Biology for Standardized Tests
Ch.1: Cellular and Molecular Biology:
L1.1: Introduction to Biology

LIFE FUNCTIONS

A characteristic of all cells is that they carry out certain life processes. They include:

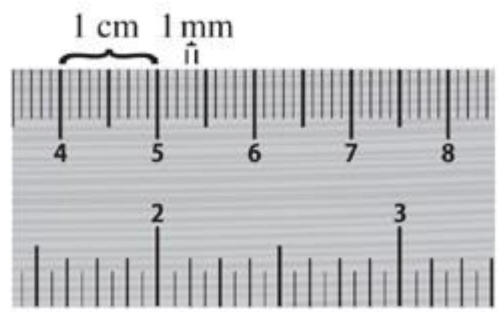
1. **INGESTION**. Intake of nutrients
2. **DIGESTION**. Enzymatic breakdown, hydrolysis, of food so it is small enough to be assimilated by the body
3. **RESPIRATION**. Metabolic processes that produce energy (adenosine triphosphate or ATP) for all the life processes
4. **TRANSPORT**. Distribution of molecules from one part of a cell to another or from one cell to another
5. **REGULATION**. Ability to maintain internal stability, homeostasis
6. **SYNTHESIS**. Combining of small molecules or substances into larger, more complex ones
7. **EXCRETION**. Removal of metabolic wastes
8. **EGESTION**. Removal of undigested waste
9. **REPRODUCTION**. Ability to generate offspring
10. **IRRITABILITY**. Ability to respond to stimuli
11. **LOCOMOTION**. Moving from place to place (animal cells only)
12. **METABOLISM**. Sum total of all the life functions

METRIC SYSTEM AND MEASURING

Length	Mass
1 km (kilometer) = 1000 M (meters)	1 kg (kilogram) = 1000 g (grams)
1 M = 0.001 km or 1 × 10–3 km	1 g = 0.001 kg or 1 × 10–3 kg
1 M = 1000 mm (millimeters)	1 g = 1000 mg (milligrams)
1 mm = 0.001 M = 1 × 10–3 M	1 mg = 0.001 g or 1 × 10–3 g
1 mm = 1000 µm (micrometers)	1 mg = 1000 µg (micrograms)
1 µm = 0.001 mm or 1 × 10–3 mm	1 µg = 0.001 mg or 1 × 10–3 mg

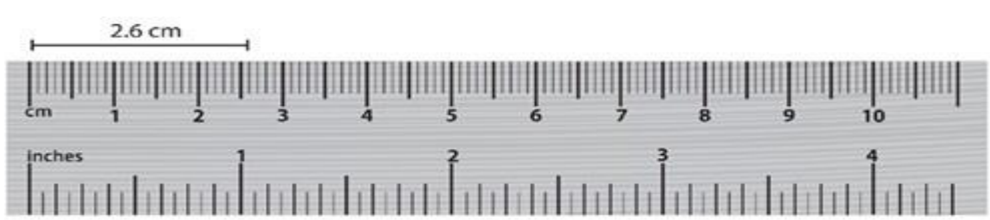
Volume
1 L (liter) = 1000 mL
1 mL = 0.001 L or 1 × 10–3 L

Here is an image of a metric ruler showing the relationship of centimeters (cm) and millimeters (mm).



Measuring with a Ruler

Here is another image of a common ruler with inches on one edge and metric on the other. The metric edge is marked with *cm* for centimeters (1 M = 100 cm; 1 cm = 10 mm).



The line shown is 2.6 cm or 26.0 mm long.

Accurate and Precise

Saying that the line is 26.0 mm in length means that the line is *exactly* 26 mm long.

Writing the value *without* the zero and decimal, simply as 26, means that the line is only *approximately* 26 mm long. It could actually be 25.9 or 26.1 mm long.

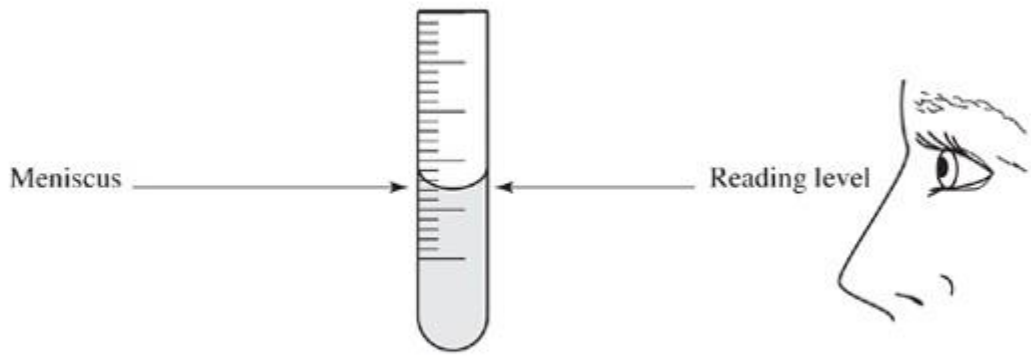
In science, we try to be both *accurate* (correct) and *precise* (exact).
To a scientist, these two terms mean very different things.
For example, if you stated that you measured that same line and found it to be 25.55 mm long, your answer would be *precise* (to the hundredths place), but it would not be *accurate*. You would, in fact, be wrong.

Error Value:

26	means	→	26	± .5
26.5	means	→	26.5	± .05
26.55	means	→	26.55	± .005
26.555	means	→	26.555	± .0005
26.5555	means	→	26.5555	± .00005

And so on.

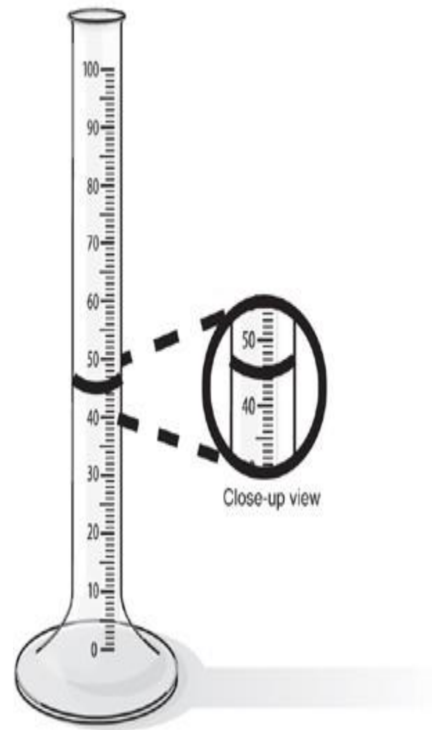
Measuring with a Graduated Cylinder



Use a *graduated cylinder* to measure liquid; and use the *meniscus* (bottom of the curve) at eye level to take your measurement.

Measure the amount of liquid in the sketch below:

The correct answer (both accurate *and* precise) .
is 44.0 mL.



TOOLS AND TECHNIQUES TO STUDY CELLS

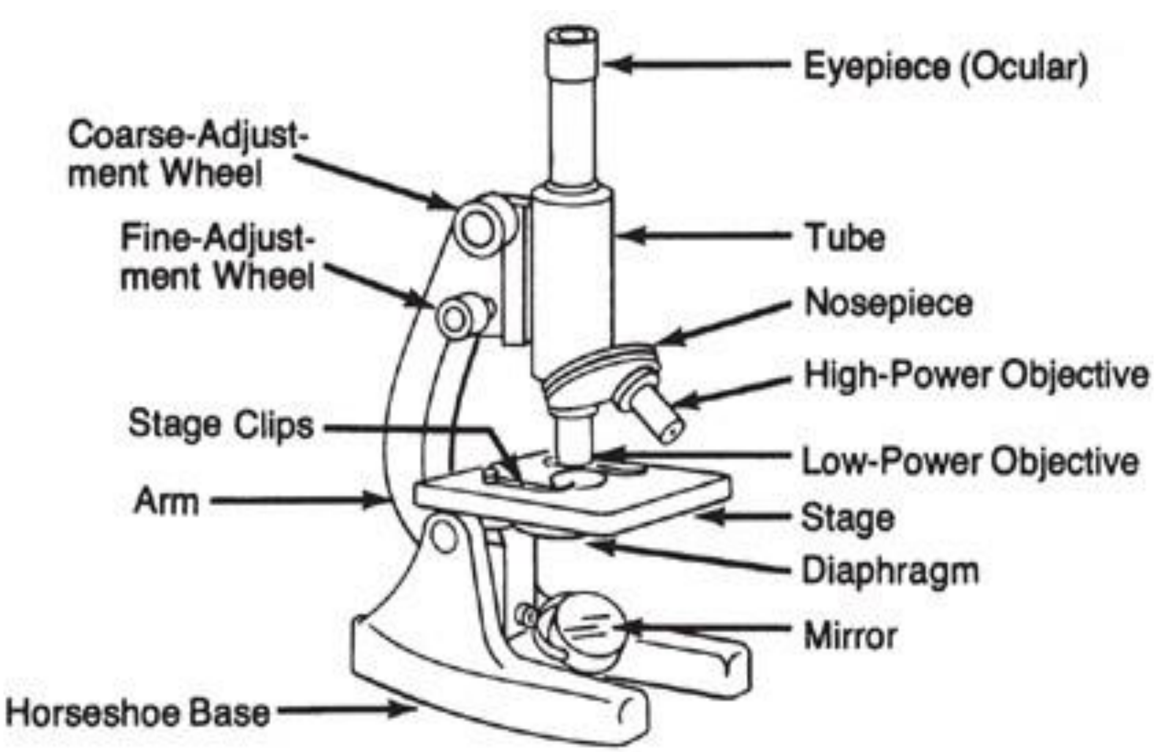
There are many tools and techniques to study cells. But, the main tool for studying cell structure (cytology) is the **compound microscope**.

Besides the ability to magnify an image, another important characteristic of a good microscope is the measure of image clarity, known as **resolution**.

The finest microscopes have both high magnification and excellent resolution.
A toy microscope, which may enlarge an image 400×, has little resolving power, so the images are blurred.

Anton van Leeuwenhoek developed the first microscope in the seventeenth century.

Today, compound light microscopes have been refined. Even the microscope you may have used in high school has fine resolution and good magnification. The figure is a picture of a compound microscope.



To determine the **total magnification**, multiply the magnification of the ocular lens or eyepiece by the magnification of the objective lens.

If the ocular has a magnification of 10×, which is customary, and the magnification of the objective lens is 40×, the total magnification is 400×.

When you use the microscope, remember that the image appears upside-down and backward from the actual specimen you placed onto the slide.

If you place a letter “e” onto the slide so that it appears the way you would read it in a book, the image will appear like it does in the Figure when you look in the microscope—upside down and backward.

Also, the higher the magnification you use, the darker the field will appear because you are viewing a much smaller area.

Today, the field of microscopy is very sophisticated.

There are many different types of microscopes fashioned for different purposes.

1.Phase-contrast microscope
2.Transmission electron microscope
3.Scanning electron microscope

A phase-contrast microscope is a light microscope that enhances contrast.

It is useful in examining living, *unstained cells*.

Electron microscopes use a beam of electrons, instead of a beam of light, to produce superior resolving power as well as magnification over 100,000×.

The transmission electron microscope **(TEM)** is useful for studying the interior of cells. The source of electrons is a tungsten filament within a vacuum column.

Although the TEM is very useful, there are some drawbacks:

■The tissue is no longer alive after processing.

■Preparation of specimens is elaborate. Tissue must be fixed, dehydrated, and sectioned on a special machine, a process that requires many hours and much expertise.

■The TEM is a delicate machine and requires special engineers to maintain it.

■Specimens must be sliced so thin that only a small portion of a tissue sample can be studied at one time.

■The machine costs hundreds of thousands of dollars.

The scanning electron microscope **(SEM)** is useful for studying the surface of cells.
The resulting images have a three-dimensional appearance.
Once again, specimens are examined only after an elaborate process that kills the tissue.

DON'T FORGET: Specimens observed under the EM are not alive.

Other Tools for Studying Cells:

Another important tool used in the study of tissue is the **ultracentrifuge**.

It enables scientists to isolate specific components of cells in *large quantities* by cell fractionation.

By using this technique, hundreds of organelles, such as mitochondria, can be studied under an electron microscope or analyzed biochemically.

First, tissue is mashed in a blender. The resulting liquid, called homogenate, is spun at high speed in an ultracentrifuge and separated into layers based on differences in density.

For example, if tissue is spun at high speed in a centrifuge tube, nuclei are forced to the bottom *first*, followed by mitochondria and then ribosomes with clear liquid above the organelles.

Freeze fracture, also called freeze-etching, is a complex technique used to study details of membrane structure under an electron microscope.
After preparation, only a cast of the original tissue is available to examine.

Tissue culture is a technique used to study the properties of specific cells in vitro (in the laboratory).

Living cells are seeded onto a sterile culture medium to which a variety of nutrients and growth- stimulating factors have been added.
Different cells require different growth media.

Cell lines can be grown in culture for years provided great care is taken with them.
While the cells are growing, they can be examined unstained under a phase-contrast light microscope.

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L1.1: Summary

Precise and accurate measurements have some different meanings.

A light microscope uses light. Its magnification = ocular lens magnification (usually 10x) times objective lens magnification (40 to 15x). The specimen will appear *upside down and backward* from the way it sits on the stage of the microscope.

Electron microscopes can magnify an image more than 300,000×.
Specimens seen by the electron microscope are dead.
The image from the electron microscope has excellent resolution (how clear the image appears).
That is because the electron beam has a very short wavelength.

Phase contrast microscope is a light microscope used to examine moving cells.

TEM, Transmission electron microscope is used to examine the inside structures. While the

SEM, Scanning electron microscope is used to examine the surface of the structures or cells.

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