. One group of dogs should be given the topical medication, and another group of dogs should be given the injection. The scientists should then observe the effectiveness of each treatment and any side effects. Remember that extensive testing is always best before a new medication or technical device is distributed to its intended audience. Once the new flea injection is tested, it can then be made available to veterinarians for use on their clients' dogs.

Scientific Evaluation and Engineering

Section 4.3
The Engineering Design Process

- **Engineer** – a person who designs or builds new processes, structures, machines, etc.
- **Engineering design process** – the steps, similar to the scientific method, used in designing and implementing a new technology

As you have seen, scientists use a series of steps called the scientific method to ask questions, develop a hypothesis, design and perform an experiment, and analyze the resulting data. Similar to scientists, **engineers** are people who design new or better ways of doing things, build structures, or create new machines. Engineers also use a series of steps called the **engineering design process** when designing and implementing a new technology, whether it is a process, a structure, or some other invention. The general steps to this process are shown below.

Steps of the Engineering Design Process

Identify the Problem
Engineers start with a problem.
Who needs what, and why do they need it?
Research existing solutions. What improvements are needed?

↓

Specify Requirements
Based on the problem, what are key requirements for a new process or product? What features must be included?

↓

Brainstorm
Generate new ideas. Discuss and consider many different possible solutions, designs, or approaches.

↓

Evaluate the Ideas
Which solutions, designs, or approaches are the most promising?
What are the pros and cons of each promising idea?

↓

Select the Best Solution
After carefully analyzing each idea, which is the best?
Choose the best solution, design, or approach.

↓

Build a Model or Prototype
Build an operating version of the solution in order to test it.
The model or prototype answers the question, “Will it really work?”

↓

Test, Refine, Redesign
Use the model or prototype to test the solution. What changes need to be made? Refine or redesign based on the testing.

Practice 1

Match each of the following terms with its best definition.

________ 1. cellulose

________ 2. starch

________ 3. dehydration synthesis

________ 4. polysaccharide

________ 5. monosaccharide

________ 6. carbohydrate

A. a macromolecule made up of carbon, hydrogen, and oxygen

B. a polysaccharide made by plants to give structural support to cell walls

C. a complex carbohydrate such as starch

D. a simple sugar like glucose

E. another name for a condensation reaction in which monomers are combined to form a polymer

F. a polysaccharide made by plants to store energy

Identifying Carbohydrates

Most people have a general idea of whether a food contains sugar or starch based on its flavor and/or consistency. For instance, let's consider two foods that most people love, candy and french fries. Candy gives a sugar "rush" that many crave, and starchy french fries are often a first choice as a comfort food.

What about being able to detect the presence of sugars or starches in the laboratory where tasting is ALWAYS prohibited? Substances called **indicators** can be used to test for the presence of a variety of compounds or macromolecules, including sugars and starches. In the case of carbohydrates, Benedict's reagent detects sugars and Lugol's iodine solution detects starches each by changing color in the presence of a specific type of carbohydrate.

Benedict's Reagent — A Carbohydrate Test for Simple Sugars (Monosaccharides and Disaccharides)
Benedict's reagent is a clear blue solution that contains copper ions. When Benedict's reagent is added to a sample containing simple sugars, such as glucose or fructose, and then heated in a hot water bath, the copper sulfate in the solution forms a copper oxide precipitate. The color change ranges from green to yellow to orange to a brick-red depending on the concentration of glucose or fructose present in the sample. See figure 6-3. Complex carbohydrates, such as starches, DO NOT react positively with Benedict's reagent.

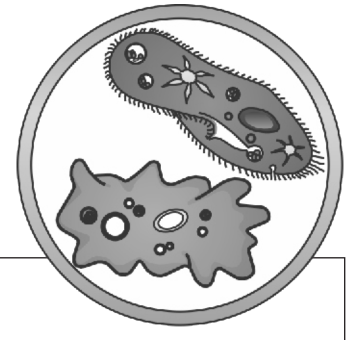
Range of Colors of Benedict's Reagent Testing Positive for Simple Sugars

Fig. 6-3

Lugol's (Iodine) Solution — A Carbohydrate Test for Starch (Polysaccharides)
Lugol's solution is a yellowish-brown indicator solution that contains iodine and water. When a sample containing starch contacts Lugol's solution, Lugol's solution changes to a bluish-black color. The color change is a result of the iodine in the solution staining the highly coiled structure of the polysaccharide. Disaccharides (such as table sugar) and monosaccharides (glucose or fructose) will not react with iodine in this manner, so no color change will be detected.

Cell Structure and Function

Section 7.3
Prokaryotic and Eukaryotic Cells



Pre-View 7.3

- **Bacteria** – living organisms made up of only one prokaryotic cell; singular is *bacterium*
- **Cell membrane** – a barrier that separates a cell from its surroundings
- **Cilia** – short, hairlike projections that some cells use for movement
- **DNA** – molecules in a cell that contain genetic information
- **Eukaryote** – any organism made up of eukaryotic cells; any organism other than bacteria
- **Eukaryotic cells** – cells that have a true nucleus and make up all other organisms other than bacteria
- **Flagella** – long, hairlike filament that some single-celled organisms use to propel themselves forward
- **Multicellular** – having many cells that work together to form an organism
- **Organelles** – structures within a cell that carry out specific functions
- **Prokaryote** – an organism made of a single cell that lacks a membrane-bound nucleus; a bacterium
- **Prokaryotic cells** – simple cells that do not have a nucleus; this type of cell is found in bacteria
- **Ribosome** – an organelle found in both prokaryotic and eukaryotic cells
- **Unicellular** – having only one single cell to form an organism; for example, bacteria are unicellular

Now let's look at different types of cells. As you've already seen, a cell is the smallest unit of life. It is the basic unit of structure of all living organisms. It is a collection of living and nonliving materials that is separated from its surroundings by a barrier called the **cell membrane**. Some organisms are made up of one single cell, so they are described as **unicellular**, which means "one cell." Other organisms are made up of many cells that work together and are called **multicellular**, which means "many cells."

Biologists classify cells into two main groups — prokaryotic cells and eukaryotic cells. **Bacteria** are living organisms that are each made up of a single cell. Bacteria are the only cells classified as **prokaryotic cells**. A single cell of bacteria, a bacterium, is sometimes called a **prokaryote**. All other cells are **eukaryotic cells**, so the cells that make up your body, or the cells in a rose bush, or even the cells in a ladybug are eukaryotic cells. In general terms, an organism that is made up of eukaryotic cells can be called a **eukaryote**.

Prokaryotic cells are much simpler than eukaryotic cells. Both types of cells are surrounded by a cell membrane and contain structures inside the cell that carry out specific functions. These structures are known as **organelles**. The organelles found in prokaryotic cells are not enclosed in a membrane. One type of organelle, the **ribosome**, is found in both prokaryotic and eukaryotic cells. Ribosomes consist of two protein subunits and are not considered membrane-bound.

DNA contains the genetic material for an organism. Both types of cells have DNA, but the DNA is found in different places. In prokaryotic cells, the DNA is located in the cytoplasm in an area called the nucleoid region. Prokaryotic DNA is not separated from the cytoplasm by a membrane. In eukaryotic cells, the DNA is enclosed in a porous membrane called the nuclear membrane. This membrane creates the organelle known as the nucleus. The absence of a nuclear membrane is one of the main differences in prokaryotic cells, so prokaryotic cells do not have a true nucleus that separates the DNA from the rest of the cell.