Biology High School

For Standardized Scholastic Tests

EST2-ACT2- Biology

Coursework

2024-2025

Dr. Mohamed Kabbany

Chapter 1

Cellular and Molecular Biology

Lesson 1.0

Introduction

Topics and Course Description

American High School Biology Topics:-

1. Ch.1-Cellular and Molecular Biology
2. Ch.2-Heredity and Molecular Genetics
3. Ch.3-Diversity of Living Organisms
4. Ch.4-Evolution

5. Ch.5-Ecology
6. Ch.6-Plants and plants Biology
7. Ch.7-Human and animal Biology
8. Ch.8-Animal behavior and Drugs

Types of courses:

1- Full year course.
2- Full semester course
3- Half-semester course
4- Coming Trial Course
5 Panic course.
6- Peer teaching cessions.

1	Ch.1-Cellular and Molecular Biology
11	Introduction to biology
12	Biochemistry
13	Enzymes
14	Cell Structure and Function
15	Homeostasis and Cell Transport
16	Photosynthesis
17	Cellular Respiration
18	Cell Division

20- 25 %

2	Ch.2-Heredity and Molecular Genetics
21	Classical Genetics
22	DNA, RNA, and Protein Synthesis
23	Gene Expression
24	Human Genetics
25	Gene Technology

10- 15 %

3	Ch.3-Diversity of Living Organisms
31	Classification
32	Virus and Bacteria
33	Protista and Fungi
34	Plants taxonomy
35	Introduction to animals
36	sponges, cnidaria,Ctenophores and worms
37	Mullosks, annelids and arthropods
38	Echinodermata, chordata and Vertebrates
39	Mammals and primates

10- 15 %

4	Ch.4-Evolution
41	History of Life
42	Evidence of Evolution
43	Theory of Evolution
44	Population Genetics and Speciation

10- 15 %

5	**50-Ecology**	15- 20 %
51	Introduction to Ecology	
52	Populations	
53	Community Ecology	
54	Ecosystems	
55	Humans and the Environment	

6	**Ch.6-Plants and plants Biology**	6- 10 %
61	Plant Histologyand physiology	
62	Plant Support	
63	Plant Transport	
64	Plants Response	
65	Plant Reproduction	

7	**Ch.7-Human and animal Biology**	10- 15 %
71	Support and Integumentary Systems	
72	Circulatory System	
73	Respiratory System	
74	The Body's Defense System	
75	Digestive System	
76	Excretory System	
77	Nervous System and Sense Organs	
78	Endocrine System	
79	Reproductive System	

8	**Ch.Animal behaviorand -Drugs**	2- 5 %
81	Animal behavior	
82	Drugs general	
83	Antibiotics	
84	Biotechnology produced drugs	
85	Nervous System drugs	

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Chapter 1

Cellular and Molecular Biology

Lesson 1.1

Introduction

Life Functions And Measurements

1.1- Subtopics:

Ch.1-Cellular and Molecular Biology	
	1.1- Introduction to biology
1	Functions of Life
2	Organization
3	The Scientific method
4	The Metric System
5	Accuracy and Precision
6	Microscopy
7	Ultracentrifuge.
8	Lab Cell Techniques
9	Lab Safety
10	**Introduction Mix Questions**

1.1.1- THE LIFE FUNCTIONS

All living organisms whether unicellular or multicellular 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 absorbed and 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 environment stabile, also called 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 produce fertile offspring of the same kind

10.IRRITABILITY.

Ability to respond to stimuli

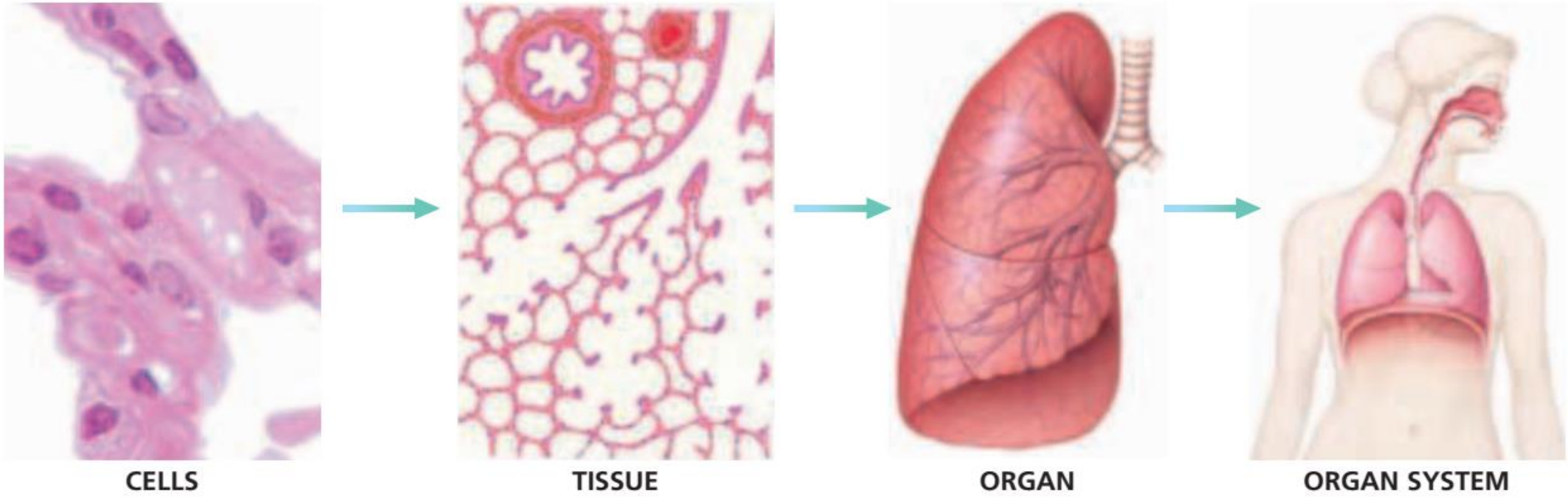
11. Movement

Moving the organism or part of the organism.
Locomotion is moving from place to place for animals or some animal like cells.

12.METABOLISM.

Sum total of all the life functions

1.1.2- Organization in a living organism



In a multicellular eukaryotic organisms, cells organize into tissues.
Tissues organize into organs. Organs are part of organ systems, in which organs work together to perform body functions.

1.1.3- The Scientific Method

SECTION 3 The Study of Biology

- The scientific method involves making observations, asking questions, forming hypotheses, designing experiments, analyzing data, and drawing conclusions.
- Trying to answer questions about observations helps scientists form hypotheses.
- A controlled experiment has a control and experimental group, and tests independent and dependent variables.
- Scientists analyze data to draw conclusions about the experiment performed.
- A theory is a set of related hypotheses confirmed to be true many times.
- Communication between scientists about their methods and results helps prevent dishonesty and bias in science.

Vocabulary

scientific method (p. 13)
observation (p. 13)
hypothesis (p. 13)
prediction (p. 13)
experiment (p. 13)
control group (p. 15)
experimental group (p. 15)
independent variable (p. 15)
dependent variable (p. 16)
theory (p. 17)
peer review (p. 19)

1.1.4- THE 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
1 km (kilometer) = 1000 M (meters)	1 kg (kilogram) = 1000 g (grams)

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

TABLE 1-1 *SI Base Units*

Base quantity	Name	Abbreviation
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Luminous (light) intensity	candela	cd

TABLE 1-3 *Some Derived and Other Units*

Quantity	Name	Abbreviation
Area	square meter	m^2
Volume	cubic meter	m^3
Density	kilogram per cubic meter	kg/m^3
Specific volume	cubic meter per kilogram	m^3/kg
Celsius temperature	degree Celsius	°C
Time	minute	1 min = 60 s
Time	hour	1 h = 60 min
Time	day	1 d = 24 h
Volume	liter	1 L = 1,000 cm^3
Mass	kilogram metric ton	1,000 g = 1 kg 1 t = 1,000 kg

TABLE 1-2 *Some SI prefixes*

Prefix	Abbreviation	Factor of base unit
giga	G	1,000,000,000 (10^9)
mega	M	1,000,000 (10^6)
kilo	k	1,000 (10^3)
hecto	h	100 (10^2)
deka	da	10 (10^1)
base unit		1
deci	d	0.1 (10^{-1})
centi	c	0.01 (10^{-2})
milli	m	0.001 (10^{-3})
micro	μ	0.000001 (10^{-6})
nano	n	0.000000001 (10^{-9})
pico	p	0.000000000001 (10^{-12})

1.1.5- Accuracy and Precision

Saying that a line is 26 mm long means that the line is *nearly* 26 mm long.

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

This depends on how many significant figures you use in your statement.

Accuracy describes how closely a measurement approaches an actual, true value.

e.g. when you measure a mass of a 1 kg cube and you find it a 1.0 kg.

Precision describes how close repeated measurements are to one another, regardless of how close those measurements are to the actual value.

e.g. when a 5 students measure the same cube and all find it to be 980 gm.
They are all precise but not accurate. That is because the balance they use has some error.

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.

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

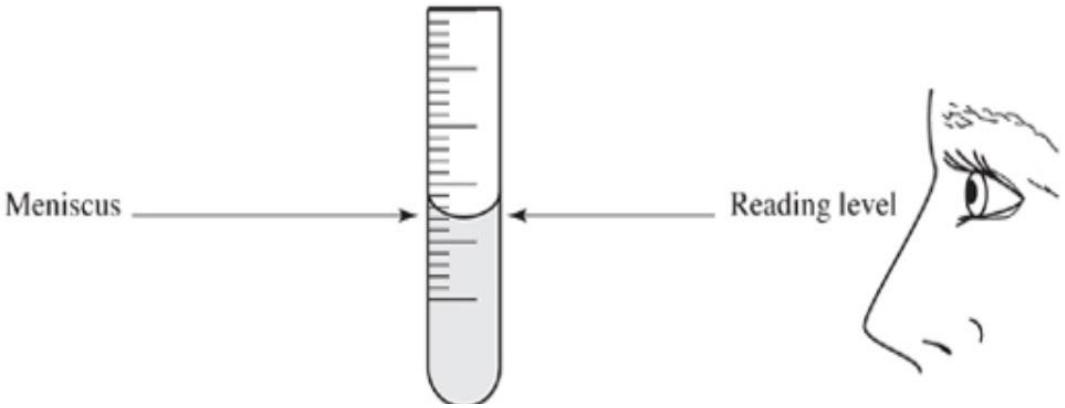
Electron microscopes can magnify an image more than 300,000×.

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.

Specimens seen by the electron microscope are dead.

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.

Measuring with a Graduated Cylinder

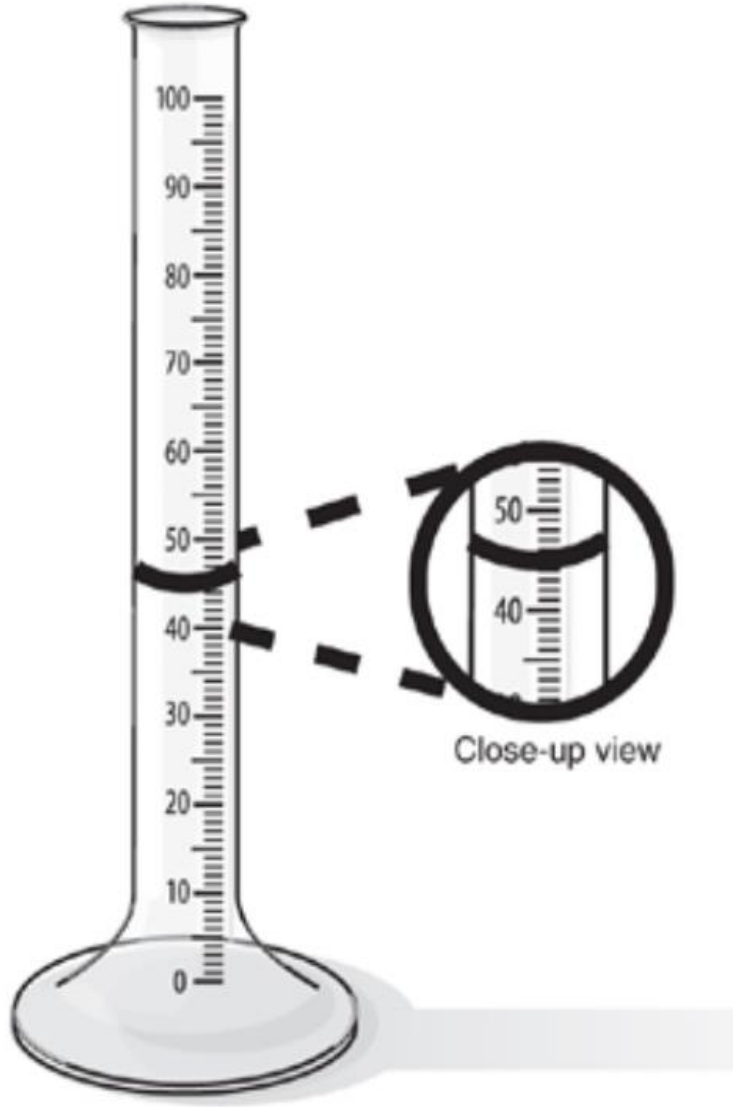


To use a *graduated cylinder* to measure liquid; use the *meniscus* (bottom of the curve) at eye level to take your measurement.

e.g. when you measure the amount of liquid in the sketch shown, the correct measure (both accurate *and* precise) is---

44.0 mL

both accurate *and* precise.



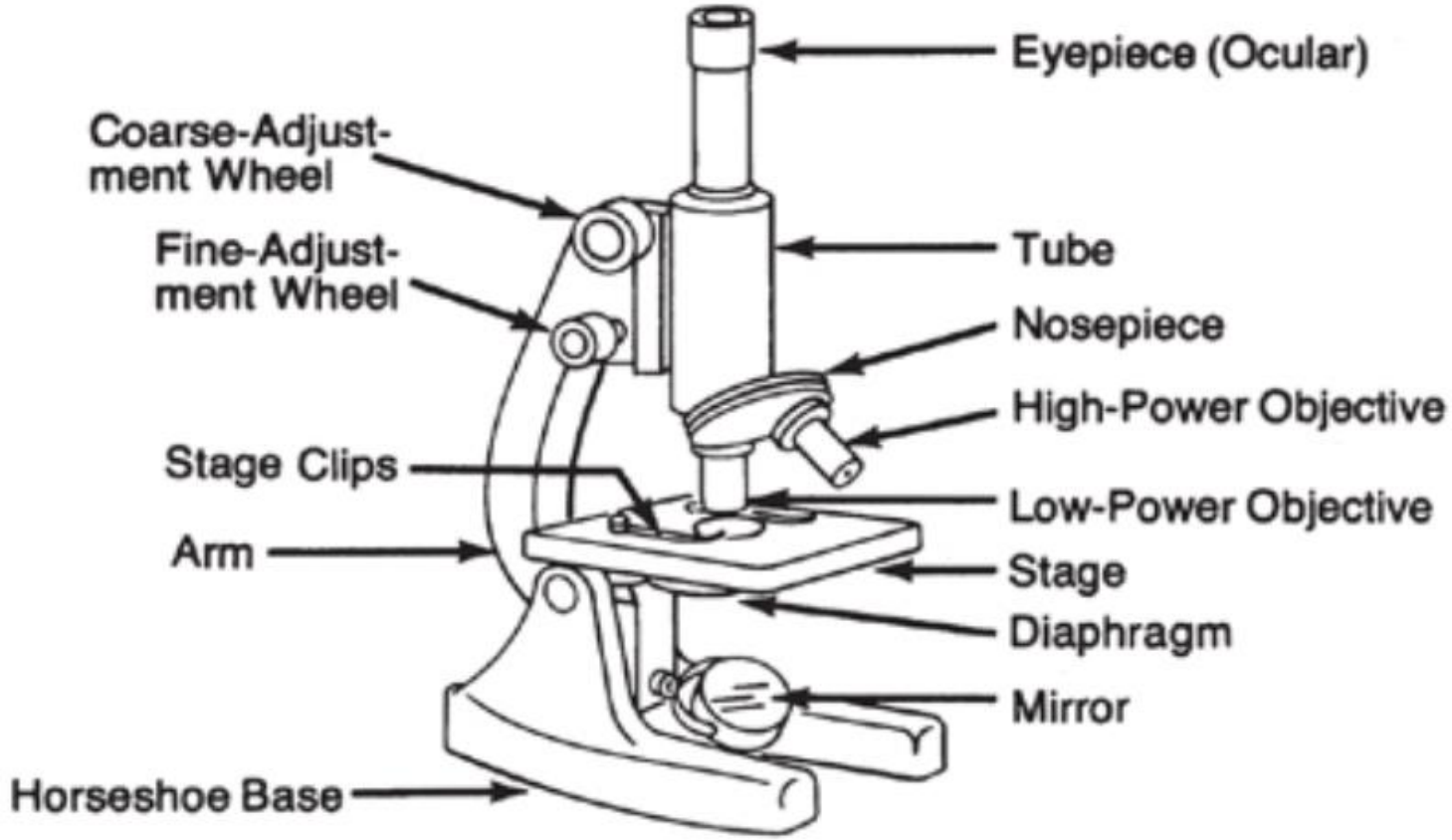
1.1.6- TOOLS AND TECHNIQUES TO STUDY CELLS- MICROSCOPY..

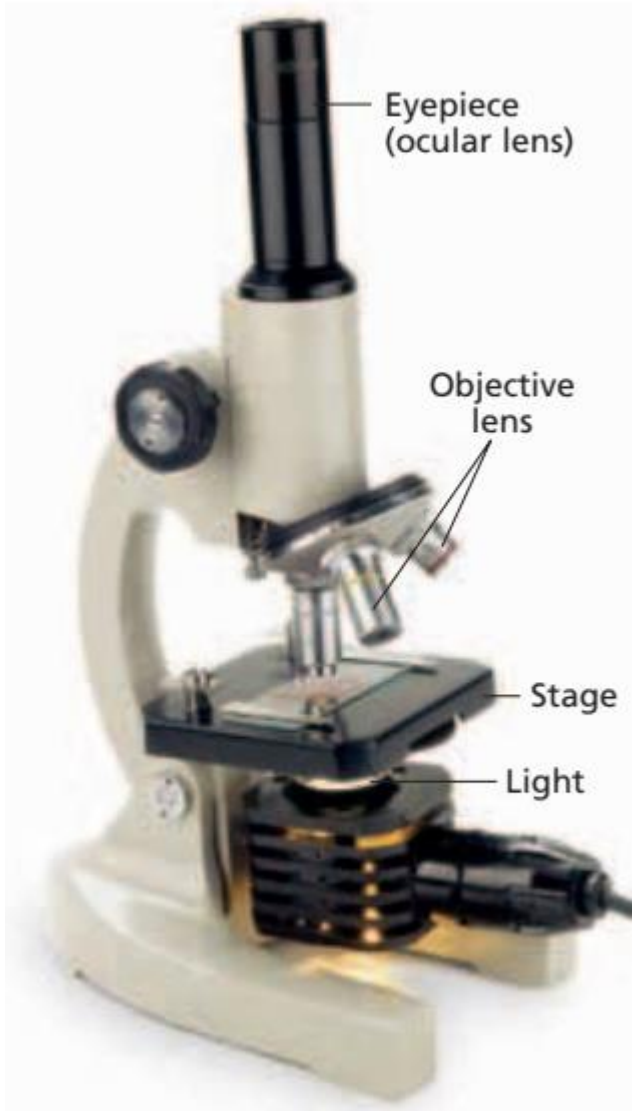
The compound microscope

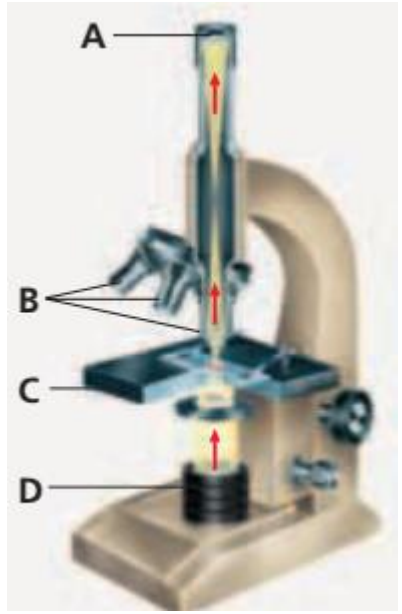
Two properties are essential to know how good is a microscope, Magnification and resolution.

Resolution describes the ability to see two distinct near points as two.

A toy microscope, which may enlarge an image 400×, has little resolving power, so the images are blurred.

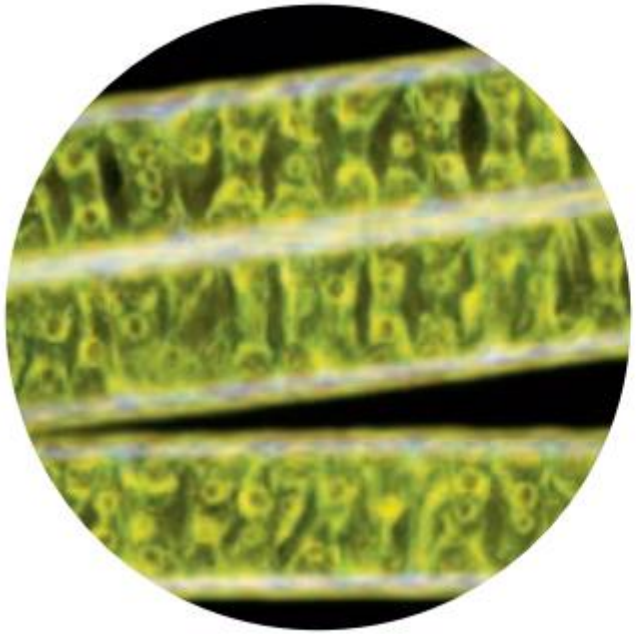




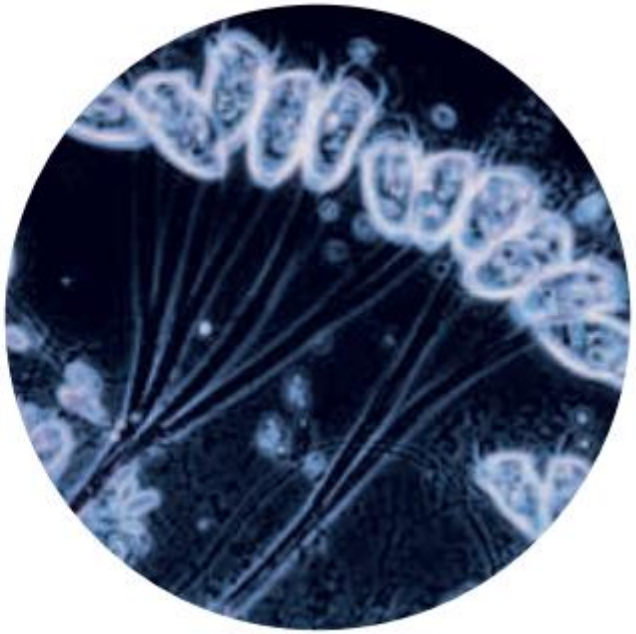


Compound light microscopes open the human eye to an interesting world including tiny pond organisms, healthy and diseased cells, and the functioning of cell parts.

(a)



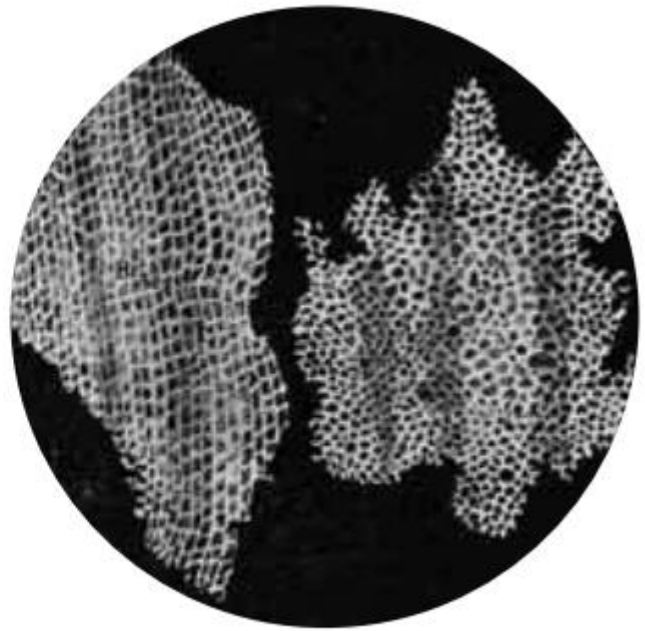
(b)



(c)

Anton van Leeuwenhoek (1632–1723) is shown here with one of his hand-held lenses (a).
Leeuwenhoek observed an alga of the genus Spirogyra (b) and a protist of the genus Vorticella (c).

(a)



(b)

(c)

Robert Hooke used an early microscope
a) to see cells in thin slices of cork. His drawings of what he saw
(b) indicate that he had clearly observed the remains
of cork cells (300) (c).

Magnification

Magnification is calculated by multiplying the magnification of the ocular lens by that of the objective lens.

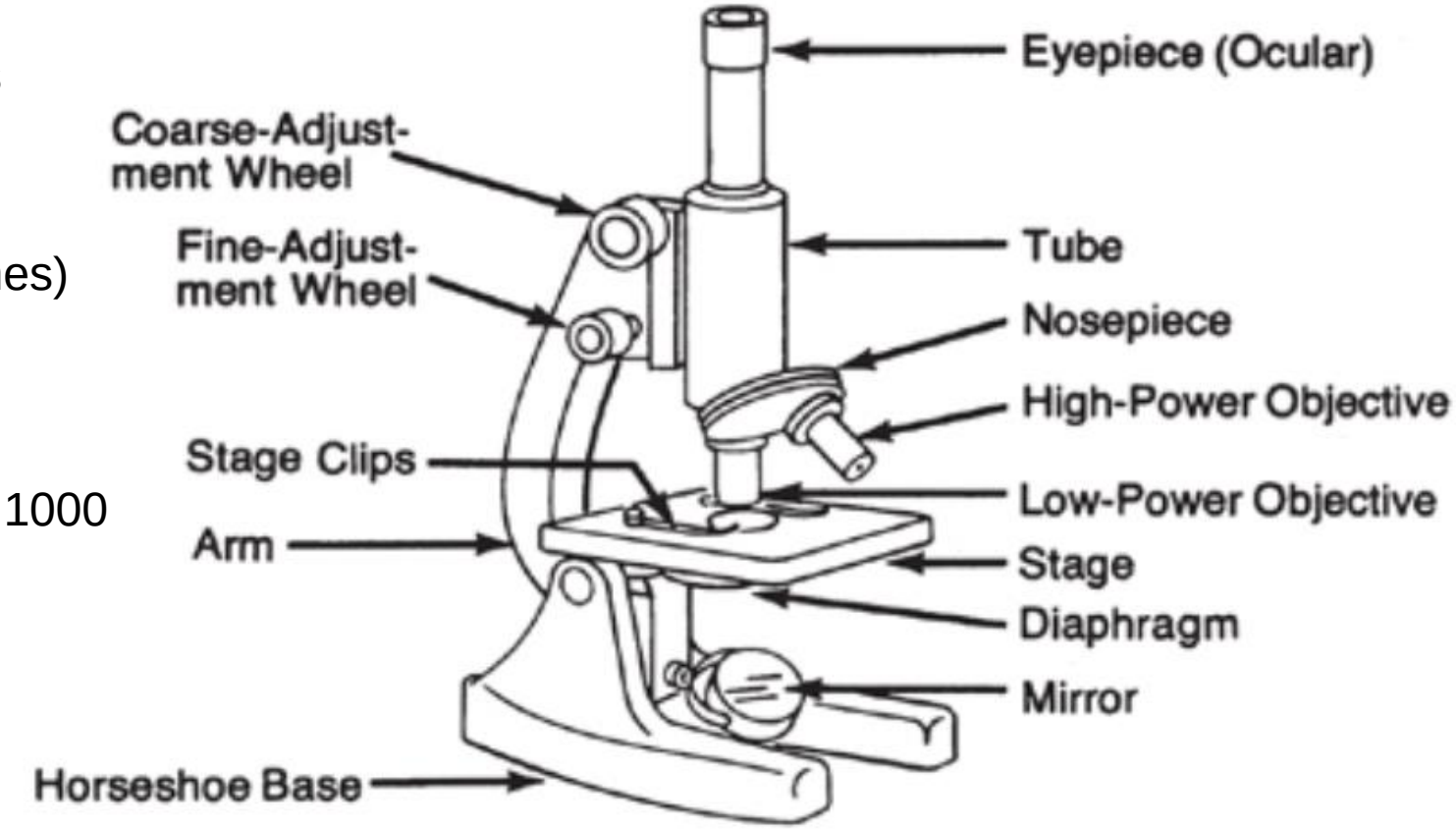
e.g. if the ocular lens = 10 x (x means times) and the objective lens = 40 x, magnification =

10x (means times) X 40x (means times)

= 400 x (means times)

The school lab microscope is usually 1000 to 1500 x magnification.

The compound microscope



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

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

e.g. the letter e

its image is -----

Special types of microscopes:

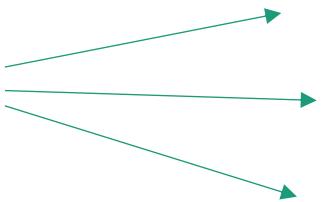
1.Phase-contrast microscope

2.Transmission electron microscope

3.Scanning electron microscope

A phase-contrast microscope is a light microscope that enhances contrast.
It uses violet light. It is useful in examining living, *unstained cells e.g. moving sperms*.

1.Phase-contrast microscope



Living

unstained

e.g. moving sperm or amoeba.

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 source of electrons is a tungsten filament within a vacuum column.

The transmission electron microscope (TEM) is useful for studying the interior of cells.

The scanning electron microscope (SEM) is useful for studying the outer surface of cells.

The resulting images have a three-dimensional appearance.
Once again, the cells are dead. Specimens observed under the EM are not alive

The tissue is no longer alive after processing.

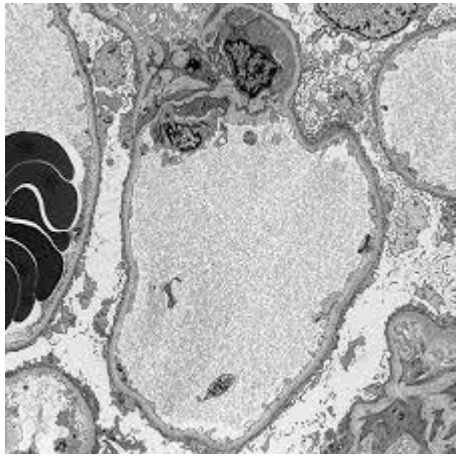
Preparation of specimens is elaborate. Tissue must be fixed, dehydrated, and sectioned on a special machine, a process that requires many hours and much expertise.

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.

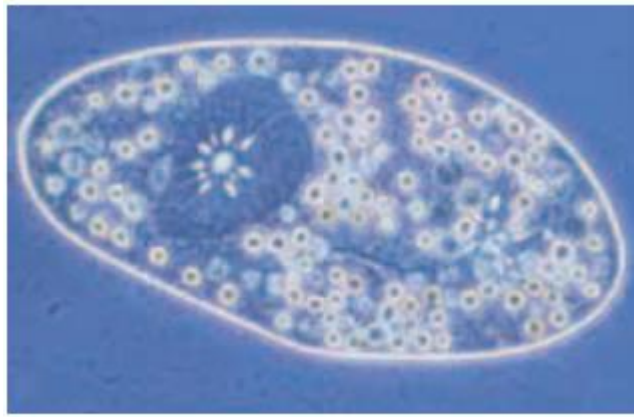
The machine costs hundreds of thousands of dollars

TEM

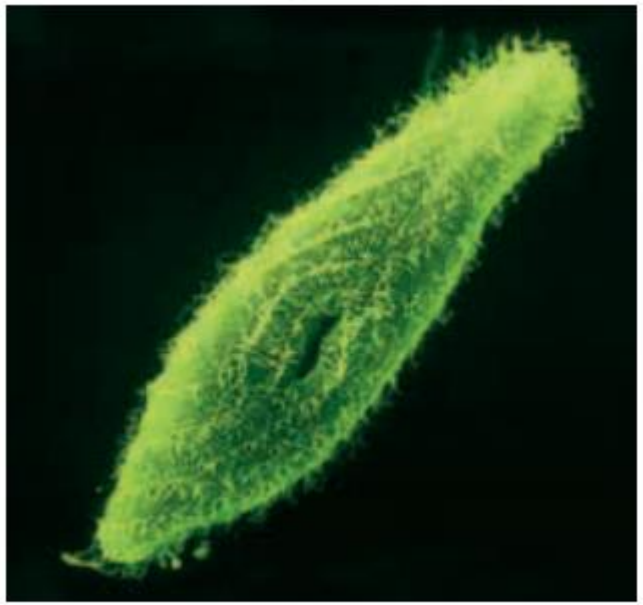


Electron Microscope

SEM



(a) *Paramecium* (light microscope)



(b) *Paramecium* (scanning electron microscope)

(c) *Paramecium* (transmission electron microscope)

The images above show a Paramecium as viewed under three different types of microscopes.

(a) Light microscopes can produce an image that is up to 1,000 times larger than the actual specimen.
(b) Scanning electron microscopes produce images up to 100,000 times larger than the specimen. SEMs provide a view of surface features.
(c) Transmission electron microscopes produce images up to 200,000 times larger than the actual specimen.

1.1.7- 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

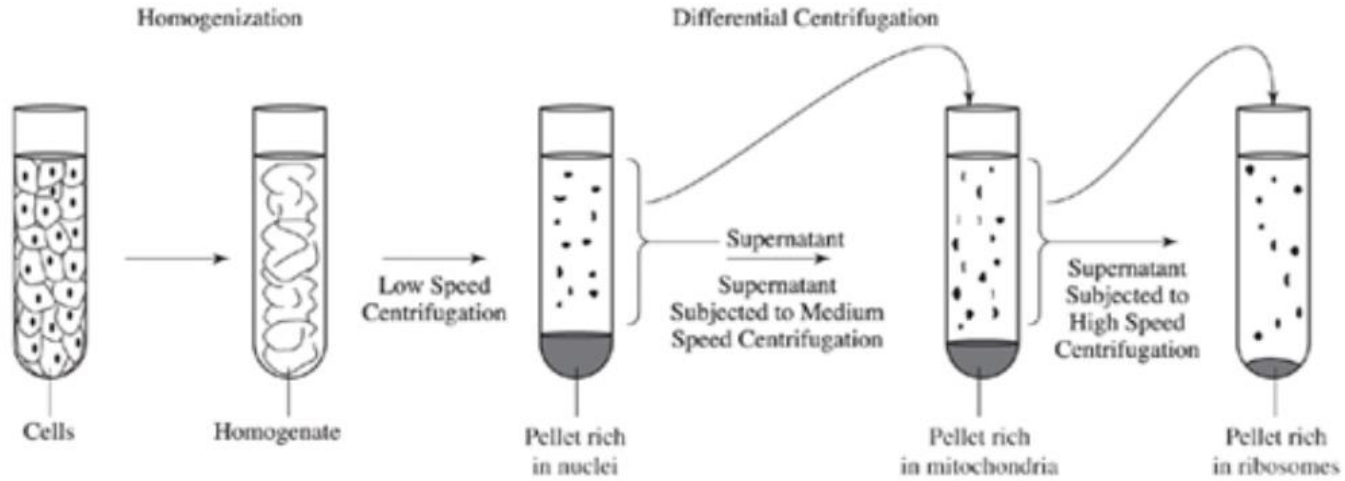
First, tissue is mashed in a blender. The resulting liquid, called **homogenate**, is spun at high speed in an ultracentrifuge and separated into layers based on differences in density.

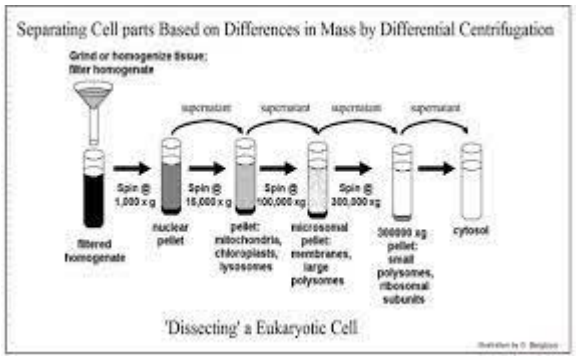
Nuclei are forced to the bottom *first*,

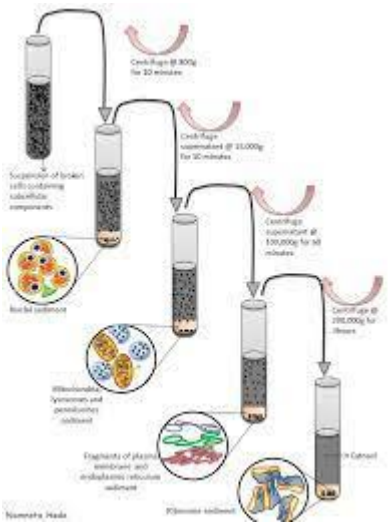
then ribosomes

followed by mitochondria

then clear fluid




Separating Cell parts Based on Differences in Mass by Differential Centrifugation
Grind or homogenize tissue; filter homogenate
supernatant
supernatant
supernatant
supernatant
Spin @ 1,000 x g
Spin @ 15,000 x g
Spin @ 100,000 xg
Spin @ 300,000 xg
filtered homogenate
nuclear pellet
pellet: mitochondria, chloroplasts, lysosomes
microsomal pellet: membranes, large polysomes
300000 xg pellet: small polysomes, ribosomal subunits
cytosol
'Dissecting' a Eukaryotic Cell



1.1.8- Cytology Lab Techniques:

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.

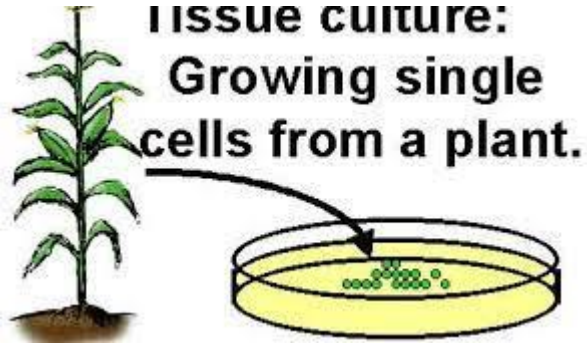
Tissue culture

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.



Tissue culture and cryo-cell banking

1.1.9- Lab Safety:

SAFETY

Studying living things is interesting, fun, and rewarding, but it can be hazardous.
The hazards can be chemical, physical, radiological, or biological and can vary between the lab and the field.
For example, getting splashed in the eye with a blinding chemical is more likely to occur in the laboratory, but falling down a cliff or getting bitten by a poisonous spider is more likely to occur in the field.

Good Laboratory Practice

Lab safety involves good laboratory practice, which means establishing safe, common-sense habits.
Never work alone in the lab or without proper supervision by the teacher, and always ask your teacher before using any equipment.
The diagram below shows the safety symbols used in this book. More information on lab safety and the safety symbols can be found in the Appendix.

Good laboratory practice involves protecting yourself and others by being safe.

Eye Safety

Hand Safety

Safety with Gases

Sharp-Object Safety

Clothing Protection

Animal Care and Safety

Heating Safety

Hygienic Care

Glassware Safety

Proper Waste Disposal

Electrical Safety

Plant Safety

Chemical Safety

Lesson Summary

SECTION 1 The World of Biology

- Biology is the study of life and can be used to both solve societal problems and explain aspects of our daily lives.
- Living things share the same 7 characteristics: organization and cells, response to stimuli, homeostasis, metabolism, growth and development, reproduction, and evolution.
- Multicellular organisms show a hierarchy of organization going from the organism to the atom.
- To stay alive, living things must maintain homeostasis, obtain and use energy, and pass on hereditary information from parents to offspring, also called reproduction.

Vocabulary

biology (p. 5)
organization (p. 6)
cell (p. 7)
unicellular (p. 7)
multicellular (p. 7)
organ (p. 7)
tissue (p. 7)
organelle (p. 7)
biological molecule (p. 7)
homeostasis (p. 8)
metabolism (p. 8)
cell division (p. 8)
development (p. 8)
reproduction (p. 9)
gene (p. 9)

SECTION 2 Themes in Biology

- Three themes in biology are the unity of life's diversity, the interdependence of organisms, and evolution of life.
- Living organisms show diversity and can be classified into domains and kingdoms.
- Organisms live in interdependent communities and interact with both organisms and the environment.
- Evolution helps to explain how species came to exist, have changed over time, and adapt to their environment.

Vocabulary

domain (p. 11)
kingdom (p. 11)
ecology (p. 11)
ecosystem (p. 11)
evolution (p. 12)
natural selection (p. 12)
adaptation (p. 12)

SECTION 3 The Study of Biology

- The scientific method involves making observations, asking questions, forming hypotheses, designing experiments, analyzing data, and drawing conclusions.
- Trying to answer questions about observations helps scientists form hypotheses.
- A controlled experiment has a control and experimental group, and tests independent and dependent variables.
- Scientists analyze data to draw conclusions about the experiment performed.
- A theory is a set of related hypotheses confirmed to be true many times.
- Communication between scientists about their methods and results helps prevent dishonesty and bias in science.

Vocabulary

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experiment (p. 13)
control group (p. 15)
experimental group (p. 15)
independent variable (p. 15)
dependent variable (p. 16)
theory (p. 17)
peer review (p. 19)

SECTION 4 Tools and Techniques

- Four major parts of a compound light microscope are the ocular lens, objective lens, stage, and light source.
- Transmission and scanning electron microscopes provide greater magnification than light microscopes.
- Scientists use the metric system to take scientific measurements.
- Lab safety is a good laboratory practice.

Vocabulary

compound light microscope (p. 21)
eyepiece (ocular lens) (p. 21)
objective lens (p. 21)
stage (p. 21)
light source (p. 21)
magnification (p. 22)
nosepiece (p. 22)
resolution (p. 22)
scanning electron microscope (SEM) (p. 22)
transmission electron microscope (TEM) (p. 22)
metric system (p. 23)
base unit (p .23)

Vocabulary

biology (p. 5)
organization (p. 6)
cell (p. 7)
unicellular (p. 7)
multicellular (p. 7)
organ (p. 7)
tissue (p. 7)
organelle (p. 7)
biological molecule (p. 7)
homeostasis (p. 8)
metabolism (p. 8)
cell division (p. 8)
development (p. 8)
reproduction (p. 9)
gene (p. 9)

domain (p. 11)
kingdom (p. 11)
ecology (p. 11)
ecosystem (p. 11)
evolution (p. 12)
natural selection (p. 12**)**
adaptation (p. 12)

scientific method (p. 13)
observation (p. 13)
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dependent variable (p. 16)
theory (p. 17)
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compound light microscope (p. 21)
eyepiece (ocular lens) (p. 21)
objective lens (p. 21)
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scanning electron microscope (SEM) (p. 22)
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base unit (p .23)

Thank you

Dr. Mohamed. Kabbany