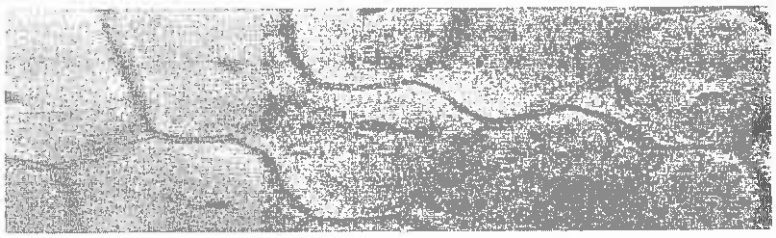
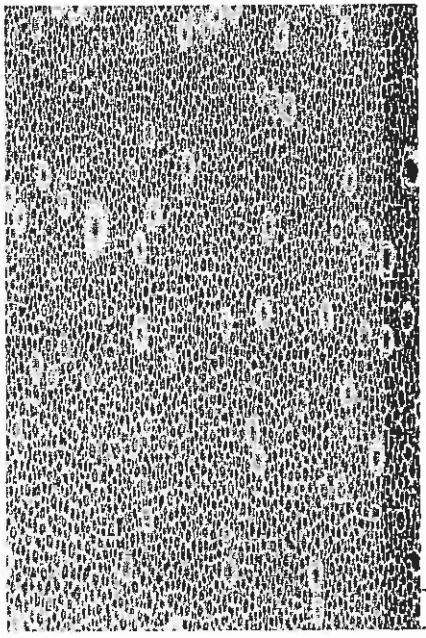
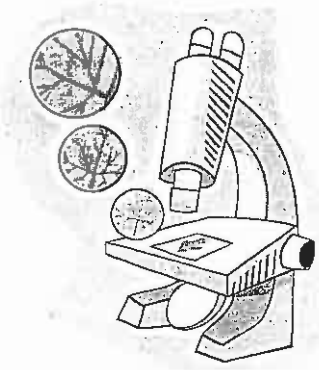
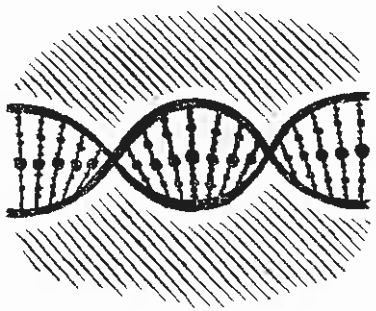


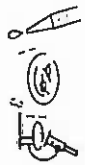


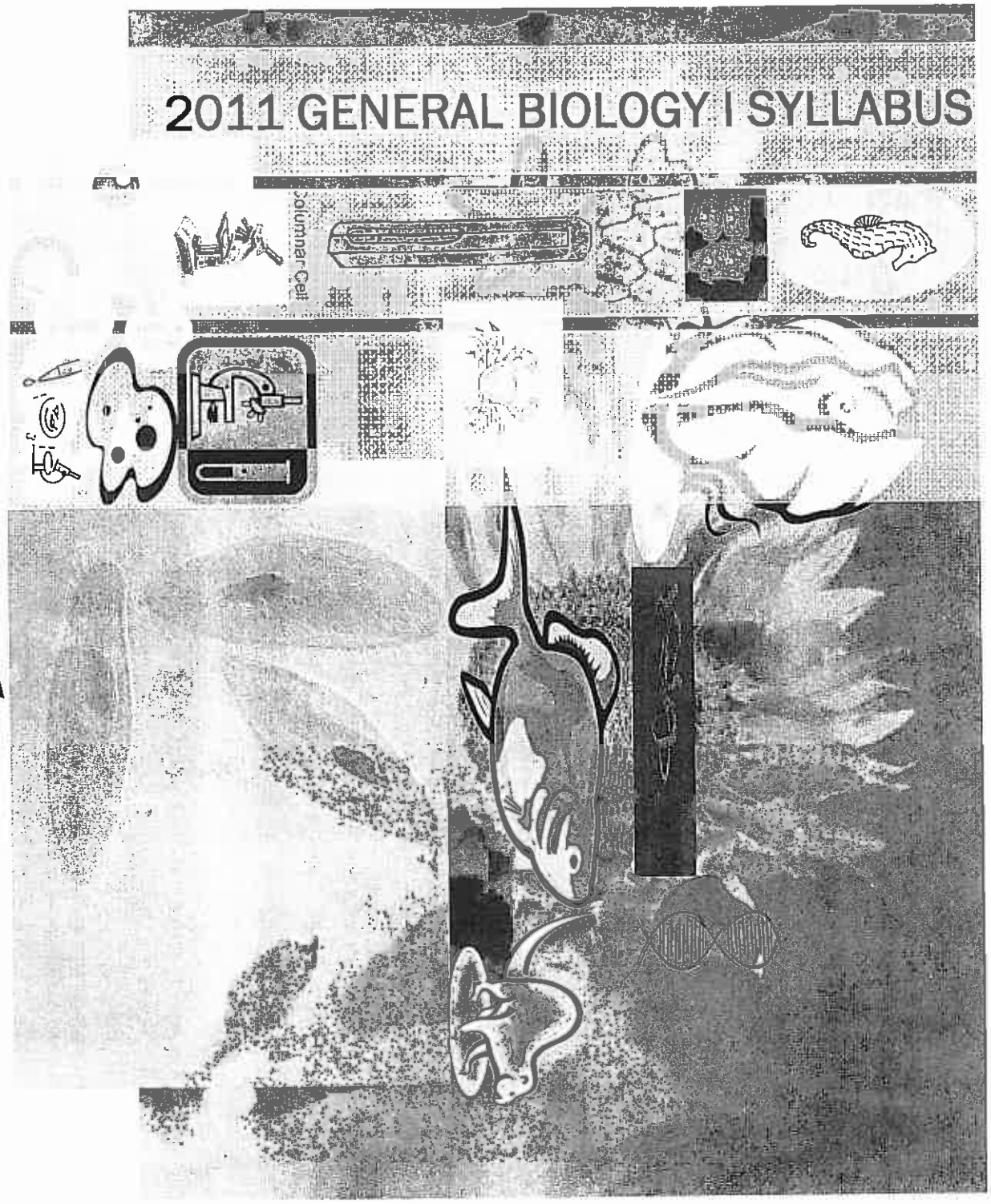


FALL 2011

2011 GENERAL BIOLOGY I SYLLABUS







General Biology I (w/Lab) Syllabus

BIO K121 (81), Four sem. hrs. credits
CRN: 50063
BIO K121 (81A or 81B)
CRN: 50064 or 50452
FALL 2011
Three Rivers Community College
Norwich, CT 06360

Instructor: Jean E. Skiba
Telephone: (860) 383-5226
e-mail: jskiba@trcc.commnet.edu

Office Hrs. – Location: C-266
TUESDAY 12:00-1:00
FRIDAY 11:00-12:00
ALL OTHER TIMES BY APPOINTMENT

Required Text:
Campbell *et al.* 2008. Biology: Custom edition for Three Rivers Community College. Pearson Custom Publishing. ISBN-13: 978-0-558-25690-6 & ISBN-10: 0-558-25690-2

Optional Text:
Pechenik, J.A. 2004. A short guide to writing about biology, 5th ed. Pearson/Longman Publishers

Catalog Description:
Prerequisite: High school chemistry or CHE K111 or higher, either course with a "C" grade or better. Placement score indicating eligibility to take ENG* K101 or ENG* K100 passed with a "C" grade or better. Co requisite: CHE* K111 - if a student has not met the above chemistry prerequisite, the student may take BIO* K121 by concurrently taking CHE* K111.*

This course introduces the major principles and concepts of modern biology. Topics to be covered include molecular and cellular biology, cell division, cellular transport systems, cellular metabolism, the specialization and differentiation of both plant and animal cells, and modern genetics. Three-hours of lecture; one three-hour laboratory period with lecture meeting on Mondays and Wednesdays at 9:30 and lab on Tuesdays from 9:00 until 12:00.

Primary Learning Outcomes:
In addition to developing an understanding of the biological sciences as it relates to other scientific disciplines, the student will be aided to contrive an awareness of the interdependence of all life forms on natural laws that ensure their own stability. An understanding of life processes and the interrelationship between humans and other life forms will be developed.

Attendance Policy:
Students are expected to attend class and laboratory sessions regularly. If a class or lab is missed due to circumstances beyond your control, **please**, be sure to notify your instructor and make the necessary arrangements for obtaining the lecture notes. **You will be responsible** for the material. **If 3-4 classes (and/or 3-4 labs) are missed, a deduction of 5 POINTS will be taken from your final grade. TEN POINTS will be deducted from your final grade if 5 or more classes (and/or labs) are missed. If 100% attendance is noted, 5 points will be added to your grade.**

Grade Evaluation:
There will be three unit examinations, two laboratory practicals. There will be eleven quizzes. The lowest quiz grade will be dropped. A **cumulative** final exam* will be

administered during finals' week. Exam and quiz questions will consist of multiple choice and/or short answers.

****Final exam exemption: >*90/100 on ALL three exams, BOTH Lab practicals must be higher than 95/100*)****

Add/Drop Procedures:

Please consult the school catalog for this policy.

Suggestions for the course:

To gain a better understanding be sure to read the required reading sections **before** coming to class. Also, be prepared to participate in classroom discussions.

Grading:

Final grade will based on the following:

Semester Grade*----------60%
Laboratory Grade£----------40%
100%

*Semester grade = 40% Unit tests + 10% quizzes + 10% final exam
£Laboratory grade = 20% Lab practicals + 10% Lab reports + 10% Formal lab report

Final Grade:

100.0-99.0= A	79.4-77.5= C+
98.9-93.5= A	77.4-72.5= C
93.4-90.5= A-	72.4-69.5= C-
90.4-87.5= B+	69.4-63.5= D+
87.4-84.5= B	63.4-59.5= D
84.4-79.5= B-	59.4-00.0= F

College Withdrawal Policy:

A student who finds it necessary to discontinue a course once class has met must provide written notice to the registrar. **See Registrar for dates.** After that period, a student wishing to withdraw must obtain written authorization of the instructor to receive a "W" grade on their academic record, non-punitive grade indicating termination of class participation. Students who do not withdraw, but stop attending **will receive** a grade of "F" for the final grade. **Verbal withdrawals cannot be accepted.**

Disabilities Statement:

If you have a hidden or visible disability that may require classroom or test-taking modifications, please see me as soon as possible. You must see Chris Scarborough who will alert me as to the accommodations you will need.

Academic and Classroom Misconduct:

The instructor has the primary responsibility for control over classroom behavior and maintenance of academic integrity, and can order the temporary removal or exclusion from the classroom, and/or laboratory, of any student engaged in conduct violating the general rules and regulations of the institution. Extended or permanent exclusion from classroom, and/or laboratory, or further disciplinary action can be effected only through appropriate college procedure. Plagiarism, cheating, or any form of academic dishonesty is **prohibited**. Students guilty of academic dishonesty directly or indirectly will receive a **zero** for an exercise or exam and may receive an **F** for the course in addition to other possible disciplinary sanctions that maybe imposed through the regular institutional procedures. Any student that believes he or she has been erroneously accused may appeal the case

through the appropriate institutional procedures if their grade was affected.

BIO K121 General Biology I
Tentative Schedule
FALL 2011
Lecture: 9:30-11:00 M & W: Room D 211
Laboratory: 9:00-12:00 T Lab A-215

Required readings in Campbell et al.

Date	Topic	Chapter
8/29	Orientation/The scientific method/Characteristics of Life	**1**
8/30	**LAB** (*Scientific Method*)	
8/31	Characteristics of Life (cont.) – **Quiz 1**	**2, 3**
9/6	**LAB** (*Introduction to the microscope*)	
9/7 & 9/12	Chemistry and life - **Quiz 2 (Monday)**	**4, 5**
9/13	**LAB** (*Chemistry*)	
9/14 &	Cytology	
9/19	The cell - **Quiz 3**	**6**
9/20	**LAB** (*The structures of the cell/ Models and microscope study*)	
9/21&	Plasma membrane	
9/26	The cell wall and membrane - **Quiz 4**	**7**
9/27	**LAB** (*Diffusion and osmosis*)	
9/28	**UNIT EXAM I**	**5**
10/3	**Cell Division**	
10/4	**LAB PRACTICAL I**	
10/5 &	Cell Division- Mitosis/meiosis - **Quiz 5**	**12, 13**
10/10	**Sexual Reproduction and Meiosis**	
10/11	**LAB** (*Mitosis/ meiosis*)	
11/12 &	Animal Histology - **Quiz 6**	**40**
11/17	**Animal tissues**	
11/18	**LAB** (*Microscopic study of animal tissues*)	
11/19&	Plant histology & plant structure - **Quiz 7**	**35, 36**
11/24	**Plant tissues**	
11/25	**LAB** (*Microscopic study of plant tissues*)	
11/26&	Photosynthesis/Cellular metabolism - **Quiz 8**	**8, 9, 10**
11/31	**Cell Respiration**	
11/1	**LAB** (*Photosynthesis*)	
11/2	Fermentation	
11/7	**UNIT EXAM II**	
11/8	**LAB** (Open - review)	
11/9&	Inheritance - **Quiz 9**	**14, 15**
11/14	**Human Inheritance**	
11/15	**LAB PRACTICAL II**	
11/16&	DNA replication - **Quiz 10**	**16**
11/21	**Protein Synthesis**	
11/22	**LAB** (*Genetics*)	
11/23&	Molecular Genetics- **Quiz 11**	**17, 18**
11/28	Genetics	

11/29 LAB (Human Genetics)
11/30 Regulation of Gene Expression
12/5 Regulation of Gene Expression in Eukaryotes
12/6 LAB (Genetics)
12/7 Review for Unit Exam III
12/12 UNIT EXAM III
12/13 Lab Report Due (class sharing)
12/14 Review for Cumulative Final Exam

12/19 **FINAL EXAM**
12/20 Exam Returns with Follow-up

Syllabus Revisions:
This schedule may be subject to change as the instructor sees fit. The instructor will announce any changes in advance.

Detailed Course Objectives - BIO K121:

1) The student will develop 'critical thinking skills' through the analysis of scientific data.

2) The student will be able to describe the scientific methods through examples.

3) The student will be able to list and describe the characteristics of life shared by all living organisms.

4) The student will be able to identify the principle elements that make up living organisms, give their symbols and their biological importance.

5) The student will demonstrate knowledge of ionic, covalent, and hydrogen bonding.

6) The student will be able to list the types of organic and inorganic compounds common to all living organisms and describe the biological importance of each.

7) The student will be able define pH in terms of the concentration of hydrogen ions and be able to identify any given pH as acid, base, or neutral.

8) The student will be able to describe how pH changes are minimized by buffers.

9) The student will demonstrate knowledge of the cell history.

10) The student will be able to list the various organelles in a typical animal cell and a typical plant cell and explain the function of each organelle.

11) The student will be able to explain the difference between plant and animal cells.

12) The student will be able to list and explain the major differences between prokaryotic and eukaryotic cells.

13) The student will demonstrate knowledge of the various mechanisms of passive and active transport systems related to the cell membrane.

14) The student will demonstrate knowledge of the processes of cell division (mitosis and meiosis).

15) The student will demonstrate knowledge of the major classes of plant and animal tissues, list the types of tissues in each class and describe their function.

16) The student will be able define energy and state the laws of energy conservation.

17) The student will be able to explain the photosynthesis process.

18) The student will be able to define the term metabolism and explain the difference between anabolic and catabolic metabolism.

19) The student will be able to define the term enzyme, list the principle properties of enzymes, and describe enzymatic action.

20) The student will demonstrate knowledge of chemical energy in cells and the cellular respiratory process.

21) The student will be able to explain the role of chromosomes and genes in inheritance and describe how they are passed from one generation to the next.

22) The student will be able to understand the relationship between meiosis.and sexual reproduction.

23) The student will demonstrate knowledge of the Mendelian Laws of genetics.

24) The student will demonstrate knowledge of the various forms of gene interactions.

25) The student will be able to discuss some common forms of human genetic diseases.

26) The student will demonstrate knowledge of modern genetic concepts and molecular genetics (the role of DNA & RNA).

27) The student will be able to explain the process of protein synthesis.

DETAILED COURSE OUTLINE:

Unit 1

I Introduction

- **A)** Early history and development of biology as a science
  - **1.** Biology as a science
  - **2.** The scientific method
- **B)** The characteristics of life
  - **1.** Level of organization
  - **2.** Irritability (response to stimuli)
  - **3.** Adaptability
  - **4.** Growth
  - **5.** Movement
  - **6.** Metabolism
  - **7.** Reproduction

II The chemistry of life

- **A)** Matter
  - **1.** Composition
  - **2.** Forms
    - **a)** solids
    - **b)** liquids
    - **c)** gases

  - **3.** Elements common to all living organisms
    - **a)** carbon
    - **b)** nitrogen
    - **c)** oxygen
    - **d)** phosphorus
    - **e)** hydrogen
    - **f)** sulfur
    - **g)** calcium
    - **h)** sodium
    - **i)** chlorine
    - **j)** iron
    - **k)** magnesium + other trace elements

- **B)** How the elements differ
  - **1.** The atom and it's structure
    - **a)** protons
    - **b)** electrons
    - **c)** neutrons
  - **2.** Atomic numbers
  - **3.** Atomic masses (weights)
  - **4.** Isotopes

- **C)** Electron arrangement and energy levels

- **D)** Electron arrangement versus reactivity

1. Chemical bonding
    a) ions and ionic bonding
    b) covalent bonding
        1) polar
        2) non-polar
    c) hydrogen bonding

E) Inorganic compounds important to living organisms
1. Acids
2. Bases
3. Salts
2. Water

F) Organic compounds important to living organisms
1. Vitamins
2. Carbohydrates
3. Lipids
4. Proteins
5. Nucleic acids

III Cells

A) The cell theory
B) Cytoplasmic organelles (structure and function)
1. Endoplasmic reticulum
2. Golgi complex
3. Mitochondria
4. Lysosomes
5. Ribosomes
6. Centrioles
7. Plastids (Chloroplast)

C) The cell nucleus

D) Appendages of the cell
1. Flagella
2. Cilia

E) The differences between plant and animal cells

F) The differences between prokaryotic and eukaryotic cells

G) The cell membrane
1. Composition
2. Membrane transport mechanisms
    a) diffusion

b) osmosis
c) dialysis

2. Membrane transport mechanisms (cont.)
d) facilitated diffusion
e) active transport
f) endocytosis
1) phagocytosis
2) pinocytosis
g) exocytosis
h) filtration

IV Cellular reproduction

A) The cell's cycle of growth

1. Interphase
a) growth phase 1 or gap 1 phase
b) synthesis phase or s phase
c) growth phase 2 or gap 2 phase

2. Mitosis
a) prophase
b) metaphase
c) anaphase
d) telophase

B) Meiosis

1. Reproductional division - Meiosis I
a) prophase I
b) metaphase I
c) anaphase I
d) telophase I

2. Equational division - Meiosis II
a) prophase II
b) metaphase II
c) anaphase II
d) telophase II

C) Gametogenesis

1. spermatogenesis
2. oogenesis

Unit II

I The differentiation and specialization of cells (Histology)

A) Tissues (defined)

B) Major classes of animal tissues (structure and functions)

1. Epithelial tissues
a) simple squamous
b) simple cuboidal
c) simple columnar
d) stratified squamous
e) stratified columnar
f) pseudo-stratified ciliated columnar

g) transitional

2. Connective tissues
   a) loose connective
      1) areolar
      2) adipose
   b) dense connective
      1) tendons
      2) ligaments

2. Connective tissues (cont.)
   c) special connective
      1) blood
      2) reticular tissue
      3) cartilage
      4) bones

3. Muscle tissue
   a) smooth
   b) cardiac
   c) skeletal

4. Nervous tissue
   a) neurons
   b) neuroglial

C) Membranes
   1. Serous
   2. Mucous
   3. Cutaneous
   4. Synovial

D) The major classes of plant tissues (structure and function)
   1. Epidermal tissue
      a) stoma
      b) guard cells
   2. Vascular tissue
      a) xylem
      b) phloem
   3. Meristematic tissue
      a) cambium - cork cells
      b) apical meristem
      c) lateral meristem
   4. Fundamental tissues
      a) parenchyma cells
      b) chlorenchyma cells
      c) collenchyma cells
      d) sclerenchyma cells

II Energy transformations
   A) Energy and chemical directions
      1. The first law of thermodynamics
      2. The second law of thermodynamics
   B) Cell energy molecule
      1. ATP

C) Metabolism
    1. Anabolic reactions
    2. Catabolic reactions

D) Enzymes
    1. Chemical properties
    2. Action
    3. Classification
    4. Factors affecting enzymatic activity

F) Photosynthesis
    1. Essential factors of photosynthesis
        a) carbon dioxide
        b) water
        c) light
        d) chloroplast - chlorophyll
    2. The process of photosynthesis
        a) the light reaction - photophosphorylation
        b) the Calvin cycle - carbon fixation (dark reaction)
        c)

G) Cellular respiration
    1. Glycolysis
    2. The Krebs cycle
    2. The electron transport system

H) Fermentation

Unit III

I Genetics

A) Meiosis and genetics
B) Mendel and his work
C) Terms
    1. Chromosomes
    2. Genes
    3. Alleles
        a) homozygous
        b) heterozygous
    4. Genotype
    5. Phenotype
    6. Dominance
    7. Recessiveness
    8. Epistasis
    9. Parent or P 1 generation
    10. First filial or F 1 generation
    11. Hybrid
    12. Second filial or F 2 generation
    13. Incomplete dominance and co-dominance
D) The law of segregation
E) Monohybrid crosses
F) The law of independent assortment
G) Dihybrid crosses
    1. The Punnett square
        a) genotypical ratios
        b) phenotypical ratios

2. Probability

H) Back crosses

I) Test crosses

J) Gene interaction
   1. Epistasis
   2. Complementary genes
   3. Supplementary genes

K) Quantitative inheritance
   1. Multiple alleles
   2. Polygenetic inheritance

L) Sex linked traits
   1. The sex determining chromosomes
   2. X - linked genes
   3. Y - linked genes

M) The Hardy-Weinberg law

N) Linkage and chromosome mapping

O) Changes in chromosome numbers
   1. Aneuploid cells
      a) monosomic cells
      b) trisomic cells
      b) polyploidy cells

P) Chromosomal aberrations
   1. Mutations
   2. Deletions
   3. Duplications
   4. Inversions
   5. Translocations

Q) Genes and diseases
   1. Sickle cell anemia
   2. Thalassemia
   3. Cystic fibrosis
   4. Tay-Sachs disease
   5. PKU
   6. Lesch-Nyhans disease

R) The role of RNA and DNA in inheritance
   1. Protein synthesis
      a) transcription
      b) translation
   2. The operon theory
      a) operator gene
      b) promoter gene
      c) regulator gene
      d) structural gene

II Evolution

A) Heredity and evolution
   1. Historical perspective
   2. Evidence of evolution

3. Adaptation and evolution
4. The modern concepts of evolution

General Biology I
BIO K121
Writing Laboratory reports

Organizational aspects of laboratory reports:

Laboratory and research reports should follow the scientific method.

-REMEMBER- *systematic knowledge is derived from observations, hypotheses, and experimentation.*

The report should consist of five* components:

1) **Introduction**
2) **Materials and Methods**
3) **Results**
4) **Discussion**
5) **Conclusion**

Before writing your first laboratory report, go to a library and study a few short papers in major biological journals

Writing the introduction: Tie together activities completed during lab. What did they all have in common? Define and exemplify the general processes of diffusion and osmosis, as it pertains to living organisms. Introduce the topic and supply background knowledge about the topic. This section should be a few paragraphs long. The last sentence (or two) should include the purpose of these experiments; state why you are writing this report (and no, "Because my instructor told me to", is not acceptable). It is always good practice to end your introduction with your hypothesis (and/or) purpose.

Writing the Materials and Methods: This section is to remind you what you did. It should include detailed instructions and directional approaches for others to repeat the experiment. Do not put together a shopping list of materials:

-Malachite green
-250 ml graduated cylinder
-tap water
-folded notebook paper or 4x6 index card
-stopwatch or timepiece

Rather, incorporate the materials used for the experiment within the procedures you performed. For example: *"To demonstrate diffusion of a liquid in a liquid, 1ml of Malachite green was added to 250ml of tap water in a graduated cylinder."*

Writing the Results section: The focal aspect of your laboratory report should be your Results section. This section is where you present your data by use of tables, graphs, and figures. A picture is worth a thousand words. Don't go overboard in describing your figures, graph, and/or tables in this section. Do not interpret the data here, save that for the *Discussion* section. Label and title all Figures and Tables for reference in the text. Again, just state your results, for example: *"The diffusion rate of Malachite green in water was 0.0.012 ml/minute (Fig. 1)."*

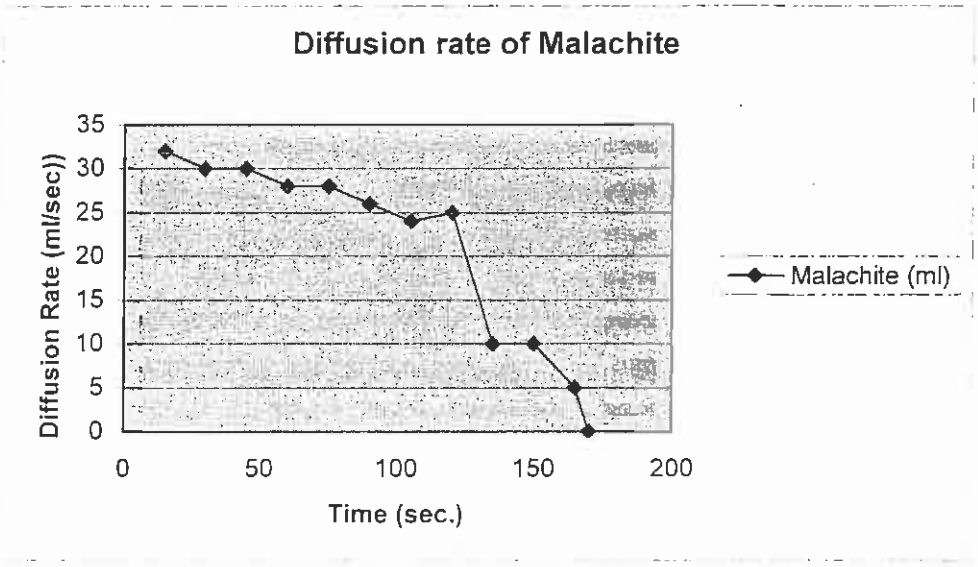


Figure 1. Two drops of Malachite green diffusing in 250 ml graduated cylinder (Diffusion rate = 0.012 ml/min.).

Writing the Discussion section: The Discussion section should be the 'meat' of your report. In your Discussion section, you should incorporate your results with the objectives, or hypotheses stated in your Introduction section. Also, **incorporate** all the thought questions here in the *Discussion* section. For example, in response the *thought question*; **What effect does increased temperature have on the kinetic energy of molecules?**

Diffusion and osmosis directly hinge on molecular movement. All molecules possess kinetic energy (Keene, 1987). Temperature was found to influence the kinetic energy associated with fat droplets in milk. Viewed under high power (400x), Brownian movement of fat droplets can be easily seen. The random vibrational movement of the fat droplets appeared to increased with heat and decreased when iced. This would imply that heat would increase the kinetic energy associated with molecular movement. Colder temperatures would slow

the movement of milk fat, therefore, less kinetic energy to collide and transfer energy.

(discussion section should not be a question and answers section)

Writing the Conclusion (or Abstract): All papers should have a Conclusion (at the end), or an Abstract (at the beginning). This section should be a brief overview of all sections, by reemphasizing thoughts and ideas from all other sections. REMEMBER...never introduce anything that had not been previously mentioned in your paper.

*Literature Cited: This section should complete your paper by always being placed last. All papers should include references that can be crosschecked with your Literature Cited section. IN OTHER WORDS, do not include any reference that had not been previously cited within your paper (and, vice versa). Literature Cited sections should always be alphabetized and be structured as follows:

Primary author's last name, primary author's first and middle initials and *any other authors first and middle initials & last names. Year of publication. Title of publication. Publisher. Pages of book (or pages used).*

EX: Sheeler, P. and D.E. Bianchi. 1983. Cell biology: Structure, biochemistry, and function. John Wiley & Sons, Inc. 668p. (**or**) p.177.

Eample of cited reference within a paper:

Sheeler and Bianchi (1983) discuss the importance of allosteric enzymes involved in feedback inhibition.

Another way to reference this same thought:

Allosteric enzymes are crucial factors involving the regulation of end products through feedback inhibition (Sheeler and Bianchi, 1983).

General Biology I
BIO K121
Spring 2006
Formal laboratory report grading

The following is a breakdown of the grade that you will receive for your quarterly lab reports. *Always remember, good scientific writing is precise.* Write to mean what you mean to say, and be sure to say what you mean.

20 points--------Introduction

Organization.....5 pts.
Conciseness.....5 pts.
Background & hypothesis.....10 pts.

20 points--------Materials and Methods

Organization.....5 pts.
Conciseness.....5 pts.
Can the experiment be replicated.....10 pts.

20 points-------- Results

Organization.....5 pts.
Conciseness.....5 pts.
Presentation of data .....10 pts.

30 points--------Discusion

Organization.....5 pts.
Conciseness.....5 pts.
Interpretation of experiment.....10 pts.
Relevant, broader issues.....10 pts

5 points--------Conclusion

Conciseness.....5 pts.

5 points--------Literature Cited

Organization.....5 pts.

---

100 points

General Biology I **Name**_____
BIO K121
Spring 2006
Formal laboratory report grade

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20 points--------Introduction

Organization.....____/5 pts.
Conciseness.....____/5 pts.
Background & hypothesis.....____/10 pts.

20 points--------Materials and Methods

Organization.....____/5 pts.
Conciseness.....____/5 pts.
Can the experiment be replicated.....____/10 pts.

20 points-------- Results

Organization.....____/5 pts.
Conciseness.....____/5 pts.
Presentation of data .....____/10 pts.

30 points--------Discusion

Organization.....____/5 pts.
Conciseness.....____/5 pts.
Interpretation of experiment.....____/10 pts.
Relevant, broader issues.....____/10 pts

5 points--------Conclusion

Conciseness.....____/5 pts.

5 points--------Literature Cited

Organization.....____/5 pts.

Total Score:

Science

-Systematic knowledge derived from observation, study, and experimentation carried on in order to determine the nature or principle of what is being studied

-The study of systems

Technology

-Applied science

-A scientific method of achieving a practical purpose

Biology

-The branch of knowledge that deals with living organisms and vital processes

-The study of life

-Major biological disciplines:

-Embryology: Study of developing embryos

-Cytology: Study of cells

-Physiology: Study of functions of life

-Genetics: Study of genes & inheritance

Early history of Biology

- 3 periods of Western World History

-Ancient, Medieval, & Modern

-Ancient times

-Aristole (384-322 B.C.)

-Prior to Darwin, Aristole made great contributions to biology

-Medieval times (1st - 15th centuries)

-Christianity & the Bible were the dominating theories

-Biological theories were dormant

-Modern times (~1500 - present)

-During the 17th & 18th centuries biology split into zoology & botany

-Darwin's natural selection - 1859

Scientific Method

-Tool used by scientists in the development of ideas.

-Systematic approach to the gathering of data and the solving of problems

Induction	Deduction
1) Observation	1) Hypothesis
2) Experimentation	2)Experimentation
3) Hypothesis	3) Confirm or Deny Hypothesis

The Characteristics of Life

-What is life?

-What is the difference between living organisms & non-living matter?

-Processes that are carried out!!

-Life can be defined best by what it DOES, not by what it is!!!

-Metabolism is the most important link between abiotic & biotic systems

-Metabolism: is the sum of all chemical reactions within an organism

-*the use of energy * or energy transfers

Energy Allocations

-all organisms allocate their energy into three prime objectives

1) Growth
2) Maintenance
3) Reproduction

Homeostasis

-Metabolism is stabilized in equilibrium

-Metabolism is maintained within a tolerable range

Reproduction

-production of offspring by parents

-transferal of suitable traits

Hierarchal Organization of Life

-ALL living organisms depend directly or indirectly on one another for energy

Energy Flows & Nutrients Cycle

Taxonomic Classification

-All organisms are systematically placed in taxonomic groups based on phylogenetic relationships

Five Kingdom Approach

-Kingdom Monera
-Kingdom Protista
-Kingdom Plantae
-Kingdom Fungi
-Kingdom Animalia

Each Kingdom is further broken:

Kingdom
Phylum
Class
Order
Family
Genus
Species

Criteria for Organismal Classification

-Basic characteristics for kingdom, phylum, + class classification

1) Number of cells
2) Nature of digestive tract
3) Presence of a coelom
4) Body segmentation
5) Support System
6) Symmetry

-Basic characteristics for order, family, genus, + species classification

1) Embryological development
2) Biochemical techniques
3) Chromosome morphology

Matter

-Material substance that occupies space and has weight.

Physical States of Matter

1) Solids
2) Liquids
3) Gases

-All matter consists of chemical forms

-Elements
-Molecules
-Compounds

-Pressure and Temperature are the primary factors that determine which state or phase of matter elements or compounds will appear as

Sublimation

-Process in which solids change directly to gas without passing through the liquid phase

-ex: Dry Ice (solid CO_2)

-Freeze dried foods

Vapor Deposition

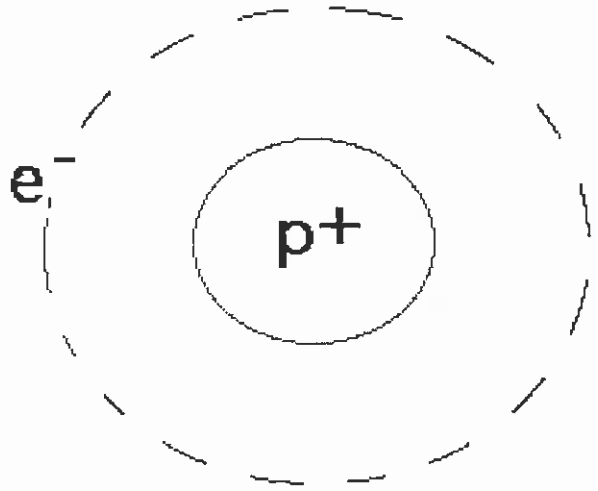
-Process in which a gas changes directly to solid phase without passing through liquid phase

-Ex: Frost

Atoms

-Smallest unit of matter

Hydrogen Atom



1 proton- positively charged
0 neutron- no charge
1 electron- negatively charged

Atomic Number = # p^+

Atomic Mass = # p^+ + # n

-ex: 17 protons + 20 neutrons = 37 Mass#

Ions

-charged atoms, by gaining or losing one or more e^- from outer shell

-uneven # of p^+ + e^-: one or more protons or electrons

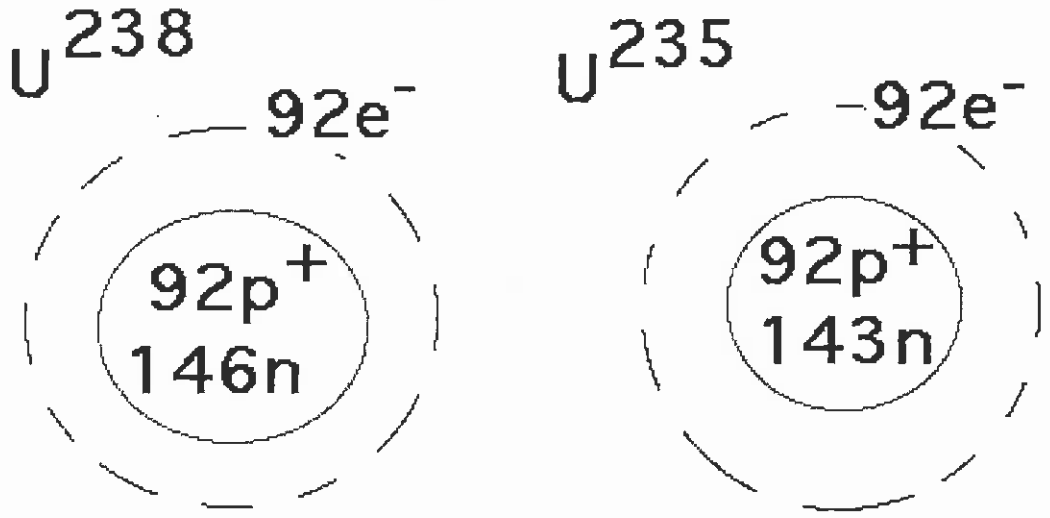
-ex: Na^+ + Cl^-

Sodium + Chloride

Isotopes

-Two or more forms of an atom that have the same # of p^+ but different # of neutrons

-ex: Uranium ^{238} + Uranium ^{235}



Energy and Stability of Atoms

Energy

-The property of a system by which work or heat is exchanged for power

-Any system, biotic or abiotic, tends to change in such a way as to minimize its energy content

-A system is most stable when it has the least amount of energy

Behavior of Electrons

-electrons determine chemical properties

-all chemical reactions involve changes at the electronic level

-reactions are exchanges of electrons

-electrons orbit the nucleus of the atom to constitute a series of **SHELLS**

-the number of electrons in the outermost shell will determine it's chemical properties

Chemical Bonding of Atoms

Chemical bond

-an attractive force between atoms

-union between electrons

-it is an energy relationship

Types of chemical bonds

1) Covalent Bond
2) Ionic Bond
3) Hydrogen Bond

1) **Covalent bonding of atoms**

-mutual attraction of shared electrons
-non-metals reacting with non-metals
-sharing 2 or 3 e^- = double + triple bonds

2) **Ionic bonding of atoms**

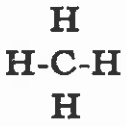
-bond between two ions
-the attractive force is between positively & negatively charged ions
-between metals and non-metals

3) **Hydrogen bonding of atoms**

-weak bond between molecules

--H_2O---H_2O---H_2O---H_2O--

-Carbon + Hydrogen



Intermolecular Forces

Polar Molecules

-slight positive + negative ends
-exhibit a dipole force

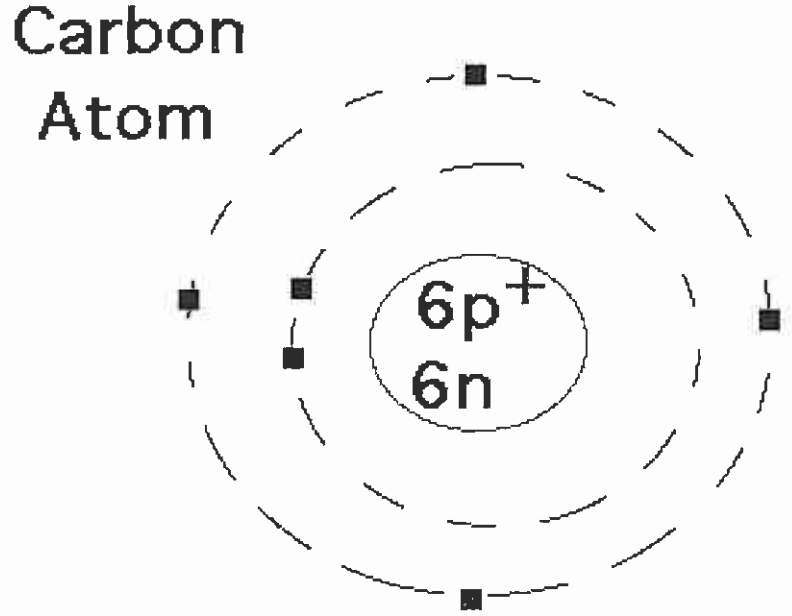
Nonpolar Molecules

-electron cloud distorts continuously
-held together dispersion forces
-higher the molar mass = high distortion
-greater strength
-I_2>Br_2>Cl_2>F_2

Organic Compounds

-any compound containing carbon atoms

-ex: sugars, carbohydrates, vitamins, plastics, ect.



Hydrocarbons

-compounds with hydrogen + carbon atoms

-ex: Methane (CH_4), Hexane (C_6H_{14})

Chlorinated Hydrocarbons

-DDT ($C_{14}H_9Cl_5$)

-PCB's ($C_{12}H_5Cl_5$)

Inorganic Compounds Important For Life

1) Acids
2) Bases
3) Water
4) Salts
5) Metals

Acids + Bases

-pH scale 1-14 (7 = neutral)

-pH = $-\log_{10}[\mathbf{H^+}]$

- $\mathbf{H^+}$ + $\mathbf{OH^-}$ (hyroxide ion)

1) **Acids** = pH between 1 + 6.9

-compounds that release $\mathbf{H^+}$ (protons)

-HCl (hydrochloric acid); H_2SO_4 (sulfuric acid)

-H_2CO_3 (carbonic acid); HNO_3 (nitric acid)

2) **Bases - pH** = 8.0 - 14

-Alkaline compounds

-posses hydroxide ion ($\mathbf{OH^-}$)

-$\mathbf{H^+}$ acceptors

Inorganic Compounds Important For Life(cont.)

3) Water (H_2O)

-imp. for all life

Physical Aspects of Fresh Water

a)FW has a high specific heat ratio

-due to it's hydrogen bonds

-provides a stable environment

-temp. fluctuation is gradual

-fog on a lake

b) Density

-due to it's physical + chemical aspects of FW water; water is most dense at 4°c (3.94°)

-dense water sinks, therefore, H_2O freezes from top to bottom

c) Surface tension

-at plane ----> AIR the normal H^+ bonds are disturbed H_2O

-created a downward pull or tension

4) Salts

-an ionic compound formed when an acid reacts with a base

EX: $HCl + NaOH \rightarrow NaCl + H_2O$

-salts in living organisms; sodium ions (Na^+) and potasium ions (K^{++}) are important for nerve impulses; calcium ions (Ca^{++}) are imortant muscle contraction, cell division, blood clotting, and nerve cell function

5) Metals

-metal ions such as iron (Fe^{+++}) act as electron carriers in ATP production

Buffers

-in natural systems & in living organisms, buffers play an important role in pH balance

-most important is the carbonic acid-bicarbonate buffering system:

$$H_2CO_3 <----> HCO_3^- + H^+$$

Organic Compounds Important for Life

-Carbon

-the most important structural element of life

-three most abundant elements in living organisms are oxygen, hydrogen, and CARBON

-each carbon atom can form up to four covalent bonds with with other carbon atoms as well as with other elements

Organic Compounds: Four Main Types or Families

1) **Carbohydrates**
   -sugars: monosaccharides, oligosaccharides, & polysaccharides
      -quick energy
2) **Lipids**
   -fatty acids: fats & oils
      -storage source of energy
3) **Proteins**
   -amino acids - enzymes
4) **Nucleic Acids**
   -RNA & DNA

Organic Chemical Compounds Vital For Life

Percent dry weight of humans:

54% Carbon (C)
18% Oxygen (O)
09% Nitrogen (N)
08% Hydrogen (H)
03% Phosphorus (P)
0.75% Sulfer (S)

These elements combine to form **functional groups**.

	Group	Structure	Macromolecule
1)	Hydroxyl	**R** - OH	Carbohydrates
2)	Methyl	**R** - C - H (H)	Lipids
3)	Carbonyl (aldehyde)	**R** - C (=O) H	Carbohydrates
4)	Carbonyl (ketone)	**R** - C (=O) - **R**	Carbohydrates
5)	Amino group	**R** - N (H) H	Proteins
6)	Carboxyl	**R** - C (=O) - OH	Carbohydrates, Lipids, Proteins

Functional groups (cont.)

7) Phosphate	**R** - O - P - OH OH	Phosphate Compounds (such as ATP)

The four main types of organic compounds (macromolecules) in living organisms are organized as such:

Elements-->Functional groups-->Monomers

Condensation & Hydrolysis Reactions

In order for macromolecule formation, or breaking down, one of two chemical reactions must occur:

1) Hydrolysis Reactions
- a H_2O molecule is added after enzymatic activity
  - -(breaking of covalent bonds)

2) Condensation Reactions
- -dehydration synthesis
  - -loss of H_2O molecule
- -enzymatic activity forms covalent bonds
  - -monomers---->polymers

Cellular Macromolecules

Substance	% of Total Cell Weight
Water	65-85
Protein	10-25
Lipid	2-10
Polysaccaride	1-5
Nucleic acid	0.5-5

These functional groups combine to form **monomers** that constitute the four types of **macromolecules** found in living organisms:

1) **Carbohydrates**
2) **Lipids**
3) **Proteins**
4) **Nucleic acids**

Carbon forms the backbone of ALL macromolecules. The union of these functional groups with carbon chains produces 4 categories of monomers, which are specific to a macromolecule. For example, simple sugars monomers of polysaccharides. The most common sugars are triose (3 - carbon), pentose (5 - carbon; **ribose & deoxyribose**)), and hexose (6 - carbon; **glucose & fructose**). Such reactions involve the loss of a water molecule between the pairs of monomers and is thus referred to a **condensation or**

dehydration synthesis reaction. On the other hand, when these macromolecules are broken back down into their monomers, a water molecule is added between each pair. This process is known as **hydrolysis**. Cellular digestion involves a series of similar reactions which break down large macromolecules or food into their smaller subunits.

Macromolecule Organization

Elements --> Functional groups --> Monomers --> Macromolecules

These macromolecules comprise the cell's structure and all of the chemical processes within the cell (i.e. **cellular metabolism**). All of these macromolecules are built upon chains of carbon atoms. As a result, biologists refer to life on earth as being "carbon based" and that the presence of **organic molecules** (molecules containing carbon) are excellent indicators of life as we know it. Before these elements form macromolecules or combine with carbon, they are first organized into functional groups and then into **monomers** of the particular macromolecule.

Monomer	Macromolecule
Monosaccharides	Polysaccharides (Carbohydrate)
Glycerol & Fatty acids	Lipids
Amino acids	Proteins
Nucleotides	Nucleic acids

Macromolecules

-important for cellular metabolism
-cell's structure & ALL chemical processes
-macromolecules consist of monomers

Four Categories of Monomers:

	Monomer	Macromolecule
1)	Monosaccharides (Carbohydrates)	Polysaccharides
2)	Glycerol & Fatty acids	Lipids
3)	Amino acids	Proteins
4)	Nucleotides	Nucleic acids

Macromolecules: CARBOHYDRATES

-simple sugars (quick energy)
-structural & supportive elements
    -cellulose (plants) + chiton (animals)

3 Classes of Carbohydrates

1) **Monosaccharides**
2) **Oligosaccharides**
3) **Polysaccharides**

Monosaccharides

-simplest unit of carbohydrates

-2 or more hydroxide groups + carbonyl group (either a ketone or aldehyde)

-gen. formula = $C_nH_{2n}O_n$

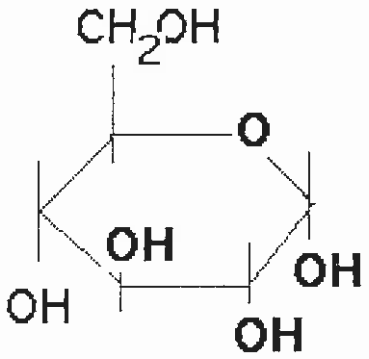
-EX: Glucose ($C_6H_{12}O_6$)

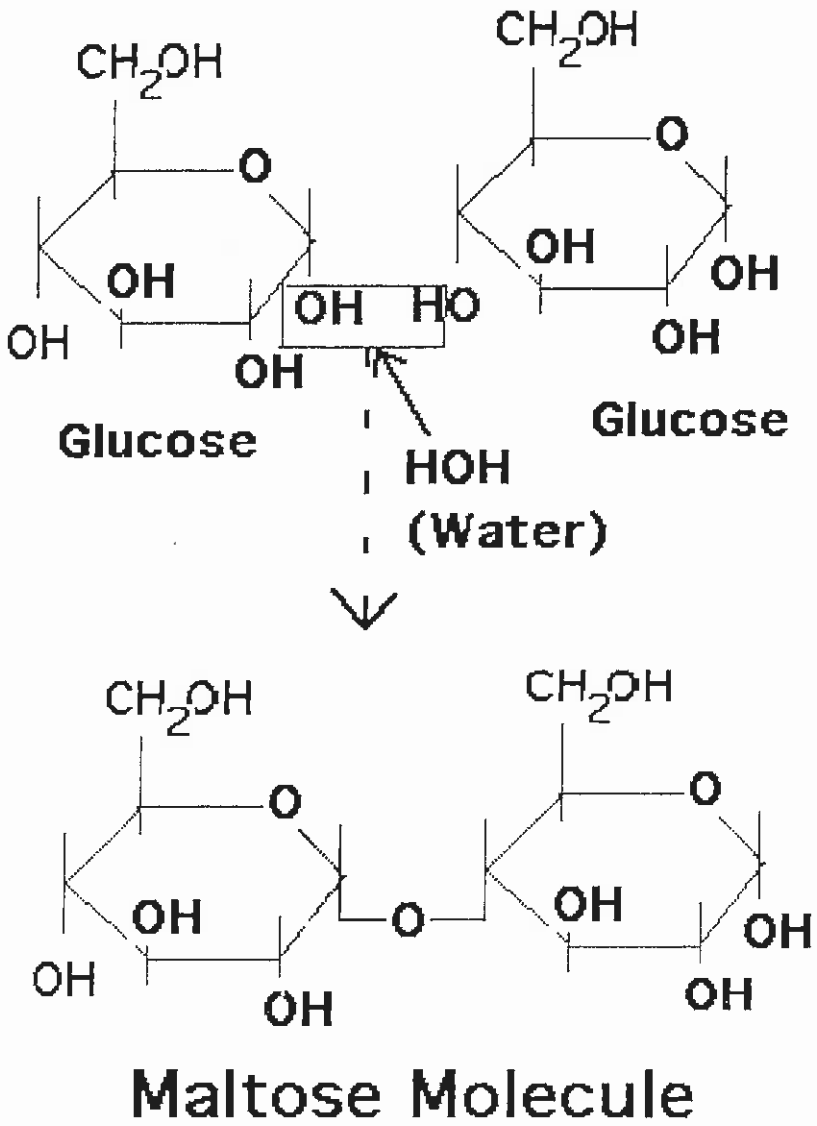
-precursor molecule

-main energy source

-through condensation reactions glucose molecules combine with other glucose molecules or other monosaccharide molecules

Glucose Molecule:





Maltose Molecule

Condensation Reaction with two glucose molecules via <u>GLYCOSIDIC BONDS</u>=Maltose

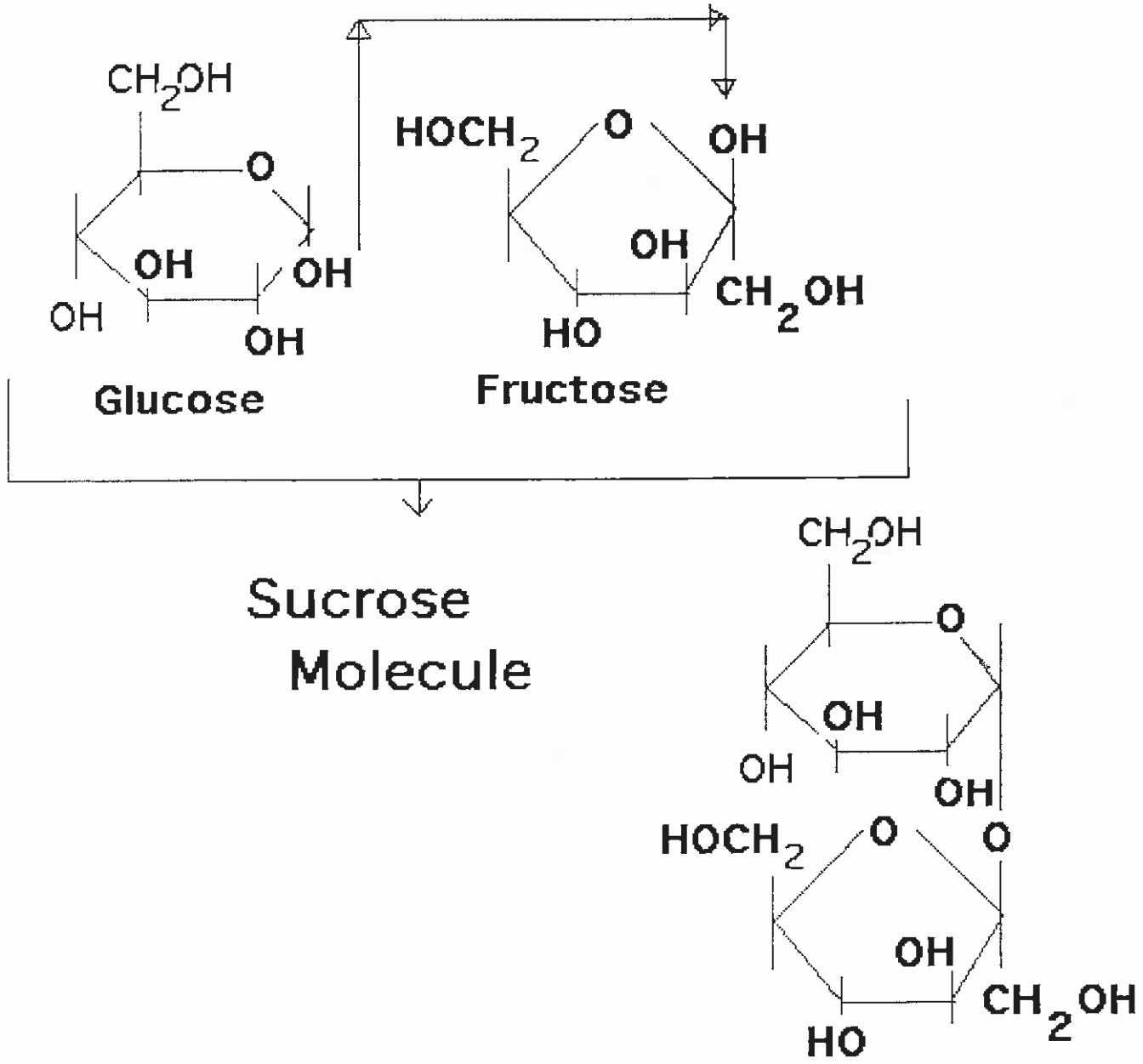
2) Oligosaccharides

-two or more monosaccharides

-Maltose, Sucrose, Lactose

- Sucrose = glucose + fructose

-Lactose = glucose + galactose



Sucrose

-table sugar; extracted from leafy plants
-formed by the condensation of glucose and fructose

3) **Polysaccharides**

-complex sugars
-Starch, Glycogen, Cellulose, Chiton
-straight or branched structure of hundreds (thousands) of monosaccharides

a) Cellulose

-most abundant organic compound
-unbranched polymer of glucose units
-structural role in plant cell walls
-parallel, cross linked **Microfibrils**

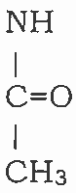
3) **Polysaccharides (cont.)**

b) Starch

-storage form of glucose in plants
-nutrient polysaccharide in plants, protists, & certain bacteria
-occurs in granules (potato or corn)
-can be readily hydrolyzed

c) Chiton

-extracellular structural polysaccharide of arthropod exoskeletons
-chemically similar to cellulose
-OH group of #2 carbon is replaced by an acetamido group:



d) Glycogen

-branched nutrient polysaccharide in nearly all animal cells & certain protozoans
-stored primarily in liver & muscles
-glucosyl units that branch by a 1-6 glycosidic bond
-"bush" or "tree" -like molecule

II **Lipids**

-fats, oils, & waxes
-relatively insoluble in water
-Serves two major roles in cells:
1) constituents of certain structural components of cells
-membranous organelles

2) may be stored intracellular as energy sources

-Common lipids: Fatty acids, Neutral fats, Phospholipids, Glycolipids, Terpenes, & Steroids

Fatty Acids

-carbon & hydrogen chain w/an attached carboxyl (-COOH) group on one end
-hydrophobic tails

-Saturated fats
-butter & lard (solids at 20°c)
-no double bonds between hydrocarbon chain

-Unsaturated fats
-oils (liquid at 20°c)
-one or more double bonds

II Lipids: Fatty Acids (cont.)

Fatty acids follow the formula:

$$CH_3\text{-}(CH_2)_n\text{-}COOH$$

n = an even # between 2-22

Fatty acid molecules contain both hdrophilic and hydrophobic parts
- -carboxyl ends are mildly soluble in H_2O
- -long hydrocarbon chains repel H_2O

Neutral Fats (Glycerides)
- -mono-, di-, or tri- glycerides
  - -depends on # of fatty acid tails
- - fatty acid tails + a glycerol molecule
  - -occur as droplets in cytoplasm
- -Triglycerides
  - -yield much energy
  - -three fatty acid tails + glycerol

Phospholipids
- -diglyceride; 2 fatty acid tails w/glycerol
- -important in cell membranes
  - -together w/proteins, constitute the lipid bi-layer of cellular membranes

Terpenes
- -no fatty acid tail
- -fat soluble vitamins (vitamin *A*, *E*, & *K*)
- -comprised of a 5 carbon building block known as isoprenes

Steroids
- -no fatty acid tail
- -system of fused cyclohexane & cyclopentane rings
- -Vitamin D_2
- -hormones
  - -testostrogen & estrogens

III Proteins

Two Major Classes of Proteins:

1) Structural Proteins

2) Dynamic Proteins

1) Structural Proteins

A) Intracellular

-mechanical framework of the cell

-microfiliments & microtubules

-certain membrane proteins

B) Extracellular

-supportive role

-collagen, cartilage, & bone

-keratin (nature's plastic)

2) Dynamic Proteins

-enzymes, certain blood pigments

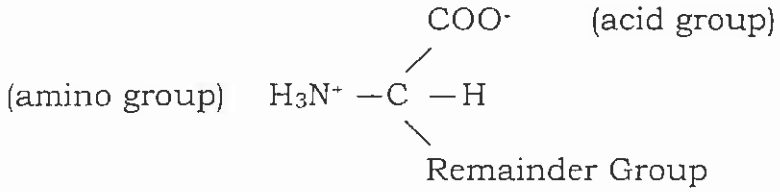
Molecular Organization

Fibrous (threadlike) Proteins

Globular Proteins

-Proteins are polymers are Amino Acids

Amino Acid general formula:



Chemical nature of R group distinguishes one amino acid from another & function

Amino acids are linked together: peptide bond

3 or more amino acids: form polypeptide chain

Four levels of Protein Structure:

1) Primary

2) Secondary

3) Tertiary

4) Quaternary

1) Primary structure of protein

-sequential delineation of covalent peptide bonds (polypeptide chain)

2) Secondary structure of protein

-polypeptide chains twisted to form a helical pattern

3) Tertiary structure of protein

-globular polypetide chain that are folded upon themselves

-interior is stabilized by ionic bonds (salt bridges), hydrogen bonds, disulfide bridges, or hydrophobic bonds

4) Quaternary structure of protein
    -two or more poypeptide chains
    -hemoglobin in human blood

Collagen
- -most common protein occurring in animals
- -fibrous protein (elastic)
- -comprised of three amino acids/chain
- -rod shaped molecule formed by the intertwining of three polypeptide chains
    - -"superhelix"

Silk Fibers
- -parallel, extended polypeptide chains
- -Anti-parallel beta-pleated sheet
- -no coiling

Conjugated Proteins
- -proteins permanently binded with nonproteins
- -Chromoproteins,Glycoproteins,Lipoproteins

Chromoproteins
- -posses color
- -hemoglobins, myoglobins, ect.

Glycoproteins
- -proteins containing carbohydrates
- -surfaces of most cells
    - - "receptor" sites
- -many of the blood plasma proteins

Lipoproteins
- -lipid-containing proteins
- -travel in blood plasma transfer fats
- -occur as membrane proteins

Denaturation of Protein
- -unfolding secondary or tertiary structures
- -disruption of H^+ bonds
- -high heat + pH
    - - "death" of protein

Nucleic Acids (RNA + DNA)
- -unbranched sub-units (**Nucleotides**)
    - -nitrogenous base, pentose, & a phosphoric acid

THE CELL

What is a cell?

- -very small, minute, (μm) 10^6 meters
- -highly organized
- -living units
- -surrounded by a membrane
- -contains variety of tiny structures
  - -each with a specific role

The Cell Theory: 3 Generalizations

1) All organisms are composed of one or more cells
2) The cell is the basic living unit of organization for all organisms
3) All cells come from preexisting cells

Two basic types of cells

1) Prokaryotic
   - -before nucleus
2) Eukaryotic
   - -true nucleus

Prokaryotic Cells

- -very simple cell with no defined nucleus
- -single-celled forms of life
- -bacteria + Blue-Green algae (Monera)
- -little visible, internal structure
  - -many ribosomes (RNA + proteins)
  - -DNA
- -biochemically complex

Eukaryotic Cells

- -defined nucleus
- -numerous membrane-surrounded organelles "little organs"
  - -each with a separate role in carrying out life processes
- -Protista, Fungi, Plantae, + Animalia
- -similar cell combine to form **tissues**
  - -similar tissues combine to form **organs**
    - -organs combine to for **organ systems**

CELL--->TISSUE--->ORGAN--->ORGAN SYSTEM

Key Functions in the Cell

1) Transport
   - -passive & active movement of matter across membranes in & out of the cell
2) Assimilation
   - -incorporation into the cell of proper matter and utilized for growth
3) Digestion
   - -chemically breaking down of foods or other materials (by enzymes)
4) Synthesis
   - -manufacture of carbohydrates, protein, lipids, & nucleic acids (by enzymes)
5) Energy Transformation
   - -formation of useful, energy-rich molecules (ATP)from inorganic matter, or food
6) Movement
   - -in or of the cell through changes in contractile fibers, cell shape, flagella
7) Response
   - -organized response to stimuli from other cells or the environment

Typical Components of Eukaryotic Cells

Plasma membrane

- -separates internal components from external environment
- -selectively permeable
- -two major components:
  - -Proteins & phospholipids
    - -Bi-lipid layer

Microtrabecular Lattice

- -skeleton of the cell
  - -mazelike network of hollow fibers
    - -connecting & suspending organelles
  - -cytoplasmic matrix

Nucleus

- -2 vital functions: reproduction + control
- -contains chromosomes (DNA)
- -nucleoli (little nucleus)
- - protein + RNA subunits of ribosomes are synthesized

Endoplasmic Reticulum (ER)

- -involved in the synthesis of protein
- -synthesis, modification, and transport of substances produced by the cell
- -two types of ER: Smooth & Rough
  - -Rough endoplasmic reticulum
    - -ribosomes adhered to one side
  - -Smooth endoplasmic reticulum
    - -lacks ribosomes
    - -secretion cells (nonproteins)

Typical Components of Eukaryotic Cells (cont.)

Golgi Bodies (Golgi apparatus)

-stacks of flattened, membranous sacs

-highly dynamic organelle

-membrane continually forming + diminishing

-continue chemical functions of the ER

Lysosomes

-contains digestive enzymes, synthesized by the golgi apparatus

Mitochondria

- "Powerhouse" of the cell

-ATP formation from sugars

-double-membrane organelle

Eukaryotic Plant Organelles

Chloroplasts

-PSN occurs in chloroplasts

-contain photosynthetic (PSN) pigments, Stroma, & Grana

-Stroma

-flattened membrane compartments

-Grana

-stacks of disk-like compartments

-2 steps involved in photosynthesis (PSN)

-Light + Dark Reactions

-Light Reaction

-occurs in grana within chloroplast

-Dark Reaction

-occur in stroma w/in chloroplast

Cytoskeleton

- "mirotrabecular lattice"

-microfilaments & mirotubules

Microfilaments

-long, thin fibers

-2 proteins (actin & myosin)

Microtubules

-much larger than microfilaments

-protein (tubulin)

-cilia, flagella, & centrioles

Centrioles & Related Organelles

Centrioles

-cylindrical organelles
-one pair/animal cell
- 9 + 0 pattern of microtubule triplets

Cilia & Flagella

-hair-like projections from some cells
-able to undulate, be like a whip, or be stiff
-cilia are much shorter than flagella
-structurally the same
-9 +2 pattern of microtuble doublets

Cellular Movement

-all cells exhibit movement
-cytoplasmic streaming
-cell division
-chromosomal movement
-flagellum, cilia, &/or pseudopod

Extracellular Matrix

-meshwork binding animal cells & tissues
-influence the cells divide & metabolize
-collagen, other fibrous protein, glycoproteins, & polysaccharides (base structure)

-**Middle Lamella**
-adjacent plant cells cemented together

Animal Cell Junctions

-cells linked together

1) **Tight Junctions - (seal)**
-cytoskeletal strands from one cell fuse with strands of neighboring cells

2) **Adhering Junctions - (stretch)**
- plasma membrane 'spot welds'

3) **Gap Junctions - (open)**
-open channels between cells

Cell Junctions in Plants

Plasmodesmata - (open)
-cell wall to cell wall link

Animal versus Plant Cells

	Animal cell	Plant cell
Cell Wall	no	yes
Cell membrane	yes	yes
Chloroplasts	no	yes
Centrioles	yes	no
Mitochondria	yes	yes
flagella & cilia	yes	no

Eukaryotic versus Prokaryotic Cells

	Eukaryotic	Prokaryotic
Cell wall	yes*	yes
Cell membrane	yes	yes
Nuclear envelope	yes	no
ribosomes	yes (large)	yes (small)

*plant cells **ONLY**

Cell Membrane: Function & Structure

Structure

-Fluid Mosaic Model

-lipid bi-layer w/ globular proteins & glycoproteins

Function

-allow nutrients to enter & wastes to leave

Globular Cellular Proteins

1) **Transport proteins**
   a) channel proteins
      -molecular "gates"
   b) carrier protein
      - "shuttle system" or pumping
2) **Recognition proteins**
   -cell to cell interactions
3) **Receptor proteins**
   -binding sites for hormones ect.

Permeability

-cell membranes are semipermeable (differentially permeable)

-certain small molecules can pass

-certain large molecules can not pass

3 General Means of Entrance &/or Exiting

1) **Diffusion (osmosis)**
   -passive transport
2) **Transport by Carriers**
   -active transport
3) **Endocytosis & Exocytosis**
   -bulk transport

1) Diffusion

-particles move from the are of greater concentration to areas of lesser concentrations

Osmosis

-diffusion of water across a differentially permeable membrane

Effects of Osmosis on Cells

Osmotic Pressure:

a) **Isotonic Solutions**
   -equal pressure (# of solute molecules) on either side of the membrane

b) **Hypertonic Solutions**
   -greater [solutes]; less [H_2O] than cell
   -cause cells to shrink or shrivel (**crenated**)

Effects of Osmosis on Cells (cont.)

c) **Hypotonic Solutions**
   -less [solutes]; greater [H_2O] than cell
   -cause cells to swell or burst (**lysis**)

Tonicity on Plant Cells

Turgor pressure

-pressure against cell wall due to hypotonic situations

Plasmolysis

-due hypertonic situations
   -withering plants

2) Transport by Carriers

-structure of proteins (1°,2°,3°, or 4°)
   -one type of protein will pick up specific types of molecules

a) **Facilitated Diffusion**
   -no energy required
   -works on concentration gradient

Transport by Carriers (cont.)

b) Active Transport

-protein actively moves solutes, ions, or charged molecules through the membrane against the concentration gradient

-energy is required (ATP)

-*Na^+(sodium)/K^+(potassium) pump

3) Exocytosis & Endocytosis

-vesicle (vacuole) mediated transport

-bulk transport

-movement of H_2O & solutes together

Exocytosis

-material leaving the cell

-substances enclosed in a vacuole, transported to cell surface, expelled contents outside the membrane

-same thing happens w/in organelles

Endocytosis

-material to be taken into a cell

-material induces the cell membrane to bulge inward producing a vesicle enclosing the material - released into cytoplasm

3 Forms of Endocytosis

a) Phagocytosis

- "eating" of other cells
- white blood cells

b) Pinocytosis

- "drinking" of cells
-human egg cells

c) Receptor-Mediated Endocytosis

-lipoproteins form coated pits

Cellular Division

-Advanced multi-cellular animals undergo two types of cellular division, throughout their life cycle: **Mitosis & Meiosis**

Meiosis

-occurs during the production of egg + sperm

-sex cells or **gametes** (nongamete cells are known as **somatic cells**)

-in humans; the combination or **zygote** contains 46 chromosomes

-each gamete contributes 1/2 or 23

Somatic Cell Cycle

-2 major parts of somatic cell life history

1) **Interphase**
2) **Mitosis**

1) **Interphase**

-the period between cell division has three subparts

- **a)** Gap 1 (G1) = growth
- **b)** S phase = replication
- **c)** Gap 2 (G2) = tublin synthesis

2) **Mitosis**

-includes four phases

- **a)** Prophase
- **b)** Metaphase
- **c)** Anaphase
- **d)** Telophase

Dividing Cells:
Overview of Division Mechanisms

-reproduction begins with the division of single cells

-each new generation must receive a duplicate of parental DNA & enough cytoplasmic machinery to start its own operation

-mitosis & meiosis are eukaryotic nuclear division mechanisms

-mitosis is used by multicellular organisms for growth by repeated divisions of somatic cells

-meiosis occurs only in gamete cells

-cytokinesis is the actual cytoplasmic division of a parental cell into 2 daughter cells

A Closer Look at Chromosome Structure

-chromosomes are molecules of DNA complexed with proteins

-prior to division, each threadlike chromosome is duplicated

-a centromere joins sister chromatids

-microtubles will attach to centromere during nuclear division

Chromosome Number & Pairs

-each species have a precise number of chromosomes

-humans have 46

-amebas have 50

-dogs have 78

-chromosomes occur in pairs

-**Homologous Chromosomes**

-somatic cells that contain both homologues of each chromosome pair are known as **Diploid** or **2n** (doubled)

Haploid or **n** (halved)

-gamete cells contain only one homologue from each pair

Somatic Cell Cycle

1) **Interphase**
-about 90% of a cell's existence

Three stages of interphase:

1) **G_1 (Gap one)**
-cell grows to nearly twice its size
-protein synthesis, organelle construction

2) **S - phase**
-DNA combines with proteins **(chromatin)** - now known as chromosomes
-each chromosome is duplicated, forming two sister **chromitids**

3) **G_2 (Gap two)**
-a period of renewed protein synthesis
-primarily **tubulin**

2) **Mitosis (stages)**
-microtubular spindle fibers
-microtubular organizing center
-astral rays radiate from centrioles
-continuous spindle fibers
-centromeric spindle fibers

Prophase
-centriole pairs migrate to cell's poles
-chromosomes condense
-nuclear envelope is dismantled
-chromosomes are drawn to cell equator

Metaphase
-sister chromotids become orientated towards either pole
-spindle fibers attach to chromotids from either side and attach to the centromere
-chromotids are aligned at the cell's equator

Anaphase
-chromotid pairs seperate
-individual chromosomes are pulled to each pole by spindle fibers

Telophase
-begins when chromosomes arrived at the poles
-nuclear envelope forms from the fusion of small vesicles

-Cytokinesis occurs

-Animal cells
-division of cytoplasm & plasma membrane formation
-contractile microfilaments at the cleavage furrow pull the membrane downward

-Plant cells
-form cellular (cellulose) plate across the two cells

A Closer Look at Meiosis

-meiosis begins with diploid (2n = 46) germ (or sex) cells produce
-humans have 23 pairs of chromosomes
-homologous chromosomes
-during meiosis, homologous chromosomes separate
-unlike mitosis, meiosis has two series of division
-meiosis I and meiosis II

During meiosis I

-homologous chromosomes come together and line up side by side (synapsis)
-four chromatids exchange genetic info
-each chromosome is still duplicated

During meiosis II

-sister chromatids of each chromosome separate
-cytokinesis follows resulting in four haploid (n = 23) cells

Stages of Meiosis

Prophase I

-homologous chromosomes pair of in synapsis
-cross over
-nonsister chromosomes exchange genes
-after cross over, chromotids separate partly

Metaphase I

-homologous chromosomes randomly line up at spindle equator

Anaphase I

-each homologue is separated from its partner, and move to opposite poles

Telophase I

-a haploid number of chromosomes (still duplicated) ends up at each pole

Prophase II

-no DNA replication - sister chromatids still attached at the centromere

Metaphase II

-each chromosome is aligned at the spindle equator

Anaphase II

-sister chromosomes split

Telophase II

-nuclei form followed by cytokinesis
-four daughter cells emerge
-gametes that are haploid (n = 23)
-all in unduplicated states

Gametogenesis

-meiosis process: the formation of gametes

Spermatogenesis

-meiosis in males
-resulting in four haploid sperm

Oogenesis

-meiosis in females
-resulting in one **ovum** & three **polar bodies**
-meiosis I results in two different sized cells; one large ovum & three smaller cells
    -cleavage plane is off to one side
-polar bodies act only as a receptacle for half off the homologues

Differentiation & Specialization of Cells

Tissues:

-an aggregate of particular types of cells
-form one of the structural materials of a plant or an animal
-all tissue cells are of similar embryonic origin
-working together tissue cells perform specific functions
    -protection, support, circulation, growth, and reproduction

Histology

-study of tissues

Animal Tissue Types

1) Epithelial Tissue
2) Connective Tissue
3) Muscle Tissue
4) Nervous Tissue

Animal Tissue Formation

Gametes-->Zygote-->Embryo

-cells within embryo arranged into 3 tissues

1) Ectoderm
    -skin & nervous system
2) Mesoderm
    -muscle, skeleton, & the organs of circulation, reproductive, & excretion
3) **Endoderm**
    -lining of the gut and associated organs

Epithelial Tissue

-protection, secretion, & absorption
-linked tightly together; one or more layers
-one "free" surface (may have cilia) & the other surface adheres to a noncellular "basement" membrane

Three Cell Shapes

1) Squamous - irregular shaped
2) Cuboidal - little boxes or cubes
3) Columnar - tall, rectangular shape

Four Arrangement Types

1) Simple Epithelial
   -one cell layer thick
2) Stratified Epithelial
   -several cells thick
3) Pseudostratified Epithelial
   -appear to be layered
4) Transitional Epithelial
   -layers of closely packed cells
   -soft & pliable easily stretched

Connective Tissue

-contain cells & fibers (collagen &/or elastin)
-bind structures together, support, protection, store fat, produce blood cells, fill spaces, and act as framework
-connective tissue cells are widely separated by a noncellular matrix

Three Major Cell Types

1) **Fibroblasts**
   - most common
   - large star-shaped cells
   - produce collagen (white fibers) & elastin (yellow fibers)

Three Major Cell Types of connective tissue (cont.)

2) Mast Cells
   - located near blood vessels
   - contain **heparin** & **histamine**

3) Macrophages (histiocytes)
   - often attached to fibers
   - play key role in immunity

Types of Connective Tissue

1) Loose (fibrous) Connective Tissue
   -joins tissue layers together & holds organs in place
   -mainly composed of fibroblasts

2) Adipose Tissue
   -specialized loose connective tissue in which fibroblasts enlarge & store fat
      -intercellular matrix is reduced
   -protective cushion for internal organs
   -insulating layer beneath the skin

3) Reticular Tissue

-thin delicate fibers
-form the framework of liver, spleen, bone marrow, and lymph nodes
-give rise to macrophages

4) Dense Connective Tissue

-close packed fibers, mainly collagen
-**Tendons** - connect muscles to bone
-**Ligaments** - connect bone to bone
-poor blood supply

5) Specialized Connective Tissue

a) Cartilage

-firm, solid matrix
-cartilage cells are named chondrocytes, located in cavities called **lacunae**
-no direct blood supply
-on the basis of predominate fibers, three types are recognized: **1) Hyaline,** **2) Elastic,** and **3) Fibrous**

5) Specialized Connective Tissue - **a)** Cartilage (cont.)

1. Hyaline Cartilage
   -most widely distributed
   -most weakest of the three
   -covers ends of long bones, costal cartilage of ribs, and flexible part of nose
2. Elastic Cartilage
   -yellow fibers predominate
   -most flexible of the three
   -external ear, epiglottis, parts of larynx
3. Fibrocartilage
   -strongest of the three
   -contains dense collagenous fibers
   -intervertebral discs, pubic symphsis

b) Bone

-hardest matrix of connective tissues
-large calcium salt deposits
-cells, **Osteoblasts**, lie in lacunae
-highly vascular tissue
- **Haversian Canals** house numerous blood vessels
-manufactures blood cells, support, protect

c) Blood

-cells are suspended in a fluid matrix
-plasma
-3 types of cells:
1) Erythrocytes- red cells
2) Leukocytes-white cells
3) Platlets- cell fragment

-cells are formed in bone marrow
-**hematopoietic tissue**

Muscle Tissue

-ability to contract - process occurs at the molecular level
-muscle cells (fibers) are elongated
-3 types of muscle tissue:

1) **Skeletal Muscle**
   -usually attach to bones
   -striations (stripes)
   -mutinuleated
   -long cells
2) **Smooth Muscle**
   -no striations
   -involuntary contractions
   -cells are smaller than skeletal muscle
   -responsible for movements of food through the digestive tract

3) **Cardiac Muscle**
   -found only in the heart & walls of the large blood vessels associated w/the heart
   -short, striated cells that function as units -involuntary contractions
   -specialized cell junctions, **Intercalated Discs**, enabling free ion exchange

Nervous Tissue

-consists of two cells: neurons & neuroglial-neuroglial cells (glue) support neurons
-neurons conduct impulses
-neurons contain: a cell body (soma), an axon, & dendrites

Plant Tissues

-plant tissues makeup plant organs
-leaves, roots, stems, & flowers
-Four basic types of plant tissue:
1) **Meristematic**
2) **Epidermal**
3) **Vascular**
4) **Fundamental**

1) **Meristematic Tissue**
-all plant tissues arise from meristematic
-apical meristem at tips roots & stems responsible for growth & elongation
-located in root & stem tips

2) **Epidermal Tissue**
-flattened multi-sided cells
-waxy cuticle covering the external surfaces
- prevents water loss & resist microbial attack
-**Stomata** - openings on underside of leaves (permit gas & water exchange)
-**Guard Cells** - control stomata activity

3) **Vascular Tissue**

-tubelike cells that act as transport

-2 types of vascular tissues:

a) Xylem

b) Phloem

a) Xylem

-conducts water & nutrients upwards from the roots

-two types of cells:

1) Vessel Cells

-non-living cells piled on top of each other to form a "pipeline" from the roots to the leaves (no end walls)

2) Conducting Tubes (tracheids)

-also dead at maturity

-tapered end walls

-Cohesion-Tension theory

-evapotranspiration

b) Phloem

-conducts sugars & other solutes (sap) downwards from leaves to roots

-sieve tubes & companion cells

-living conducting cells

-end walls of sieve tubes are perforated with small openings (sieve plates)

-Pressure-Flow theory

4) **Fundamental Tissue**

-pith and cortex regions of the stem are usually used for storage

-3 types of fundamental tissue:

1) parenchyma

2) sclerenchyma

3) collenchyma

-parenchyma & sclerechyma cells are found in most tissues

-cortex contains all three cell types

-sclerenchyma cells are hollow, nonliving cells w/strong walls for support

Energy

-The property of a system by which work or heat is exchanged for power

Law of Conservation of Matter

-In all physical + chemical reactions, we can not create nor destroy any of the atoms involved, just rearrange them

1st Law of Thermodynamics

-(Law of Conservation of Energy)
-Energy can not be created nor destroyed
-Energy input = Energy output

2nd Law of Thermodynamics

-(Law of entropy)
-Systems in the universe tend to go from order to disorder
-Degradation of energy
  -conversation of high grade energy to a lower grade
-When energy is converted, useful energy is always converted to a less useful form, or lower quality form
-This low-quality energy is mostly unusable + dissipates into the surrounding environment as heat

From Ordered Energy---->Disordered Energy

Q: Why do we need the 2nd law of thermodynamics?

A: Energy conservation is a one-way process

Ex: 1) Playing a VCR on rewind
2) Hot pizza on cold ice
3) Ball hitting a wall

Types of energy:

Kinetic Energy

-Energy associated with the motion of an object
  -Ex: Moving car, waterfall, ect.

Potential Energy

-An object that has the potential or capability to gain kinetic energy
-Ex: batteries, unlit match, dynamite, ect.

Energy Transfer

Food Chain

Producers ----->Consumers ----->Decomposers (autotrophs)-->(heterotrophs)-->(detritivores)

Emergy

-loss of energy through the food chain

Cellular Metabolism

-Flow of Energy w/in a Cell

Metabolism of Cells include:

-all the individual chemical reactions
-the sequence of these reactions
-the interrelationships w/in sequences
-regulatory mechanisms

A sequence of reactions w/in a cell is referred to as a **Metabolic Pathway**
Overall reaction sequences may be classified:

Catabolic
-degradative (breaking down)
Anabolic
-synthetic (building up)
Exergonic reactions
-energy producing
Endergonic reactions
-energy consuming

Participants in metabolic pathways

Reactants
-substances that enter the reaction
(=substrate =precursor)
Intermediates
-compounds formed between the start & the end of the pathway
Enzymes
-proteins that catalyze reactions
Cofacters
-small molecules or ions that help enzymes by carrying atoms or e^-
Energy carriers
-mainly ATP
End Products
-substances present at the conclusion of a pathway

Flow of Energy w/in the cell

-In degradative (catabolic) pathways, macromolecules are broken down to form products of lower energy - the released energy can be used for cellular work

-In biosynthetic (anabolic) pathways, small molecules (monomers) are assembled into macromolecules

EX: simple sugars ---> complex carbohydrates

Oxidation/Reduction Reactions

-if an atom or compound looses an electron it is said to be **Oxidized**
-if an atom or compound gains an electron it is said to be **Reduce**
-both reactions go together
-takes place simultaneously

$$C_6H_{12}O_6 + 6O_2 \text{ <----> } 6CO_2 + 6H_2O + E$$

Enzymes

-types of proteins that initiate chemical reactions
-enables reactions to proceed under different conditions than otherwise possible
-act as catalysts
-speed up reactions
-they are not consumed by reactions
    -can be reused
-extremely selective
-can recognize both reactants & products in order to catalyze in both directions

Enzyme Structure & Function

-Active site
    -crevice for substrate to bind with during the reaction
-Transition State
    -reactants must reach a 'transition" state in order for a reaction to occur
-Activation Energy
    -amount of energy needed to bring colliding molecules to the transition state

-Enzymes increase the rate of a reaction by lowering the activation energy through extensive bonding of the substrate at the activation site

Effects of temperature and pH on Enzymes

-high temperatures decrease reaction rate
    -protein denaturation
-high or low pH also disrupts the enzyme shape
    -halt function
-most enzymes function best at a pH ~7
    -pepsin (stomach enzyme) is an exception

Control of Enzyme Activity

-inhibitors can bind with an enzyme or compete with the active site
-cellular controls regulate the number of enzyme molecules available by speeding up/slowing down their synthesis

Cofactors

-nonprotein groups that bind to many enzymes and make them more reactive
-2 main kinds of cofactors:
    1) Coenzymes are large organic molecules such as NAD^+ & $NADP^+$ that transfer protons & electrons from one substrate to another
    2) Inorganic metal ions such as Fe^{++} also serve as cofactors to transfer electrons in the chloroplasts & mitochondria

Electron Transfers in Metabolic Pathways

-energy released from glucose is controlled by intermediate molecules

-e^- released from bond breaking are transferred through e^- transport systems

-each time a donor gives up an e^- it is oxidized; if it gains e^- it is reduced

- e^- transport systems are like staircases where e^- flow down from top (most energy) to the bottom (least energy), releasing small amounts of energy w/each step

-the energy is harnessed to move H^+ ions, which in turn establish pH & electric gradients necessary for ATP formation

ATP: Universal Energy Carrier

-Structure & function of ATP

-composed of adenine, ribose, & three phosphate groups

-energy transfer to many reactions

-almost all metabolic pathways directly or indirectly run on energy supplied by ATP

ATP/ADP Cycle

-energy input links phosphate to ADP->ATP

-ATP can donate a phosphate group (phosphorylation) to another molecule, which then becomes primed and energized for specific reactions

ADP can be recycled to ATP very rapidly

Photosynthesis

-2 step process --> Light & Dark reactions

1) Light reactions convert light energy to chemical energy stored in ATP NADPH
2) Dark reactions assemble sugars & other organic molecules using ATP & NADPH

Glucose Formation:

$$12H_2O + 6CO_2 \xrightarrow{\text{SUNLIGHT}} 6O_2 + \mathbf{C_6H_{12}O_6} + 6H_2O$$

Chloroplast function (glucose synthesis)

-light reactions occur in the thylakoid system

-thylakoid discs are folded into **grana**

-interior spaces are filled w/H^+ for ATP synth.

-carbohydrate formation occurs in **stroma**

Light-Dependent Reactions

Light Absorption

-light energy is packaged into photons

-varied energy (wavelength)

-organisms use 400-750 nm of wavelength for, PSN, vision, & other processes

-pigment molecules on thylakoid membranes absorb photons

-chlorophyll; absorbs blue + red/reflect green

-carotenoid; absorbs **V** + **B** /reflect **Y, O, & R**

Photosystems of PSN

-a cluster of 200-300 light-sbsorbing pigments located in the thylakoid
-pigments 'harvest' sunlight
    -absorbed photons boost e^- to a higher level
- e^- quickly return to lower level---> ENERGY
-released energy is trapped by chlorophylls;
    -all other pigments transfer their energy to chorophyll
-2 photosystems w/in light reactions
    1) Photosystem II
        -P_{680} chorophyll
    2) Photosystem I
        -P_{700} chlorophyll

Cyclic & Noncyclic Pathways

Cyclic Pathways
    -photosystem I **only**
    - e^- excited-->pass through e^- transport system-->return back to photosystem I
-phosphate is added to ADP --> ATP
    -Photophosphorylation

Noncyclic Pathway of Light Reaction

Photosystem II ---> Photosystem I

-noncyclic photophosphorylation transfers e^- through two photosystems and two ETS w/in the thylakoid membranes

-begins w/chorophyll P_{680} absorbing energy
    -boosted e^- moves through ETS releasing energy for phoshorylation
        - e^- fills 'hole' left by the e^- boost in photosystem I (chorophyll P_{700})
        -Water is then split: e^- fills the 'e^- hole' left in photosystem II; producing O_2
        -boosted e^- from P700 passes through ETS--> joins w/NADP to form NADPH

****ATP & NADPH may be used for Organic Compound Synthesis****

Light-Independent (Dark) Reaction of PSN

-Production of Carbohydrates
Key Molecules necessary for sugar production

1) **ATP**: provides energy
2) **NADPH**: provides H^+ & e^-
3) **Atmospheric Air**: provides carbon & oxygen from CO_2

-reactions** occur w/on the stroma of chloroplasts & is not dependent of sunlight

Calvin-Benson Cycle

-stored chemical energy from the light reactions "power" the carbohydrate synthesis reactions of the Calvin-Benson cycle

-**CYCLIC** pathway:

1) Carbon dioxide becomes attached to ribulose biphosphate (RuBP) to form a six-carbon intermediate molecule

2) The intermediate molecule splits at once to form two PGA (phosphphoglcerate) molecules

3) Each PGA receives a P_i from ATP plus H^+ & e^- from NADPH to form PGAL (phosphoglyceraldehyde)

4) Most of the PGAL molecules continue in the cycle to fix more carbon dioxide, but two PGAL join to form a sugar phosphate, which in will be modified to sucrose, starch, and cellulose

Final Tally:

$$12H_2O + 6CO_2 + 18ATP + 12NADPH \text{ ----> } C_6H_{12}O_6 + 18ADP + 18P_i + 12NADP^+ + 6H_2O + 12H^+$$

How Autotrophs use Intermediates & Products of Photosynthesis

-sugar phosphates are used as cellular fuel and as building blocks in carbohydrate synthesis
-sucrose is transported from the leaves to all parts of the plant
-starch is the main carbohydrate storage
-PSN also yields intermediates & products that can be used in lipid & amino acid synthesis

C4 Plants

-plants that fix carbon twice to produce oxaloacetate (a four-carbon compound) which can then donate the carbon dioxide to the Calvin-Benson cycle
-plants in hot, dry environments close their stomata to conserve water
-oxygen builds up in leaves
-carbon dioxide is limited

Photorespiration

-O_2 (not CO_2) becomes attached to RuBP to yield one PGA (instead of two) and one phosphoglycolate (not useful).

Chemosynthesis

-autotrophic organisms that obtain energy from the oxidation of inorganic substances
-soil bacteria strip p+ & e- from ammonia (nitrogen cycle)
-hydrothermal vent systems

Energy-Releasing Pathways

-ATP is the primary energy carrier for all cells
-ATP can be produced by different pathways:
1) PSN produce ATP to drive carbohydrate synthesis
2) Aerobic respiration (w/O_2) is the main pathway for energy release from carbohydrate to ATP
3) Fermentation & Anaerobic e^- transport (both w/out O_2) release lesser amounts of energy for transfer to a small number of ATP

Aerobic Respiration

-Fermentation yields 2 ATP
-Aerobic respiration yields 36 ATP
-aerobic respiration:
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

-three series of reactions:
1) Glycolysis (breakdown of glucose)
-1 glucose -->2 pyruvate + 2 ATP (net)
-produce small amount of ATP
-occurs in cytoplasm
2) Krebs Cycle (breakdown of pyruvate)
-pyruvate enters the mitochondria and is converted to **acetyl-CoA** which joins oxaloacetate already present from the previous turn of the cycle
-2 ATP molecules
-H^+ & e^- are transferred to NAD^+ & FAD
-CO2 is tproduced as the byproduct
3) Electron Transport Phosphorylation
-NADH & $FADH_2$ give up their e^- to transport systems embedded in mitochondrion inner membrane
-drives a H^+ pump out of the membrane
-H+ flow back ATP synthase to yield ATP
-O_2 joins with the spent e^- & H^+ to yield water
e^- transport yields 32ATP + Glycolysis (2ATP) + Krebs Cycle (2ATP)= 36ATP/glucose

Patterns of Inheritance

Mendel's Peas (knew nothing of genetics)

-Gregor Mendel, a Catholic priest, grew garden peas & observed the offspring

-factors are passed on

1) both parents
2) factor can be hidden
3) can reappear in the same strain

-discrete colors

-white + black = grey

-it does not work like that

-his studies lead him to conclude that inheritance is governed by **factors** that exists in individuals & are passed on to offspring

-Mendels Observations:

-every **trait** is controlled by two **factors**

-one of these **factors** can be **dominate**

Mendel's Factors ~chromosomes

Some Genetic Terminology:

Genes - instructions for producing traits

Locus - position of gene on chromosome

Alleles - various molecular forms of a gene for the same trait

Homozygous - both alleles are the same (AA)

Heterozygous - the alleles differ (Aa)

Genotype - sum of all genes

Phenotype - how genes are expressed

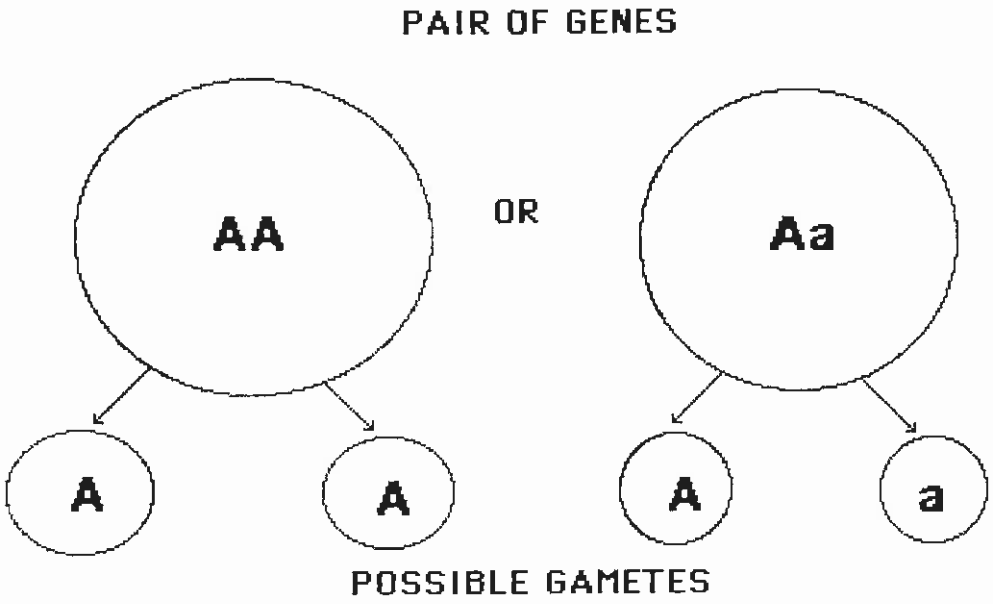
P - parental stock
$\mathbf{F_1}$ - first generation
$\mathbf{F_2}$ second generation

Mendels Laws

1) Alleles segregate from one another during the formation of gametes

2) Alleles of different genes are assorted independently of one another during the formation of gametes

1) <u>Law of Segregation of Gametes</u> - Genes in an organism exist as pairs. When that organism produces gametes, there will be one and only one of each kind of gene in each gamete formed.



<u>Concept of Segregation</u>

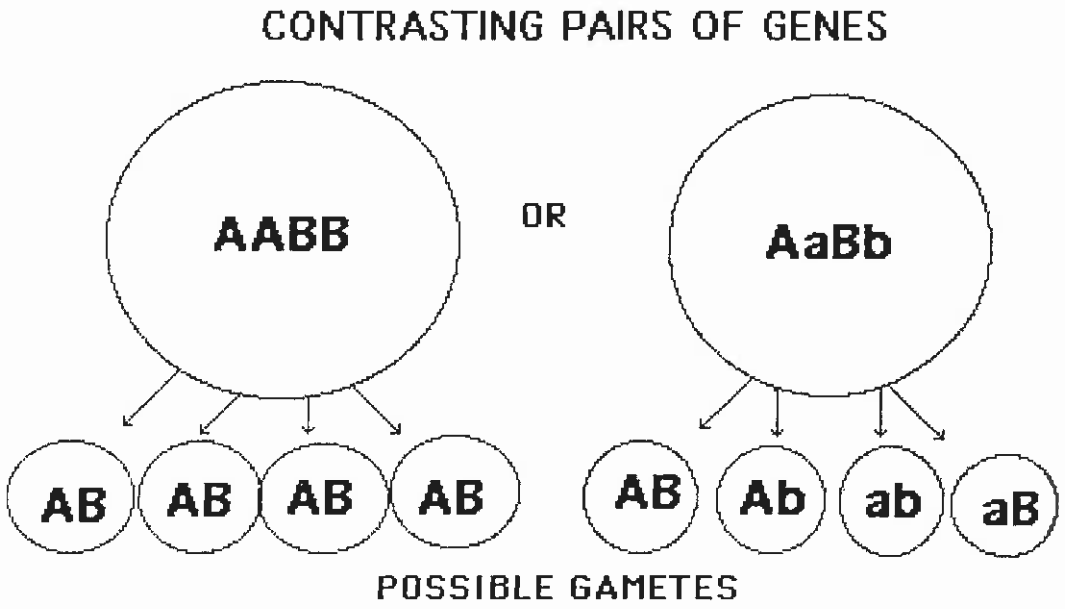
-one form of a trait is not expressed in F1, only to show up in $\mathbf{F_2}$
-$\mathbf{F_1}$ was heterozygous (w/a recessive gene)
-$\mathbf{F_2}$ requires mathematical analysis
    -Punnett square
        -$\mathbf{F_2}$ showed a 3:1phenotypic ratio
-numerical ratios of crosses suggest that genes do not blend

Mendelian Princple of Segregation:

-Diploid ($2n$) organisms inherit two genes per trait
-Each gene segregates from the other during meiosis
-Each gamete will receive only one gene per trait

Concept of Independent Assortment

-Mendel furthered his experiments involving two traits (dihybrid cross)
-predicted $\mathbf{F_1}$ plants would show both dominate alleles(ex;all tall + all purple flowers)
-wondered if genes for flower color & plant size would travel together when two $\mathbf{F_2}$ plants were crossed



Law of independent Assortment - When two or more contrasting genes are within the individual, the genes from one pair will segregate from its member and go into the gametes independently of the segregation of the other pair of genes.

Mendelian Principle of Independent Assortment:

-each gene of a pair tends to assort into gametes independently of the other gene pairs on nonhomologous chromosomes

In a monohybrid cross (single gene pair) only 3 genotypes are possible (AA, Aa, or aa)

When multiple gene pairs are involved, the # of genotypes compoundly increase
EX: if parents differ in only ten gene pairs:
~60,000 different genotypes
-if parents differ in twenty gene pairs:
~3.5 billion possible genotypes

Polygenic Inheritance

-two are more genes may effect the same trait
-ex: a black person has offspring by a white person = mulatto - 2 mulattoes can produce skin possibilities = black-white

Dominance Relationships

Incomplete Dominance

-neither member of the allelic pair is dominate over the other and the phenotype is intermediate between the two

-to signify neither allele is dominate = (H')

Codominance

-each member of an allelic pair is dominate and the phenotype exhibits both characteristics

Multiple Allele System

-more than two forms of alleles existing at a given locus

-ex: three alleles for the same gene control for A-B-O blood types

-these alleles determine the presence or absence of antigens on the red blood cells

I^A = type A antigen on red blood cells

I^B = type B antigen on red blood cells

i^o = type O antigen on red blood cells

I = immunogen gene

BLOOD TYPES

Phenotype	Genotype
A	$I^A I^A$, $I^A i^o$
B	$I^B I^B$, $I^B i^o$
AB	$I^A I^B$
O	$i^o i^o$

Note* two possible genotypes for blood types A & B. On the other hand, I^A and I^B are fully expressed in the presence of each other. Therefore, if a person inherits one each of these alleles, that person will have type AB blood. Type O can only result from the inheritance of two i^o alleles.

Every possible phenotype will be represented if mating of blood type A (genotype $I^A i^o$) by blood type B (genotype $I^B i^o$) occurs.

$P_1 = I^A i^o \times I^B i^o$

$F_1 = I^A I^B ; I^B i^o; i^o i^o; I^A i^o$

Interactions Between Different Gene Pairs

-one gene pair can influence other gene pairs, w/their combined activities producing some effect on phenotype

-ex; comb shape in poultry

2 gene pairs cooperate to form comb

-hair color in mammals is determined by epistatsis:

-the masking effects of one gene pair on another

-one gene pair codes for the quantity of melanin produced while another codes for melanin deposited & still another gene locus determines whether melanin will be produced at all

-lack of any melanin produces an albino

Mutations

-a heritable change in the molecular structure of DNA

Multiple Effect of single Genes

Pleiotropy- a single gene affects unrelated aspects of of the phenotype

-the gene for sickle-celled anemia codes for a variant form of hemoglobin

-the altered hemoglobin in turn affects the shape of red blood cells, which clump together & block capillaries

Environmental Effects on Phenotype

-animal fur will be darker due to melanin production

-at cooler temperatures = higher prod.

-at higher temps. = low production

-qualitive evolution of selection

-peppered moths

-moth predation = selective agent

-natural selection

-variation w/in spp. dependent on environmental factors

-relative fitness

-ability to successfully reproduce

Autosomes & Sex Chromosomes

-Most of the chromosomes are of the same quantity & type in both sexes and are called autosomes (44 in humans)

-one or two (spp. specific) chromosomes are different w/in the sexes and are called sex chromosomes

Sex Chromosomes Determine Gender

-human females have two **X** chromosomes

-males have one **X** & one **Y** chromosome

-each human egg will contain 22 autosomes plus one **X** chromosome

-each human sperm will contain 22 autosomes plus either an **X** or **Y** chromosome

Linkage & Crossing Over

-linkage is the tendency of genes located on the same chromosome to be transmitted together in inheritance

-linkage can be disrupted by crossing-over

-the probability of that crossing-over will lead to the separation of two genes on a chromosome is directly proportional to the distance between them; that is, the farther apart two genes are, the greater their frequency of crossing over and recombination between them

DNA Structure & Function

-Deoxyribonucleic Acid (DNA) is the master blueprint of heredity in in cells

Components of DNA

-four types of nucleotides

-each nucleotide consists of:

1) a 5-C sugar (deoxyribose)
2) a phosphate group
3) a nitrogenous base

-2 types of nitrogenous bases:

a) purines = double ringed structure
b) pyrimidines = single ringed structure

-4 forms of nitrogenous bases:

1) Adenine (**A**)
2) Guanine (**G**)

> purines

3) Thymine (**T**)
4) Cytosine (**C**)

> pyrimidines

Patterns of Nitrogenous Base Pairing

-purines always bond with pyrimidines

-via hydrogen bonds

-single-ringed structures always bond with double-ringed structures

-**T** (pyrimidine) always pairs w/**A** (purine)
-**C** (pyrimidine) always pairs w/**G** (purine)

-DNA backbone consists of sugar-phosphate chains

-DNA is a double stranded & looks like a ladder w/a twist to form a double helix

Molecular Foundation for the Unity & Diversity of Life:

-base pairing between the nucleotide strands of DNA is constant for all species

-the sequence of base pairs in a nucleotide strand is different from one spp. to the next

RNA's Nucleotide Bases:

Uracil (**U**) replaces DNA's Thymine (**T**)

-it is a pyrimidine (single-ring structure)

-nitrogenous base

-like thymine; Uracil pairs with Adenine

DNA----------->RNA----------->Proteins

(transcription) (translation)

Transcription of DNA to RNA

-RNA differs from DNA in the following ways:

	DNA	**RNA**
Sugar:	deoxyribose	ribose
Bases:	A, T, G,& C	A, G, C, & U
Strands:	double-stranded w/base pairs	single-stranded
Helix:	yes	no

Transcription Differs from Replication in 3 ways:

1) only one region of one DNA strand is used as the template
2) RNA polyermase is used instead of DNA polymerase
3) RNA is singe-stranded; DNA is double

-Transcription begins when RNA polymerase binds to the promoter region of the gene and then moves along to the end of the gene

-An RNA 'Transcript' is the result

-this is the *m*RNA

Messenger RNA Transcripts

-ONLY *m*RNA carriers protein-building instructions

-*m*RNA transcripts are modified before leaving the nucleus

-the 5' end is capped w/a special nucleotide that may act as 'start' signal for translation

-a poly-A tail is added to the other end

-100-200 molecules of adenylic acid

-noncoding portions (introns) are snipped out, and actual coding regions (exons) are spliced together to produce the mature transcript

Translation of *m*RNA into Proteins

THE GENETIC CODE

-both DNA & its RNA transcript are linear sequences of nucleotides carrying the heredity code

-every three bases (a triplet) specifies an amino acid to be included into a growing polypeptide chain; this is the genetic code

-each base triplet in RNA is a **codon**

-the genetic code consists of 61 codons that specify amino acids & 3 that serve to stop protein synthesis

-AUG (methionine) is the 'start' codon

****Universal Genetic Code****

-from bacteria to whales

Codon-Anticodon Interactions

-each *t*RNA has an anticodon that is complementary to the *m*RNA codon

-each *t*RNA also carriers one amino acid

-after the *m*RNA arrives in the cytoplasm, an anticodon on a *t*RNA bonds to the *m*RNA codon, and thus the correct amino acid is brought into place

Ribosome Structure

-a ribosome has two subunits (each composed of *r*RNA & proteins) that perform together only during translation

-there are two binding sites for *t*RNA (called P & A) and one site for binding *m*RNA

3 Stages of Translation

1) Initiation

-initiator *t*RNA + small ribosomal subunit + large ribosomal subunit

2) Chain Elongation

-series of *t*RNA's deliver a.a. in sequence by anticodon-codon matching

3) Chain Termination

-stop codon is reached & polypeptide chain is released into the cytoplasm or enters the cytomembrane for further processing

-release factor enters the ribosome & dismantles the whole structure

General Biology I **Name**_____
BIO K121
[redacted]
Laboratory exercise

Introduction to the Scientific Method

Objectives
After completing this exercise, you should be able to:
- use the scientific method to solve problems
- organize information to facilitate analysis of your data
- draw graphs that present data clearly and accurately
- interpret data in tables, charts, and graphs
- draw conclusions that are supported by experimental data
- analyze data using common statistical measures
- apply your knowledge of the scientific method to real-life situations.

CONTENT FOCUS

What is science? What do scientists *do* all day? These are not easy questions for most of you to answer. So, what are scientists really like? They all have the "**three** Cs" in common.

Just as you are, scientists are **curious** about the world around them. They ask questions about everything. Can my diet cause heart disease? Why does the river look brown instead of blue? How can squirrels remember where they bury their nuts? Why do some cars get better mileage than others? Science is a method for answering these and many other questions.

Scientists don't accept things without **collecting information.** All the facts relating to a problem or question have to be carefully explored and checked for accuracy. Scientists are **comfortable with new concepts.** If a better explanation can be found, scientists are not afraid to give up old ideas for new ones.

To make the three Cs happen, scientists have developed a series of steps in investigation called **the scientific method.** Through trial and error, the scientific method has proven to be an efficient and effective way of attacking a problem. You have probably used some version of the scientific method many times in your life—without being aware of the steps you were following.

FORMING HYPOTHESES:

There are several different ways that a problem can come to your attention. Someone may assign you the problem (this happens often in a school or a work situation, the problem may thrust itself upon you (your car won't start), or you may discover the problem by simply being curious about something you have seen.

Let's begin with a simple situation that you might face any day.

Problem

You drive to school and park in your usual spot. As you walk across the campus after your morning biology class, you discover that you can't find your car keys. You have a problem!

An easy way to attack the problem is to make an educated guess about the possible solution to the problem. It is an "educated" guess because you use all the background information that is available when making your guess.
In scientific terms, an educated guess is called a hypothesis.

1. Below (in Table 1), you will find a hypothesis that might shed some light on this problem.
2. Complete the table by adding some hypotheses of your own.

a) The keys are in my book bag.
b)
c)
d)

Table 1. Key loss: Possible hypotheses

ACTIVITY 2 SOLVE PROBLEMS

Problem

You were absent from chemistry class the day your professor gave out the instructions for making an important solution needed for your laboratory experiment. No problem. Your roommate was in class and had copied down the formula for you. You rush off to chemistry lab and prepare the solution, but when you use it in your experiment, it doesn't perform as expected.

In table 2, list three hypotheses about why the formula did not work.
Don't forget – the hypotheses must be ***TESTABLE***

a)
b)
c)

Table 2. Chemistry experiment hypotheses

Some hypotheses can *be* tested by observation only, but more often, you will need *a* **combination of observation and experimentation** to be sure about the accuracy of your results. To understand how scientists work, you must follow the steps of the scientific method as they are used in actual **experiments. In Activities** 3 **and** 4, you will **see how scientific method skills** are used to **set up experiments** and analyze the **information (data)** that is collected.

ACTIVITY 3 TESTING HYPOTHESES

Problem: Investigate the effects of fertilizer on plant growth.

STEP 1:

You form a hypothesis about what you think will happen.

Hypothesis: *Adding fertilizer will make plants grow taller.*

STEP 2:

You design an experiment that compares the growth (in height) of plants that receive fertilizer with those grown without fertilizer. Your design might be similar to the following:

Begin with 20 plants (same size, same type), planted in the same-size pots, with the same amount and type of soil, placed on a windowsill with the same exposure to light. All these factors will be held constant.

• An experiment is designed to isolate the factor you are interested in testing. All other conditions must be held constant. In this way, you are sure that your observed results were caused by the only factor that was varied.

• Since you are investigating the effect of fertilizer, you will want to hold all other factors constant (plant type, plant size, pot size, amount of water, amount of light, etc.) to avoid confusion. This way you can be sure that any differences in height are due to the presence of fertilizer and not some other factor.

You decide to measure the growth of your plants (height in centimeters) once a week for a month. You will keep detailed records of your observations.

It is helpful to plan an experiment with a group of plants (or animals). There are two good reasons to use groups:

• If unexpected factors (such as disease) affect one or two experimental subjects, it will not ruin the experiment.

• Natural genetic variability will cause some plants to grow taller than others (just as some people grow taller than others). You can separate this effect from that of the fertilizer by measuring the height in a group of plants for each treatment (fertilizer and no fertilizer).

You decide that ten plants will receive identical measured amounts of fertilizer each week. These are the experimental plants. They are receiving the treatment (fertilizer) that will help you test your original hypothesis (does fertilizer make plants grow taller?).

Ten plants will receive no fertilizer. These are the control plants. They do not receive the experimental treatment. You will use these for comparison with the experimental group to help you interpret your results, and to show that any observed differences in height between the two groups are due to the only difference between them—application of fertilizer.

In the above example, there are ten replications of the experimental treatment and 10 replications of the control treatment.

Thought questions:

1) Why is it necessary to divide the plants into two groups (a control and experimental group)?

2) Why is it important to keep conditions exactly the same in the two groups?

3) Why is it better to do the plant/fertilizer experiment with ten plants in each group instead of one or two?

The month is up. You are ready to draw conclusions from your **data** (the information you have recorded). You will be thinking about what your results mean and whether your hypothesis is **supported.**
The information you collected during your experiment is presented in **Tables 3 and 4.**

Thought Questions:

1) Were there differences in growth between the control and experimental plants?
If so, which group grew taller? How do you know?

2) Do the results support the original hypothesis? Explain your answer.

3) Why is it more accurate to compare the *AVERAGE* height gain of the control and experimental groups (rather than comparing individual plants)?

Plant Number	Initial Height (cm)	Week 1	Week 2	Week 3	Week 4	Total Height Gain	Avg Height Gain
1	10.0	1.6	2.0	3.0	2.5	9.1	2.3
2	11.5	2.2	1.5	1.5	2.0	7.2	1.8
3	9.6	1.5	2.3	2.6	2.0	8.4	2.1
4	9.2	2.0	3.0	2.8	1.5	9.3	2.3
5	10.2	2.3	1.2	1.6	2.0	7.1	1.8
6	11.0	3.2	1.7	2.0	3.2	10.1	2.5
7	10.0	2.6	3.0	3.0	1.4	10.0	2.5
8	9.7	4.0	2.6	4.0	2.3	12.9	3.2
9	10.4	DIED	–	–	–	–	–
10	10.4	2.3	2.3	2.7	2.0	10.0	2.5
TOTAL						**84.1**	**21.0**

Table 3. Height Gain (cm) Over Four Weeks – Control Plants

Plant Number	Initial Height (cm)	Week 1	Week 2	Week 3	Week 4	Total Height Gain	Avg Height Gain
1	9.6	4.2	5.0	3.0	4.7	16.9	4.2
2	9.8	6.0	4.0	5.5	5.0	20.5	5.1
3	10.3	5.3	5.5	3.6	4.2	18.6	4.7
4	11.0	2.1	3.2	6.2	3.8	15.3	3.8
5	10.1	3.4	4.0	4.4	4.0	15.8	4.0
6	9.2	4.7	3.1	3.1	4.0	14.9	3.7
7	9.5	4.2	5.2	3.9	3.6	16.9	4.2
8	10.0	3.3	6.0	5.6	4.2	19.1	4.8
9	9.7	5.8	6.1	6.5	5.0	23.4	5.9
10	10.4	5.1	3.4	5.8	5.3	19.6	4.9
TOTAL						**181.0**	**45.3**

Table 4. Height Gain (cm) Over Four Weeks –Experimental Plants

Now that you have had some experience using the steps of the scientific method, you will develop a hypothesis and test it in a simple experiment.

Table 6 contains some examples of physical traits and physiological factors that may or may not be related. You can choose to investigate any two factors from Table 6.

1. Working alone, form a hypothesis to test in your experiment.

2. Table 5 contains a sample hypothesis about the relationship between a physical trait (height) and a physiological factor (pulse rate) that are listed in Table 6: Finding Relationships.

Complete the table by adding your hypothesis:

Example: The taller you are, the faster your pulse rate will be
Your Hypothesis:

Table 5. Hypothesis about relationships

CHARACTERISTIC	METHOD OF INVESTIGATION
Height	Remove your shoes and stand against the wall. Use a meter stick to measure the distance from the floor to the top of your head (in centimeters).
Arm Length	Use a tape measure to measure the length of your arm from your shoulder joint to the tip of your middle finger (in centimeters).
Head Circumference	Use a tape measure to measure the distance around your head, just above your ears (in centimeters).
Pulse Rate	Place your index and middle fingers on your carotid artery (on either side of the neck). Using a watch that indicates seconds, count the total number of pulse beats for fifteen seconds. Multiply your answers by four to get the pulse rate per minute. Repeat the process twice more and then calculate the average number of pulse beats per minute.
Shoe Length	Measure the bottom of your shoe from the tip of the toe to the back of the heel (in centimeters).

Table 6. Finding relationships

1. Work in groups of three to four students.

Choose one hypothesis to investigate from those developed by your group members.

2. Form a plan for getting the data you will need to test your hypothesis. The following supplies are available to conduct your experiment: meter sticks and tape measures.

Collect your experimental data and record the results in Table 7.

Subject		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Table 7. Experimental Data

To determine if there is a relationship between the two factors, *rearrange your data* and copy it into the empty table below (Table 8).

Subject		

Table 8. Rearranged Data

1) Graphs provide a good visual representation of the relationships between the factors investigated in an experiment. *Bar Graphs* and *Line Graphs* are frequently used to present scientific data.

Figure 1 illustrates the two different ways to present the same information:

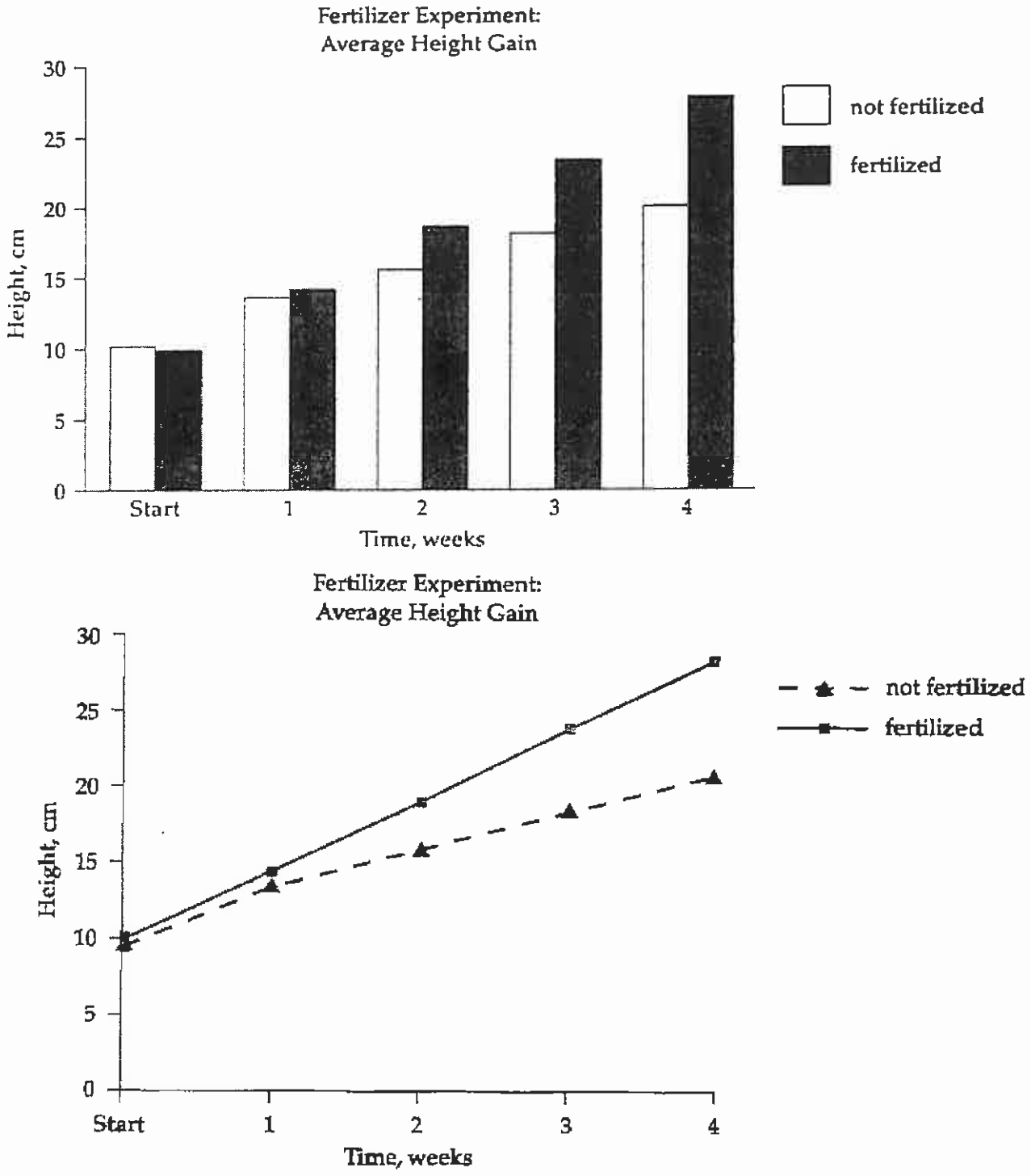


Figure 1. Comparison of Bar Graph and Line Graph

2) Look at the graphs in **Figure 1** and note the following *key points*:

- The horizontal axis is referred to as the *X-axis*. The vertical axis is called the *Y-axis*. Each axis **must** have a title that clearly explains the numbers listed there.

- Numbers on the X and Y axes must have an **equal interval** between them (for example, 5,10,15 but not 5,10, 20, 50).

- Lines or bars should be **large and easy to read.**

- *Numbers on the X and Y axes are chosen carefully to make **best use** of the space available.*

- Each graph should have a **title** that describes the subject matter being graphed.

- It is not permissible to extend lines or bars **outside the margins** of the graph. Adjust the graph scale to make the data fit comfortably.

3) On the graph paper in **Figure 2, plot a graph of your experimental results.** Plot one characteristic on the **vertical (Y) axis** and the other on the **horizontal (X)axis.**

Whenever possible, plot the **first characteristic mentioned in your hypothesis on the X (horizontal) axis and the second** characteristic on the **Y (vertical) axis.**

4) **Discuss the results** with your other group members.

Write a conclusion based on your hypothesis and collected data. Support your conclusion *by mentioning facts collected during your experiment.*

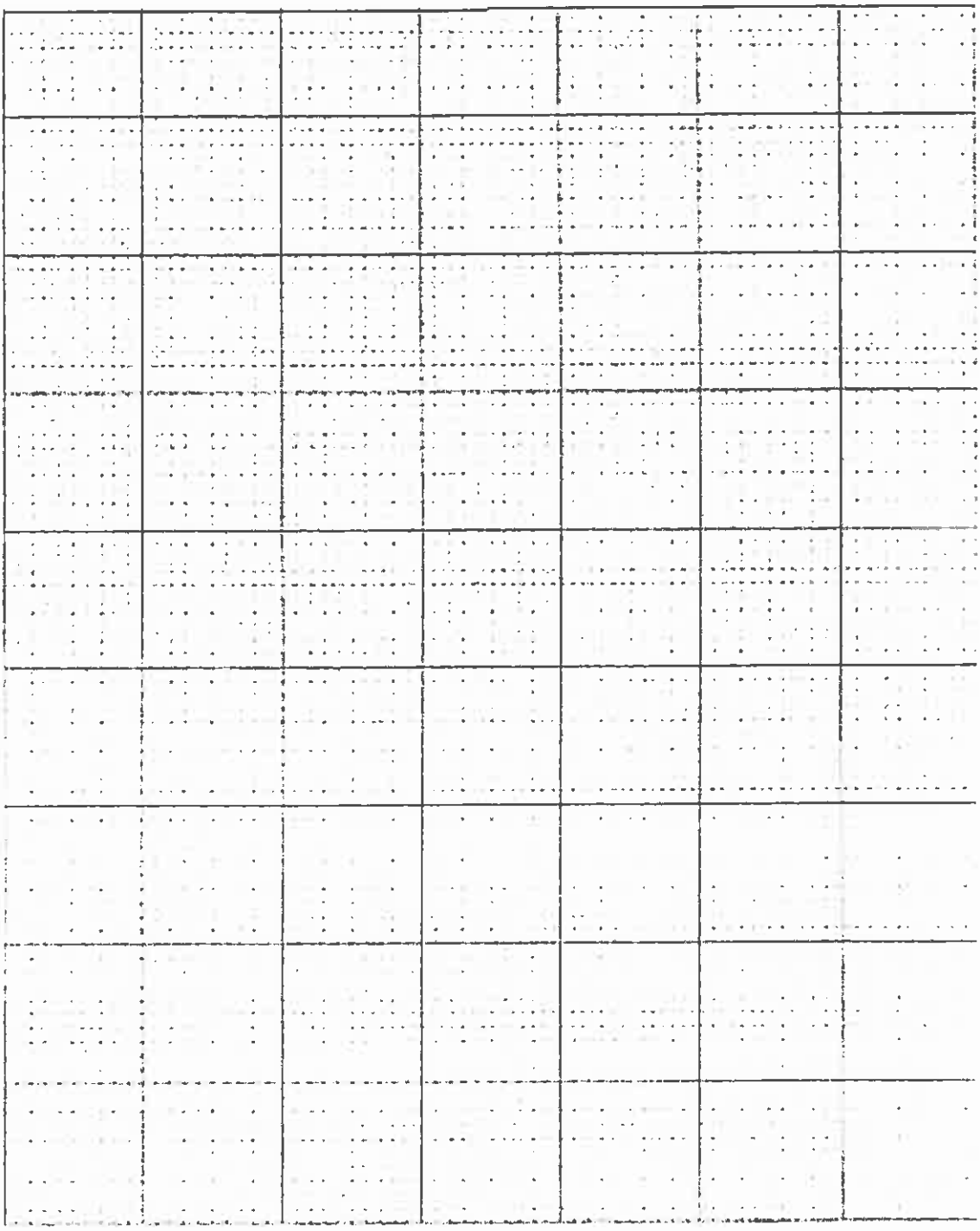


Figure 2. Experimental Results

Often, the data collected in an experiment is in a form that is not easily understandable. Measurements have been established to make it easier to interpret and draw conclusions from large collections of information. We're all familiar with the U.S. Census, which collects huge amounts of information on family size, income, housing conditions, population distributions, and so on.

Simple statistical analysis can reduce the data and convert it to a useable form. A similar approach is used when analyzing the results of large experiments (such as evaluating the effectiveness of new medications or airbags in automobiles). The most commonly used statistical measures are the mean, the mode, the median, the range, and the standard deviation.

The mean is the average of a set of numbers. The mean is equal to the sum of all the numbers in the set divided by the sample size. For example, to find the average pulse rate of a group of ten students, you would add the pulse values for each of the students together and then divide the answer by the number of students (10).

The mean of a group of numbers often doesn't really give you the information you need to correctly interpret the data. For example, the following two sets of numbers have exactly the same mean, but the spread (dispersion) of numbers is quite different.

Set 1: 39, 38, 38,40,40 mean = 39
Set 2: 3, 29, 25, 38,100 mean = 39

The mode is the most frequently occurring number in a set. The mode represents the most common response and, therefore, can be used as a prediction to determine market response (for example, which car model will sell the best in a specific area of the United States).

The median is the middle number of a set when they are arranged in either ascending or descending order. If your income level is above the median, for example, your salary is in the upper 50% of salaries being compared. If a set of numbers has no middle value, you can find the median by averaging the middle two numbers in the set.

The range is the difference between the largest and smallest value in the set.
For example, the difference between the number of yards gained by the best and worst running backs in the National Football League.

To demonstrate how applying different statistical measures changes the meaning of results, consider the following set of 20 biology exam scores in Table 9.4

Student Number	Score: Exam 1	Student Number	Score: Exam 1
1	90	11	88
2	94	12	54
3	80	13	32
4	82	14	47
5	91	15	25
6	46	16	56
7	97	17	59
8	96	18	60
9	87	19	87
10	84	20	86

Mean = 72.05 Mode = 87 Median = 83

Table 9. Biology Exam Scores

---

1) What is the **range** of exam scores in **Table 9?**

2) If your **exam score was** 80, was your score in the top 50% of the class? **Explain your answer.**

3) In this situation, is the **mean** a good representation of the class scores? **Why or why not?**

4) While watching television last night, you saw an advertisement for Lose-Fast Weight Control Pills. The 12 women shown, lost an **average** of 30 pounds, while taking the pills. What additional **statistical** information would you need to make an informed decision whether or not to purchase this product?

Self-Test

For each sentence below, enter the letter of the correct step of the scientific method.

a. Test hypothesis (by experiment or observation)
b. State hypothesis
c. State results (facts only)

1) ___ Seeds will grow faster if you fertilize the ground before you plant them.

2) ___ In an experiment, 70 of 80 household cockroaches were attracted to peanut butter.

3) ___ Tanya grew bacteria from her mouth on special plates in the laboratory. She placed drops of different mouthwashes on each plate.

4) ___ Kevin designed a survey to determine how many of his classmates had dimples on their chins and how many did not.

5) ___ Plants grown under red light will grow faster than those under white light.

6) ___ If acid rain affects plants in a particular lake, it might also affect small animals that live in the same water.

7) ___ *Maria's experiment showed that chicken eggshells are more resistant to crushing when the hens are fed extra calcium.*

Identify the graphing mistakes in **Figures 3, 4,** and **5**:

8)

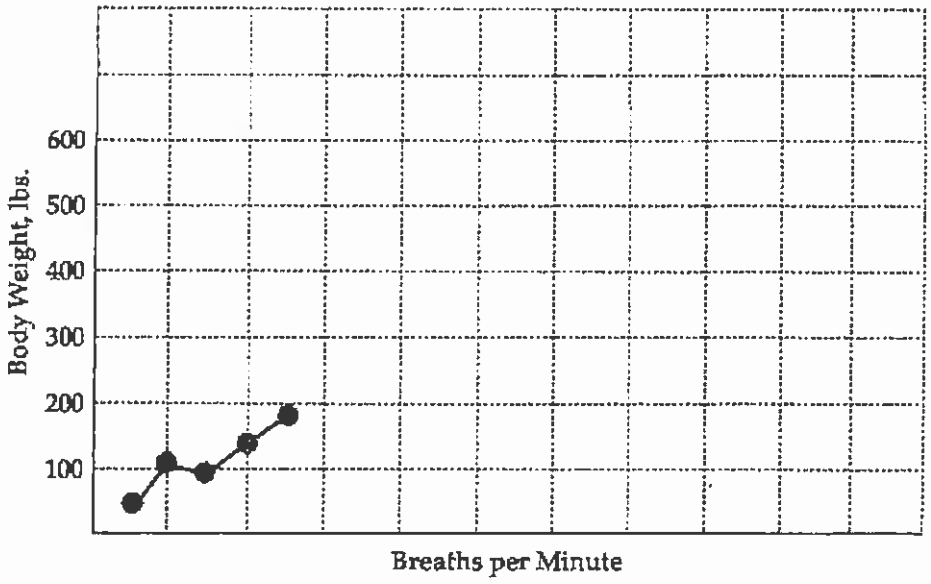


Figure 3. Sample graph one

9)

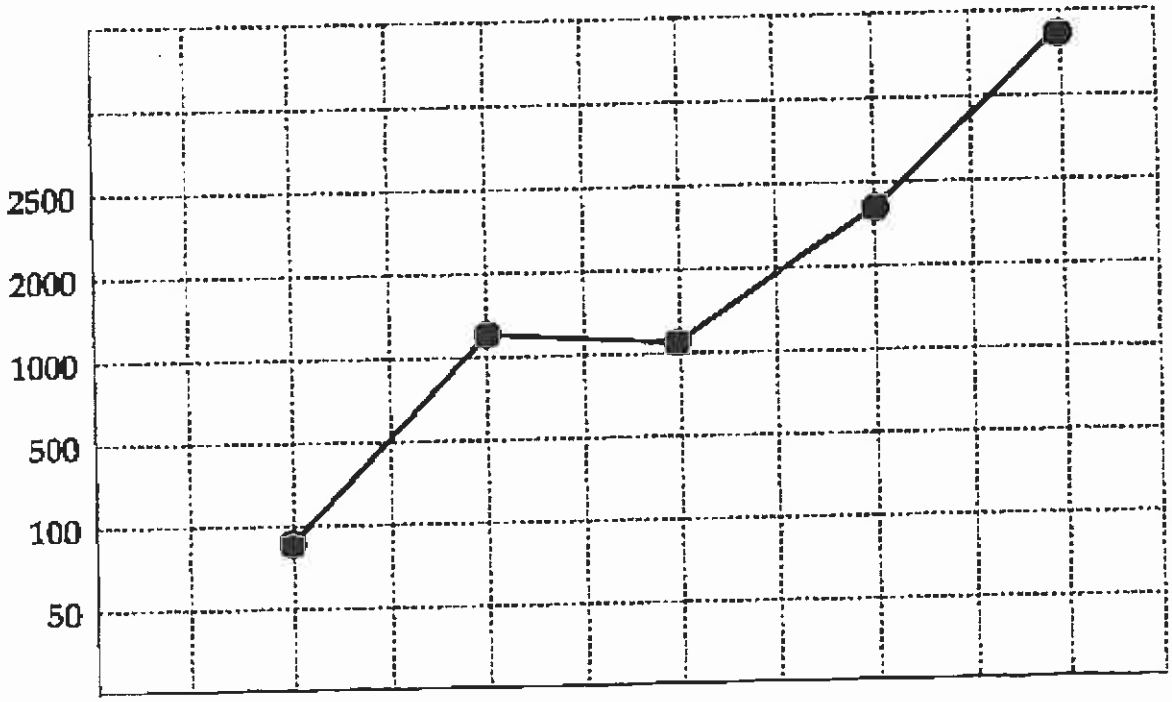


Figure 4. Sample graph two

10)

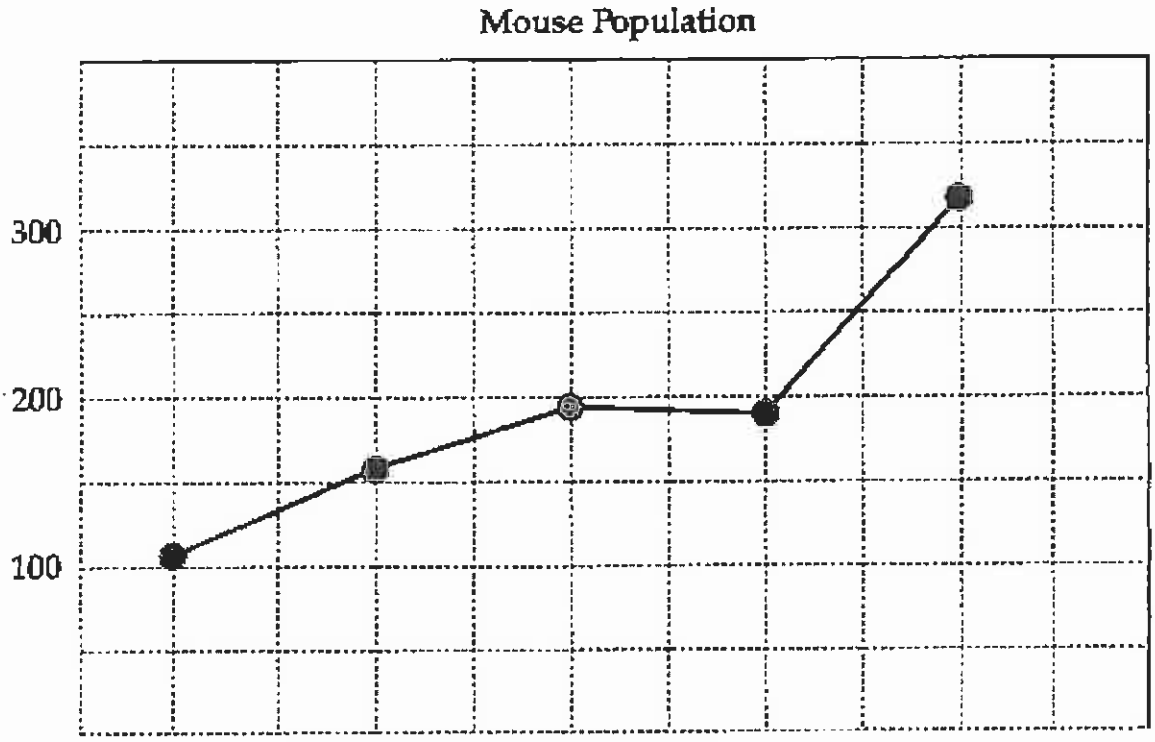


Figure 5. Sample graph three

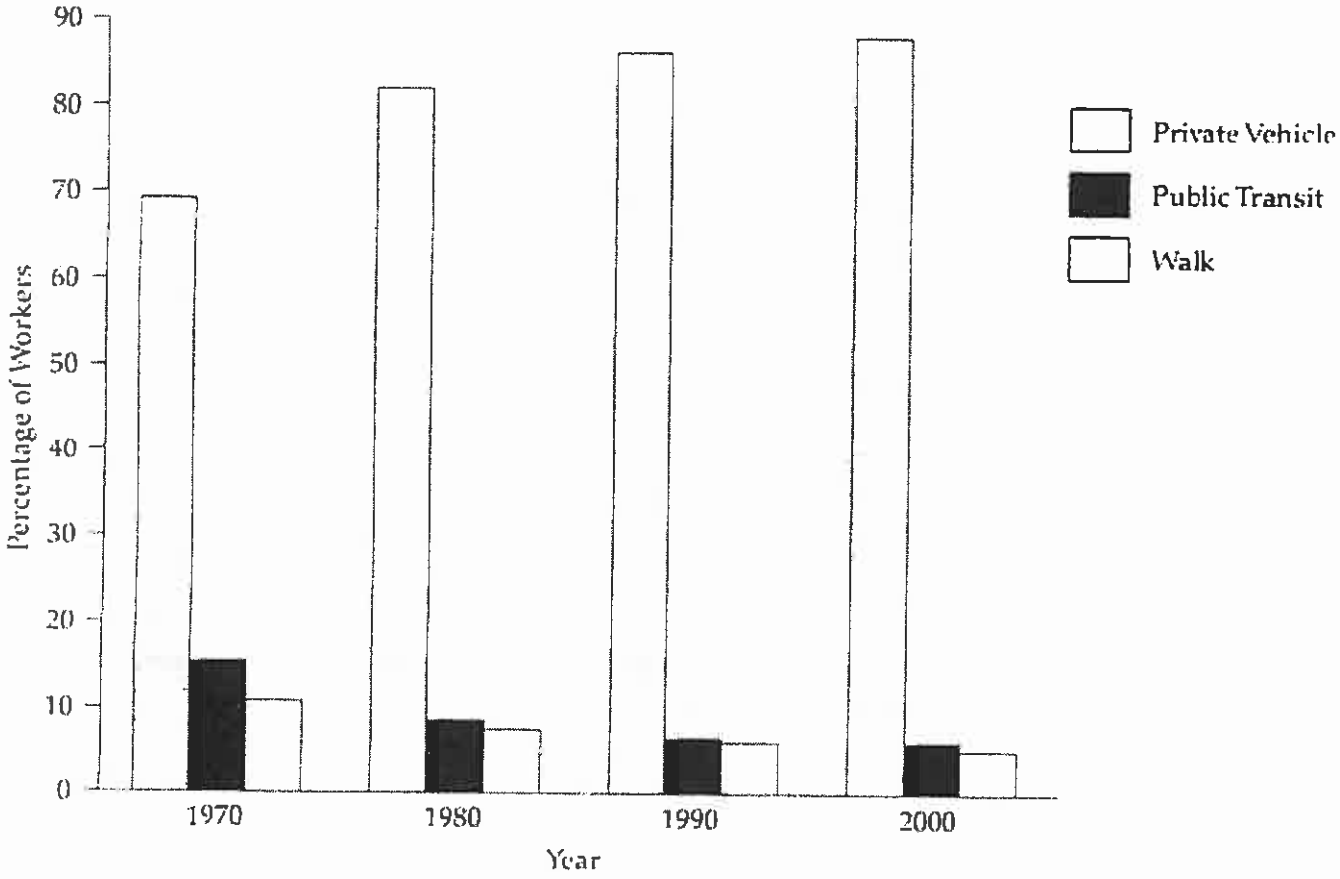


Figure 6. Percentage of workers using various modes of transportation.

Answer the following questions in reference to the graph in Figure 1-6.

11) Between 1970 and 2000, the percent of workers who walked to work increased/decreased/remained the same. (*Circle one answer*)

12) Between 1970 and 1980, the number of people who drove cars to work increased by _____%.

13) In 2000, what percent of workers drove cars to work? ___.

14) The number of workers who used public transportation dropped by 7% between 1970 and ___.

General Biology I
BIO K121

Laboratory exercise 2 (part A)

Introduction to the Microscope

The purpose of a microsope is to see inside of organisms and cells - to see what is invisible to the naked eye. The eye can be aided with a simple microscope which is nothing more than a magnifying glass with one lens, or with a compound microscope which has two lenses at opposite ends of a tube. The **ocular lens** is the one nearest the eye, and the **objective lens** is nearest the object or specimen. The microscope you will be using most often in this lab is compound and quite a bit more sophisticated than exquisite simple microscope with which Anton van Leeuwenhoek made his discovery of microbes.

A microscope is a precision instrument, and is **easily damaged**. You should not attempt to use it until you have grasped the function of each vital part. Refer to Fig. 1 as you locate each of the following:

Arm: Supports the body tube and is the part that you can grasp to carry the microscope. Pick up your microscope by its arm, keeping it upright, and supporting it underneath with your free hand. Set it gentle on the table.

Base: Gives the microscope a firm, steady support.

Ocular lens: Magnifies ten times (10x). This lens is unattached, and thus it may fall unless the microscope is kept upright.

Objective lens: Magnifies the object by the factor marked on the particular lens. Low power (4x and/or 10x) gives the smallest image, high power (sometimes called high dry) gives a larger image (40x), and oil immersion gives the largest image (100x - 125x). Objective lenses are always used in the order: low, high, oil immersion. You should not use the oil immersion lens without immersion oil.

Nosepiece: The revolving part to which objectives are attached. It must be firmly clicked into position when the objective is changed. Rough treatment can cause it to snap off.

Body tube: Joins the nosepiece to the ocular lenses.

Stage: Supports the slide that is held onto it by stage clips, and has a hole so that light can shine up through the specimen. Always center the specimen over this hole.

Coarse adjustment: Moves the body tube or stage up and down, depending on the design of the microscope, to approximately the right position so that the specimen is in focus. This knob is used only with low power objectives.

Fine Adjustment: Moves the body tube or stage up and down to precisely the right position so that the specimen is perfectly in focus. Use it to achieve fine focus with the low power objective and for all focusing with the high power and oil immersion objectives.

Light source: Usually a small electric light beneath the stage that is controlled by a push button light switch. Sometimes a mirror is used to reflect light from another source into the microscope.

Iris diaphragm: Regulates how much light and lamp go through the specimen. It is controlled by a lever that is moved back and forth.

Condenser: A lens located above the diaphragm, which concentrates the light before it passes through the specimen.

Observer: The microscope is useless when the observer looks but does not see.

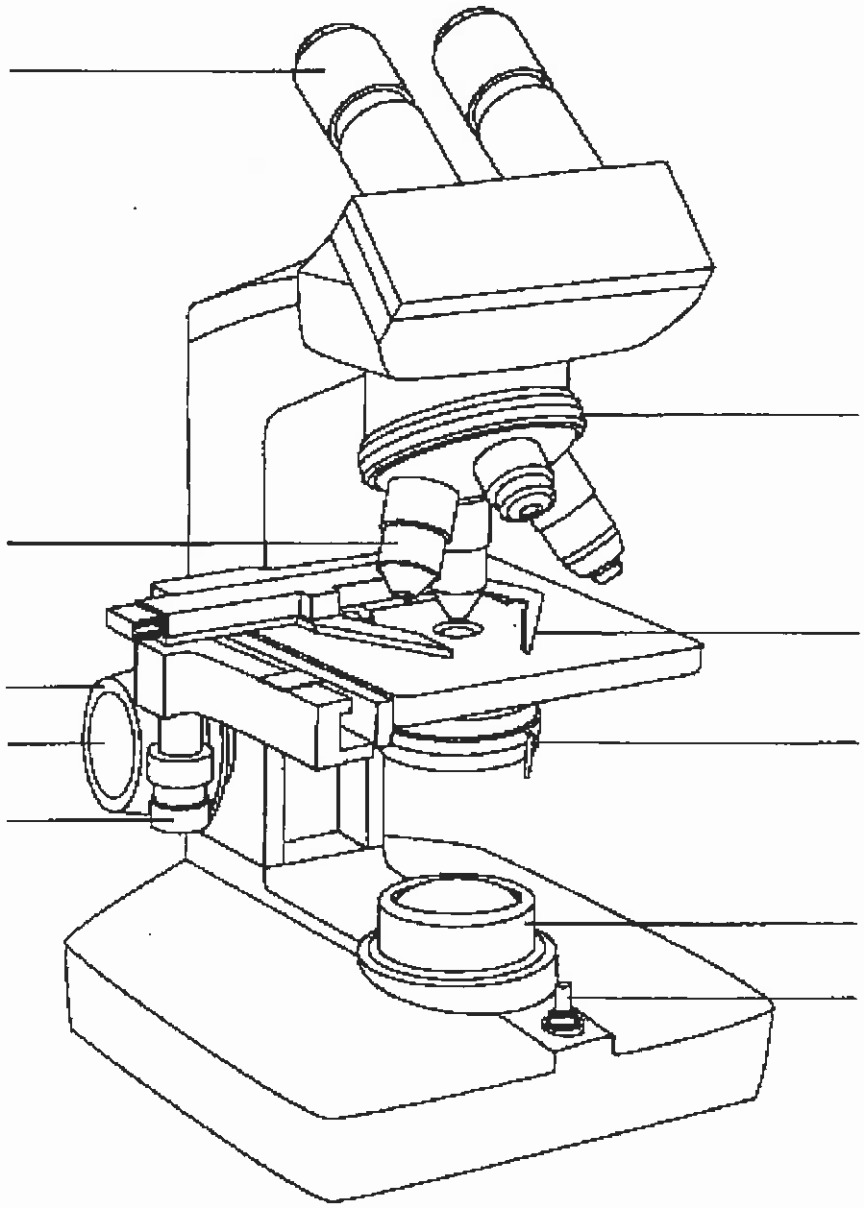


Figure 1. Parts of the compound light microscope

HOW TO USE THE COMPOUND MICROSCOPE

NOTHING SHOULD TOUCH THE MICROSCOPE LENSES EXCEPT THE SPECIAL LENS PAPER. USE A CLEAN PIECE OF LENS PAPER TO WIPE THE OCULAR AND OBJECTIVE LENSES.

The moving parts of the microscope should operate so smoothly that very little force is required to move or operate them. the microscope is a delicate instrument; never use excessive force to manipulate any part of the microscope. If the microscope part does not seem to operate as it should, report the trouble to your instructor immediately.

DO NOT ATTEMPT TO REPAIR THE INSTRUMENT YOURSELF !!

Computing Magnification & Resolution

Learn how to compute the magnification of your microscope.

Magnification: is a measure of how big an object looks to your eye. "Life size" images are specified as "1x". Magnification is usually written by a number followed by an "x", which stands for "times life size" (for example: 10x means 10 times life size). A simple lens like a magnifying glass magnifies 3x to 10x or so. A compound microscope can magnify up to 1000x.

TOTAL MAGNIFICATION IS CALCULATED BY MULTIPLYING THE MAGNIFICATION OF THE OCULAR LENS BY THE MAGNIFICATION OF THE OBJECTIVE LENS. For example: With low power magnification of 10x and an ocular magnification of 10x, the total magnification of the specimen is 100x. On high power, total magnification is 400x.

Resolution: measures how clearly you can see details in the microscope, and is usually given as the distance between two objects that can just barely be resolved. It depends in part on the quality of the lenses used. Resolution increases with magnification up to a theoretical point. The use of oil immersion will increase the resolving power somewhat.

The objectives on a microscope are **parfocal**. Meaning, when the specimen is focused with one objective, it will be in focus, or nearly so, with all the other objectives. Only slight adjustment of the fine focus should be necessary after initial focusing using the scanning (low power) objective.

LABORATORY EXERCISE

OBJECTIVES

1) You should feel competent when operating the compound microscope.

2) You should be able to calculate the total magnification for any combination of eyepiece and objective on the microscope.

3) You should understand resolution as it pertains to objects when viewed under a microscope.

4) You should be able to prepare a wet mount for examination under a compound microscope.

5) You should understand depth of field as it pertains to objects when viewed under a microscope.

Materials

A compound microscope
Glass slides and coverslips
Lens paper
Prepared slides
Scissors
Water in dropping bottles
Newspaper

Laboratory Procedures

When you are confident you know how to use and care for the compound microscope, prepare a slide for observation. The slide you will prepare is a wet mount, a temporary preparation used when the observations are expected to be completed within a single laboratory period. A wet mount can be made from many materials; however, for the purpose of practice you will examine a small piece of newspaper. Regardless of the material used for the wet mount, the procedure is essentially the same and is as follows:

1) Obtain a clean slide and coverslip and with your scissors cut out a small square of newspaper that contains only one or two letters. Select small letters, not headlines or captions. Place your piece of newsprint in the center of your slide.

2) Flood the piece of newsprint with one or two drops of water that has been provided in dropping bottles. Cover the preparation with a clean coverslip as in accordance with **Figure 2**. The fluid used to cover a specimen varies; for most live materials water or saline (salt) solution is used.

3) The coverslip must not be dropped haphazardly on the specimen for two reasons: (1) the specimen,if delicate, may be crushed, and (2) numerous air bubbles will be trapped beneath the coverslip and obscure the specimen.

4) Place one edge of the coverslip near enough to the specimen so that the specimen will be centered under the coverslip when it is lowered into place. The water with which you flooded the specimen will flow along the junction of the edge of the coverslip and the slide. Carefully lower the coverslip over the specimen keeping the edge of the coverslip mentioned above in contact with the slide. In this way the water will flow slowly and uniformly beneath the coverslip.

5) Learn to add just the right amount of water so that no air remains beneath the coverslp after it has been lowered into place. Too much water will spill out under the coverslip onto the slide and stage of the microscope. This should be avoided.

REMOVE EXCESS WATER BY APPLYING PAPER TOWELING OR LENS PAPER TO THE EDGE OF THE COVERSLIP.

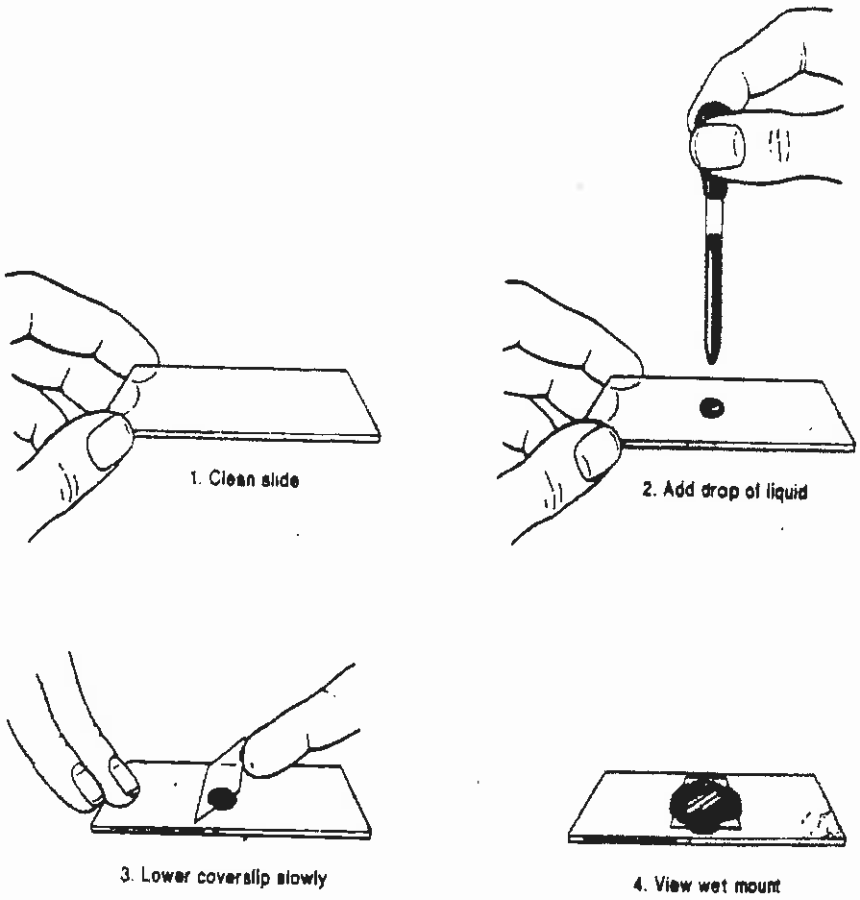


Figure 2. Preparation of a wet mount

Questions for thought

Once your preparation is made place it on the center of the stage of your compound microscope. Practice focusing with both high and low power on a single letter. After you have practiced focusing with both high and low power adjust your microscope so that a single letter is in focus under low power.

1) What happens to the image when you focus downward (turn the fine adjustment away from you)?

2) What happens to the image when you focus upwards (turn the fine adjustment towards you)?

3) Would it be practical to attempt to examine thick objects with the compound microscope? Why?

4) Look at your slide on the stage of your microscope. Is the letter you have been focusing on upside down or rightside up? Now look at it through your microscope. Is the letter, when viewed under the microscope upside down or rightside up?

5) Again, with the single letter in focus under low power, move the slide slowly towards you. Which way did the letter move? Return the slide to the center of the field. Now, move the slide slowly away from you. Which way did the letter move?

Depth of Field

Obtain a slide with three or four colored threads mounted together, or make a slide by crossing different colored hairs (using the wet mount directions). With low power, find a point where the threads or hairs cross. Slowly focus up and down. Notice that when one thread or hair is in focus, the others seem blurred. Determine the order of the threads or hairs.

The vertical distance that remains in focus at one time is known as the depth of field. Switch to high power and notice that the depth of field is more shallow with high power than with low power. If you make constant use of the fine adjustment when viewing a slide with high power, you will get an idea of the specimens's three-dimensional form.

This lab exercise should be repeated completely or in part until you are familiar with the operation of the compound microscope. You should also be familiar with the general orientation of an image when seen through the compound microscope.

*NOTE: The microscope is an important tool in the study of biology and will be used in other laboratory exercises.

YOU MAY BE EXAMINED AT ANY TIME ON THE OPERATION AND PROPER CARE OF THE COMPOUND MICROSCOPE !!

Microscope Procedure Review Sheet

To Start:

1) Lock scanning lens or lowest power objective in place

2) Place slide on stage, with coverslip side up, secure with stage clips.

3) Position slide so that specimen is in the center of the light aperture of the stage.

4) Look through the microscope, use the coarse adjustment to focus the image of the specimen.

5) Use fine focus adjustment for more refined focus.

6) As you look through the microscope, move the slide until you find the desired area of the specimen to be observed.

7) Adjust the light intensity, as needed.

To increase Magnification:

1) While looking through the microscope, move the slide so that the area of observation is in the center of the field of vision.

2) Make sure the image is focused.

3) Rotate the nosepiece to the next highest power objective lens.

4) Using ONLY the FINE adjustment, focus the image.

5) Repeat steps 1-4 to further increase magnification.

Comments:

1) When observing on high power magnification, always keep one hand on the fine adjustment and slowly turn it back and forth to see through the depth of the specimen.

2) Too much light may produce glare so that you can not see the specimen.

3) If you loose the specimen you were observing, start the procedure again with the lowest power objective lens.

Principles of Microscopy

If we follow the light rays in the microscope we would start with the lamp as the source of illumination.

To get the most out of the objective, the condenser system must be capable of delivering as large as an angular cone of light that the objective lens is cable of utilizing. If you look at the condenser or objective lens you will see a number with stands for **Numerical aperture (N.A.).** The **N.A.** for the substage condenser is 1.40. This means that it is cable of delivering a wide cone of light onto the object. The **N.A.** of the objective lenses vary and relate to the angle of the cone of light which will be picked up by the lens.

The calculations of **N.A.** depends on light wavelength, refractive index of medium (air, glass, oil, water) and sine of angle of the cone of light. Without going into these formulas, suffice it to say that, generally, as the **N.A.** increases, **resolution** (the ability two separate two adjacent points on an object) also increases. This is why, for example, more cellular detail can be seen using a 40x objective lens rather than a 10x objective.

General Biology I
BIO K121
Laboratory exercise 2 (part B)

Microscopic Study of Pond &/or Lake Water

To further tone your skills in the care and use of the microscope, you will explore microscopic organisms of pond water (planktonic organisms). These planktonic organisms, although few can be seen by the naked eye, or vital for the productivity of a pond. Plankton (meaning wanderers) can be divided into two groups:

1) **Phytoplankton**- of plant origin
2) **Zooplankton**- of animal origin.

Phytoplankton constitute the base of the food chain, known as primary producers (autotrophic organisms), in aquatic ecosystems. Although they photosynthesize (convert inorganic chemicals to organic energy by using sunlight), they also require key nutrients for their survival. Zooplankton constitute the secondary level of the food chain, known as primary consumers (heterotrophic organisms), in aquatic ecosystems. Zooplankton receive their nutrients for the consumption of phytoplankton. Both phytoplankton and zooplankton are consumed by larger organisms primarily, fish & invertebrate larvae. Perhaps this laboratory exercise will reveal the rarely seen world of plankton.

Materials

A compound microscope
Glass slides and coverslips
Lens paper
Eye dropper
Pond or lake water

Laboratory Procedures

Obtain a clean microscope slide and coverslip. Using an eyedropper, add a drop of pond water to the center of the slide, and slowly lower the coverslip over the drop. To reduce the chance of air bubbles and to not crush the specimen, touch the coverslip the slide and lower it supporting the free end with a dissecting needle or pencil tip. Do not drop haphazardly.

Using reduced light, examine your pond drop sample under the compound microscope, using the low power objective. Remember, this is just one drop, from one jar, from a large pond; observations will differ. Prepare and examine at least five pond water samples and identify as an planktonic organisms as possible. Diagram here:

General Biology I
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[redacted]
Laboratory exercise 3

Adapted From; *Levine, Harvey R. 1989. Introduction to the biological sciences, Twenty-Five laboratory exercises, 2nd ed. Quinipiac College*

Chemical Composition of Cells

All living organisms are composed of both inorganic and organic compounds, with the latter group comprising about 99% of their total weight. The organic compounds consist of four main types of molecules: **Carbohydrates**, **Lipids** (fats and oils), **Proteins**, and **Nucleic Acids**.

A) Carbohydrates

Carbohydrates include a number of familiar and important biological compounds, such as sugar, starch, cellulose, and glycogen. Most carbohydrate molecules consist of carbon, hydrogen, and oxygen, in a 1:2:1 ratio.

Basically all carbohydrates are made up of simple sugars or **Monosaccharides**. Most monosaccharides, such as glucose, are composed of six linked carbon atoms, and thus they have the chemical formula $C_6H_{12}O_6$.

Monosaccharides may exist in cells as single units, or they may be bonded together to form a chain of repeating molecules. **Disaccharides (oligosaccharides)**, for example, consist of two monosaccharides bonded together. Both sucrose and maltose can be expressed by the formula $C_{12}H_{22}O_{12}$.

Another form in which carbohydrates may exist in a cell is as **polysaccharides**, a long chain of repeating monosaccharides. Polysaccharides are frequently utilized as storage fuels (glycogen in animals & starch in plants) or as structural components (chitin in animals & cellulose in plants).

B) Lipids

Lipids, or fats and oils, are made up of a molecule of glycerol bonded to three fatty acids. Lipids are carbon, hydrogen, and oxygen, but the ratio of oxygen present is considerably less than in carbohydrates. The fats are important as concentrated storage sources of energy and actually supply more than twice as many calories per gram as do proteins and carbohydrates.

C) Proteins

Protein makes up the structural and principle functional components of a cell. Proteins are composed of units known as **amino acids**, so called because they contain both an amino group and an acid (carboxl) group.

Proteins are constructed of long chains (sometimes thousands) of amino acids linked together by **peptide bonds**. Although only twenty kinds of amino acids of found in living organisms,the variety of proteins that can be formed is almost infinite.

Materials

Benidict's solution	5% Glucose solution	5% Sucrose solution
Hydrochloric Acid	1% Starch solution	Biuret solution
Sundan IV dye	Iodine solution	Clean test tubes
Marking pencils	Metric ruler	Potato juice
Rice grains	Salad oil	Egg albumin
Milk	Paper towels	Dilute gelatin solution

PROCEDURES

A) Carbohydrates

1. Sugars

The most widely used tests for sugars are based on their ability to reduce (in an alkaline solution) copper sulphate to cuprous oxide, which forms a precipitate. The resultant color varies with the amount of reducing sugar present, and ranges from blue, through green, yellow, orange, and brown.

The reagent to be used is Benedict's solution, which is available as Clinitest tablets. Heat is required for the chemical reaction to occur, but the Clinitest tablet itself will generate heat as the contained ingredients (sodium hydroxide and citric acid) react with water. ***FIVE drops of Benedict's solution + heat (if no Clinitest tablets are available)**

Using wax pencil and a metric ruler, mark at 2 cm from the bottom of seven test tubes. In one tube, add a 5% glucose solution up to the 2 cm mark. In a second tube, add a similar amount of tap water. Add a Clinitest tablet to each test tube. (Caution: the tubes will be become somewhat warm to the touch) Record your observations in your laboratory journal.

Repeat the above test with milk. Record observations.

Repeat the test again, but this time use a 5% solution of sucrose, a disaccharide and a non-reducing sugar. Record observations.

Repeat the test once more, but cautiously add several drops of concentrated hydrochloric acid to the sucrose solution before adding the Clinitest tablet. Record observations.

Repeat the test twice again, using a 1% starch solution -- one without the hydrochloric acid and the second with the acid. Record observations.

2) Starch

The iodine test is for the detection of specific polysaccharides, such as starch. To several drops of a 1% starch solution in a test tube, add a few drops of iodine solution (iodine-potassium iodide).

Record observations in your laboratory journal.

Repeat the test with tap water. Record observations.

Test a sample of potato juice and a few rice grains for the presence of starch. Record observations.

Thought Questions:

1) Why was the test performed on water?
2) If so, does milk contain as much as the glucose solution?
3) Explain your results with the 5% sucrose solution.
4) Why was it necessary to treat with hydrochloric acid before testing with the Clinitest tablet?

B) LIPIDS

1. Dye Test

Mark a clean test tube with a wax pencil at 2 cm from the bottom of the tube. Put water up to the 2 cm mark. Add a few drops of Sundan IV dye. Now add several drops of salad oil to the tube and mix thoroughly. Set aside until the layers of oil and water separate. Describe in your laboratory journal the distribution of the dye with respect to the oil and water layers.

2. Grease Spot Test

Fats have the ability to produce translucent grease marks on paper. Add a few drops of salad oil to one area of a paper towel. Add a few drops of water to another area on the towel. Let the fluids evaporate and examine each spot by holding the paper up to the light. Record observations.

C) PROTEINS

1. Biuret Test

In the presence of protein, Biuret solution will turn violet. In the presence of polypeptides (protein fragments) the solution will turn pink. Mark two test tubes with a wax pencil at 2 cm from the bottom. Add egg albumin to the first tube up to the 2 cm mark. Add several drops of Biuret reagent (sodium hydroxide and copper sufate). Note the color change. Record observations.

In a second test tube, repeat the Biuret test with a dilute gelatin solution. Record observations.

Thought Question:

1) Is the principle component of gelatin protein or polypeptide?

D) UNKNOWNS

Select at least three of the samples provided by your instructor and, utilizing the aforementioned tests, determine whether they are composed primarily of monosaccharides, disaccharides, starch, lipids, or proteins. Record all observations.

General Biology I
BIO K121

Laboratory exercise 4

Microscopic Study of Animal & Plant Cells

Living organisms contain many kinds of cells, each specialized for, or adapted to, a certain function. Most are invisible to the naked eye. Since cells have different functions, they vary in structure, for example shape and size. Each cell is a living dynamic entity, capable of propagating themselves. Most cells reproduce by a process known as mitosis, which will be explored in detail in another laboratory exercise.

Animal cells and plant cells are different in structure. A thin covering known as the plasma membrane, or cell membrane encloses animal cells. Plant cells also have a cell membrane, but covering the cell membrane is a rigid **cell wall** which is absent in animal cells.

The semigelatinous or colloidal matrix the cell, excluding the cell's nucleus, is referred to the **cytoplasm**. Within the nucleus is found the **nucleoplasm**.

Within the cytoplasm are a number of structures known as **organelles**. Most of the organelles will not seen without the aid of a compound microscope.

The following is a list of some of the structures located within the cytoplasm and nucleoplasm, as well as, their functions:

Nucleus: Ovid structure containing the chromosomes which are responsible for all cellular activity.

Nucleolus: Small, spherical structures located within the nucleus; associated with RNA synthesis.

Chromosomes: Rod shaped structures within the nucleus; genes are found on chromosomes, genes determine heredity, as well as, cellular activity.

Cytoplasm: The more fluid portion of the cell surrounding the nucleus and contain various organelles. The cytoplasm is often semigelatinous in nature, and frequently observed streaming around within the cell; termed **cytoplasmic streaming** or **cyclosis**.

Mitochondria: Rod or granular shaped structures within the cytoplasm associated with intracellular respiration. The mitochondria are often referred to as the "powerhouse" of the cell. Most of the cell's ATP (usable energy) is produced within the mitochondria.

Endoplasmic Reticulum: A system of paired membranes within the cytoplasm; protein packaging and transport function.

Ribosomes: Very small granules located on the endoplasmic reticulum which serves as the site for protein synthesis.

Vacuoles: Aqueous solution of various substances located within the cytoplasm.

Plastids: Bodies within the cytoplasm frequently associated with photosynthesis; pigments associated with plant color mat be found here.

Materials

Compound microscopes	Microscope slides	Coverslips	Live *Elodea*
Onion	Yogurt	Distilled water	Stain
Dissection needles	Forceps	Paper towels	Toothpicks

Procedures

I Eukaryotic Cells

A) Plant Cells

1. Onion Epidermis

Obtain a small piece of onion. Using forceps, remove a small piece off the thin, transparent membrane (epidermis) from the surface of the concave side of the onion.

Place a drop off stain on the onion tissue. Cover with a coverslip.

Observe under the compound microscope. Locate the nucleus. The chrosomes are not generally visible. Draw and label fully the cells in your laboratory journal.

Note the thickness of the cell wall. What are the shape and arrangement of the cells? Does each cell have a separate cell wall?

2. *Elodea*

Elodea is a flowering plant found in freshwater lakes and ponds. Its leaf cells are green due to **chorophyll**, a plant pigment essential for photosynthesis. The chorophyll absorbs light energy and converts it to chemical energy.

Using forceps, remove one *Elodea* leaf from the plant. Make a wet mount.

Observe under low power. Locate the midrib of the leaf and observe the long, slender cells composing it.

Focus under high power. Find the nucleus, it is often difficult to find as it may be hidden by other parts of the cell. Locate a vacuole. This would appear as a clear area within the cytoplasm occupying a considerable space within a mature cell. Now look for cytoplasmic streaming within these cells. Do you see any cells in which the chloroplasts (a type of plastid) are moving? Draw and label these cell fully in your laboratory journal.

General Biology I
BIO K121

Laboratory exercise 5

Membrane Selectivity: Diffusion & Osmosis

Surrounding all living cells is a structure known as the **cell membrane** which functions in regulating what enters and exists the cell. Without a membrane, cells would have no way to control what entered or existed the cell. Harmful or unnecessary chemicals would enter, or vital compounds would leave, disrupting the cell's ability to function.

While there are a number of processes that allow the cell to control these events, today we will concentrate on **diffusion** and **osmosis**. Diffusion is defined as the movement of particles from an area of higher concentration to an area of lower concentration of the same particles. You are already familiar with diffusion if you have ever spilled some perfume or when cooking in the kitchen. In either case, the aroma from both is at first detectable only where you spilled the perfume or only in the kitchen. However, the smell quickly spreads throughout the house during the process. Diffusion governs the movement of <u>all</u> molecules. The energy that powers diffusion is **kinetic energy**, the energy of movement.

All cells exist in a liquid system in which a major component of both the external and internal environment of any cell is water. Water serves as the **solvent** in which **solutes**, solids or gases, are dissolved to form a **solution** in which the cell exists and which forms the cytoplasm inside the cell. Water is also required for the second process we examine, osmosis. A simple definition of osmosis is that it is the diffusion of water through a **semi-permeable** (or selectively permeable) membrane, such as that surrounding a cell. Semi-permeable indicates that the membrane will allow certain things to pass through it while preventing others. To expand on this definition, the process of osmosis occurs whenever water moves from and area where it is of high concentration, across a semi-permeable membrane, to an area where it is found in a lower concentration.

Whenever two solutions are compared, there will exist three possible relationships depending on the concentration of each solution. In dealing with living systems, it is convenient to think of the cell's outer environment in relation to its internal environment. Thus, if we place a cell having an internal solute concentration equal to 0.9% NaCl into a beaker containing a solution of identical concentration, it is said to be in an **isotonic** (Iso = same) solution, as their concentrations are identical. In this case, the water concentrations are equal and the water moves into and out of the cell at equal rates. However, if we were to place the cell into a beaker containing a higher concentration of salt than inside the cell, 10% NaCl for example, the water concentration would now be greater inside the cell and the water would move out of the cell, causing the cell to shrink or become **crenated**. The cell is now in a **hypertonic** (hyper = greater) solution, as the salt is at a higher concentration outside the cell. Finally, the cell would be in a **hypotonic** (hypo = lower) solution if we were to place the cell in pure water, as the concentration outside the cell would now be lower than the cell's cytoplasm. In this case, water would tend to move into the cell causing it to swell and burst or **lysis**.

****Water moves towards a hypertonic solution and away from a hypotonic solution****

Materials

Cellophane dialysis tubing	metric ruler	1000ml beaker	Whole milk
[starch solution]	laboratory scale	Droppers	Coverslips
250ml graduated cylinder	Distilled H_2O	String	Compound Microscope
Microscope slides	Ice Cubes	Hot plate	Methyl blue (crystals)
500 ml beaker	Live *Elodea*	Salt solution	Malachite green

Iodine solution (iodine potasium iodide)

Procedures

A) Diffusion of a Gas in a Gas

Particles in a solution tend to move from areas where they are highly concentrated to areas where they are less concentrated until a uniform distribution of particles is achieved. This phenomenon is known as **diffusion**.

In the front of the lab room the instructor will open a bottle of chemical cleaner, perfume, or similar substance. The fluid molecules will evaporate and escape from the bottle into the air.

B) Dialysis Tubing Experiment

Cellophane dialysis tubing is a synthetic semi-permeable membrane which permits diffusion of water and other small molecules while restricting passage of larger molecules. Much like the semi-permeable membrane of most cells. We will create artificial "cells" with strips of this material.

The tubing is flattened when dry. Soak the strip in distilled water for about a minute. then open by rolling between your thumb and fingers.

Fill a 10 cm strip of tubing with a concentrated starch solution and tie off both ends tightly with string. Tie off one end first, then fill, then tie off other end. Be sure to leave enough room after filling to allow for a secure tie.

NOTE **Fold the ends of the bag before tying and remove most of the air.**

Rinse with tap water, then weigh the bag. Record the weight.

Submerge in water, in a 1000 ml, beaker containing enough iodine (iodine potassium iodide, I_2-KI) to approximate the color of beer.

When starch molecules touch iodine, a blue or purplish color appears. Iodine is an indicator of starch.

Observe the bag after about one hour for any color change. After making this observation, remove the bag from the beaker, dry it again weigh it again. Record weight and color change, if any.

C) Brownian Movement

In order to understand how substances pass, or diffuse, through a membrane, it is important to realize that molecules, when at temperatures above absolute zero (0°K), are in constant motion. Molecular motion is a form of energy: the translational, vibrational, and rotational kinetic energies of molecules. Although individual molecules are impossible to see, their existence is revealed by the jiggling of minute particles suspended in water, this is known as **Brownian Movement**.

Brownian movement can be detected by observing whole milk diluted with distilled water. The large fat particles can be seen randomly moving as they collide with, and are deflected, by smaller water molecules.

Dilute 5 ml of whole milk with an equal of distilled water. Then, place a drop on a clean microscope slide and cover with a coverslip.

Observe the preparation under the compound microscope using the high power objective.

***NOTE* In order to see the fat droplets in milk, you will have to turn your light source way down.**

Place the slide preparation on ice for 90 seconds and then observe the movement of fat droplets on your slide. Record observations in your laboratory journal.

Heat the slide preparation **OVER** (not on) a hot plate for 90 seconds. Then, observe the movement of fat droplets on your slide. Record your observations.

D) Effect of Heat on Diffusion

We can make some observations about the rate of diffusion and changes in concentration of a diffusing substance by observing the diffusion of a colored liquid in water. The rate of diffusion is determined by the magnitude of difference in the concentration of a diffusing substance in two different locations, the area of origin and the area of destination.

Place several (just a little bit) of methylene blue crystals into a 500 ml beaker with cold tap water. **RECORD THE TIME**. When equilibrium is reached (even color dispersal), record the time again. The difference in times represents the total net diffusion time.

Repeat the procedure with a 500 ml beaker of water that has been heated to almost a boil. **Heat the water first, then remove the beaker from the hot plate before adding the crystals**. (Sometimes not all of the methylene blue crystals will dissolve, leaving a residue on the surface of the water. Thus, even dispersal of color, not amount of dissolved substance, represents the time).

E) Diffusion of a Liquid in a Liquid

In diffusion, the random movements of individual molecules produce a net movement from an area of greater concentration to an area of lesser concentration. Eventually both types of molecules will be evenly distributed.

Fill a 250 ml graduated cylinder almost to the top with tap water. Position the cylinder so that you can see the milliliter scale. Allow the cylinder to stand undisturbed for a few minutes to be sure that all water convection has ceased.

Gently add one drop of Malachite Green to the surface of the water. Take care to avoid disturbing the surface of the water. Cover the container to prevent disturbance by air currents (a piece of paper will do).

Find the rate of diffusion of the stain into the water by recording the milliliter mark reached by the leading edge of stain at least 15 second intervals until the bottom is reached.

Graph your results as milliliter marks traveled per minute in your laboratory journal.

F) Turgor and Plasmolysis

If a plant cell is immersed in a solution that has a higher solute concentration than that of the cell, then water will leave the cell, moving from an area of higher water concentration to an area of lower water concentration. The loss of water from the cell will cause the cell to lose **turgor pressure** (internal pressure applied to a cell wall when water moves by osmosis into a cell). Macroscopically, you can see the effect of loss turgor pressure in wilted house plants or limp lettuce. Microscopically, increased loss of water and loss turgor pressure becomes visible as a withdrawal of the cytoplasmic membrane from the cell wall (**plasmolysis**) and as a decrease in the size of the vacuole.

Obtain a leaf from the tip of an *Elodea* plant. Place it in a drop of water on a slide, cover with a coverslip, and examine the material first at 10x and then at 40x. Locate a region of healthy cells and sketch the location of the chloroplasts in your laboratory journal.

While touching one corner of the coverslip with a torn piece of paper towel to draw off the water, add a drop of concentrated salt solution to the opposite corner of the coverslip.

Be sure that the salt solution moves under the coverslip.

Wait about 5 minutes, then examine as before. Record observations in your laboratory journal.

Thought Questions:

A) Diffusion of a Gas in a Gas

1) Note how long it takes for your sense of smell to detect the gaseous molecules.

2) Which students detected the gaseous molecules first?

3) What might cause irregularities in the distribution of these molecules in the room?

B) Dialysis Tubing Experiment

Based on the location of the stain, and the difference in weight, you should be able to answer the following questions:

1) Could iodine get through the membrane? How do you know?

2) Could starch get through the membrane? How do you know?

3) Does this experiment demonstrate diffusion or osmosis or both?

4) Was your "cell" isotonic, hypertonic, or hypotonic to the solution?

C) Brownian Movement

1) What effect does decreased temperature have on the kinetic energy of molecules?

2) What effect does increased temperature have on the kinetic energy of molecules?

D) Effect of Heat on Diffusion

1) What conclusions might you make concerning the effect of temperature on diffusion time?

E) Diffusion of a Liquid in a Liquid

1) Does the net movement of molecules slow down as equilibrium is reached? Why?/Why not?

2) Does net diffusion come to an end? Why?/Why not?

F) Turgor and Plasmolysis

1) What happened when the water in which the *Elodea* cells were mounted in was replaced by the salt solution?

2) Assuming that the cells were not killed, what should have happened if the salt solution were to be replaced by water?

3) Plasmolysis is the effect you should have seen when you flooded *Elodea* a hypertonic solution. What structural difference between plant and animal cells would account for this effect?

General Biology I
BIO K121

Laboratory Exercise 6

Cellular Reproduction

One generalization of the cell theory, the **biogenetic law**, states that all cells come from preexisting cells. The process in which the biogenetic law is carried out, is known as cellular reproduction, or cell division. Multicellular organisms usually begin life as a single cell, the fertilized egg or **zygote**. This cell, through repeated division gives rise to all of the cells that make up the organism. In most cells of your body, the **somatic** or **nongamete cells**, cellular reproduction results in two cells which have exactly the same amount of identical hereditary material as the original cell from which they arises from. This process is known as **mitosis.** Cellular reproduction of somatic cells consists of two processes: **Mitosis** and **Interphase**, the former being nuclear division, as well as, division of the cytoplasm and membrane formation. The latter includes three subparts **G_1, S-Phase, + G_2 (Fig. 5.1).** Somatic cellular division is a cycle.

This is a continuous process; however, for the purpose of discussion the process is divided into phases. The process may take from a few minutes in some cells to several hours in others. The different phases require different amounts of times, as the proportional diagram below illustrates:

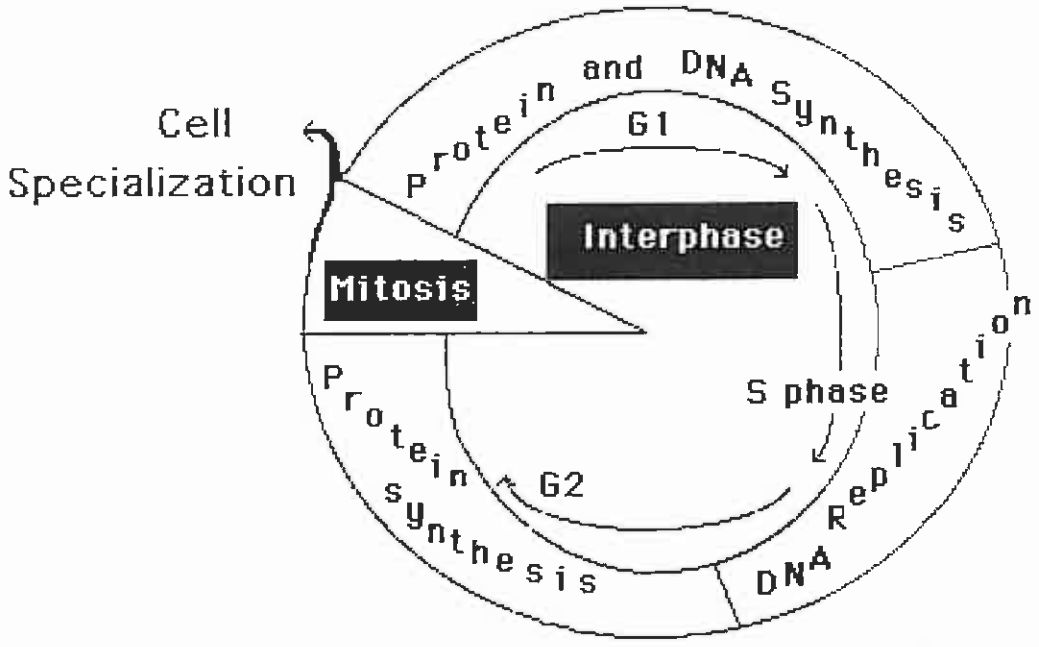

Figure 5.1

The cell cycle consists of mitosis and interphase. During interphase there is growth before and after DNA synthesis. DNA synthesis is required for the process of replication, by which DNA makes a copy of itself. Some daughter cells "break off" of the cell cycle and become specialized cells performing special function.

Materials

Compound Microscope
Mitosis model
Mader '*Biology*' textbook &/or Art notebook
Prepared slides of onion (*Allium*) root tips
Prepared slides of whitefish (*Merlangius* spp.) blastula

Procedures

A) Plant Mitosis - Onion root tip

Obtain a slide of onion (*Allium*) root tips and examine it under low power and high power. Keep in mind the various stages in the cell sequence, but do not attempt to find them in sequence. Refer to your textbook or the mitosis model to properly identify the stage.

Interphase:

This stage occurs before the visible phases of actual cell division begin. Although changes cannot be detected by the compound microscope, it is here that the chromosomal or hereditary material is being duplicated. Interphase may be further divided into three stages: **1) G_1 (Gap one)**; during this stage the cell grows to nearly twice its original size. Growth includes protein synthesis, organelle construction, and storage of materials. **2) S - phase**; during this stage DNA is replicated. The genetic material is in the form greatly extended fibers of DNA that form a tangled mass called **chromatin** The fibers are too small to be seen in the compound microscope so the nucleus looks homogeneous. It is a vital prerequisite for cell division in which each DNA molecule forms an exact replica of itself. Following DNA replication; **3) G_2 (Gap two)**; begins, a period of renewed protein synthesis. Most of the protein constructed is **tubulin**, which will later be assembled into numerous **microtubles**, structures important for chromosomal seperation.

Since the cell is in interphase most of its life cycle, most of the cells visible on your slide of the onion root tip will be in inerphase. Note the intact nuclear membrane, the network of thin chromotin strands, and the nucleoli.

Prophase:

During prophase the nuclear membrane breaks down and the nucleoli disappear from view. The chromosomes shorten and thicken and become visible. Although each chromosome is already duplicated, the separate strands, the **chromotids**, may not be visible. The mitotic spindle begins to form at opposite poles of the cell. From each pole, a cluster of microtubules, called **spindle fibers**, extends towards the equator of the cell.

Metaphase:

The paired chromotids become arranged precisely at the equator of the cell. Each chromotid becomes attached to two spindle fibers, one from each pole of the cell. Each fiber is attached to the chromotid at a specific point called a **centomere**.

Anaphase:

At the beginning of anaphase the centromeres duplicate, and the chromotid pairs separate into individual chromosomes. The two duplicated chromosomes move apart, apparently pulled by the spindle fibers, and move toward opposite poles of the cell.

Telophase:

Telophase begins with the chromosomes at each pole becoming tightly packed together. New nuclear membranes are assembled and new nucleoli are formed. **Cytokinesis** or cytoplasmic division starts with the formation of a **cell plate** across the equator, thus separating each original cell into two **daughter cells**. New cell walls are formed on either side of the cell plate. The growth phase of interphase begins once again.

In your laboratory journal, carefully draw and label each of the stages of mitosis described above.

B) Animal Mitosis - Whitefish Blastula

Obtain a slide of a whitefish blastula and examine it under low power and high power. Keep in mind the various stages in the cell sequence, but do not attempt to find them in sequence.

Locate cells that are undergoing mitosis, some of which have large, large prominent miotic spindles and condensed chromosomes. Refer to your textbook or the mitosis model to properly identify the stage.

Mitosis in animal cells can be readily demonstrated by examining a whitefish blastula (an early stage in the development of the whitefish). The behavior of the chromosomes is identical to that observed in plant cells. There are, however, certain auxiliary structures involved in animal cell division which has no counterpart in the division of a typical plant cell.

During interphase (**G_2 phase**), the **centriole** pairs duplicate, and at the onset of prophase, they migrate to the poles. As they separate, additional fibers surround them. These radiations are called **astral rays** (devoid in plant mitotic division).

Try to find a metaphase stage and try to locate both centrioles and the astral rays, as well as , the spindle fibers.

After ansphase, in which the chromotid pairs separate, telophase commences. Since no cell wall is formed, **cytokinesis** is accomplished by the formation of a **cleavage furrow**, or by pinching of the cell in two, resulting in two daughter cells.

In your laboratory journal, carefully draw and label each of the stages of mitosis described above.

General Biology I
BIO K121

Laboratory Exercise 7 & supplement handout

Specialization & Differentiation of Animal Cells

Most of the living organisms in our environment, including humans are composed not of one cell, but rather of millions or billions of cells. These multicellular organisms are more than collections of cell; they are organized into groups of specific kinds of cell, each carrying out a specific function. An aggregation or groups of similar cells, of similar embryonic origins, working together to perform specific functions are called tissues. The study of tissues is referred as **Histology**. In both plants and animals, tissues provide protection, support, circulation, growth, reproduction, and other vital requirements of life. However, plants and animals versions of these tissues are structurally and functionally different, so we shall study them separately.

ANIMAL TISSUES

Most animals move in order to obtain food and to avoid dangers. The movements in most animals are accomplished by muscle tissue. Most animals have developed nervous tissue to coordinate bodily functions and to respond to environmental stimuli. In addition to nervous and muscle tissues, animals also have connective tissues for support and circulation and epithial tissues for protection. Animal tissues are subdivided into four major categories: **Epithelial, Connective, Muscular, and Nervous.**

Epithelial Tissue

Epithelial tissue functions in protection, absorption, secretion, and excretion. Epithelial tissues line body cavities, cover body surfaces, and compose the secretory portion of glands. Epithelial cells are close knit and not so readily penetrated as other tissues. They lack blood cells so that the network of blood vessels in the underlying connective tissue provides nutrient and waste removal. Epithelial cells are anchored to a specialized structure called the basement membrane, which in turn anchors the cells to the underlying connective tissue. Cells composing epithelial tissues are classified according to their shape, arrangement of cell layers, or function.

Epithelial Tissue Shape

Epithelial cells are classified as:

Squamous - irregular shaped, somewhat flattened cells with a centralized nuclei.
Cuboidal - resembling small cubes.
Columnar - tall and often rectangular shaped cells.

Epithelial Tissue Arrangement

The four most common arrangements of epithelial cells are:

Simple - one cell thick.
Stratified - several cells thick.
Pseudostratified - one layer of cells, resting on the basement membrane, that appears as several.
Transitional - several layers of closely packed, soft, pliable, and easily stretched cells. When stretched the cells appear flat, when relaxed the cells appear sawtoothed.

Epithelial Tissue Function

In addition to the epidermis, epithelial tissue consists of four types:

Mucous membrane - act to protect, support for associated structures, absorption of nutrients into the body, and secretion of mucous, salts, and enzymes.

Glandular Epithelial - specialized in synthesizing certain special compounds. Glands are divided into two types: those with ducts, **Exocrine**, and those without ducts (ductless), **Endocrine**.

Endothelium - a thin layer of epithelial cells that line blood and lymphatic vessels, as well as, the heart.

Mesothelium (serous membrane) - protection and friction reduction, mesothelial cells secrete serous fluids that contain a lubricant.

EPITHELIAL TISSUES

TYPES	LOCATION	FUNCTION
SIMPLE SQUAMOUS	Air sacs of lungs, walls of capilaries, linings of blood lymph vessels	Filtration, diffusion, osmosis
SIMPLE CUBOIDAL	Surface of ovaries, linings of kidney tubules, linings of ducts of various glands	Secretion, absorption
SIMPLE COLUMNAR	Linings of uterus and tubes of digestive tract	Protection, secretion, absorption
PSEUDOSTRATIFIED COLUMNAR	Linings of respiratory passages, and various tubes of the reproductive system	Protection, secretion, cells mucous movement
STRATIFIED SQUAMOUS	Outer layer of skin, linings of the mouth cavity, throat, vagina, & anal canal	Protection
TRANSITIONAL EPITHELIAL	Linings of the pelvis of the kidney, the ureters, urinary bladder, and the upper portion of the urethra	Stretching

Connective Tissues

Connective tissues occur in all parts of the body. They bind structures together, provide support and protection, serve as frameworks, fill spaces, store fats, and produce blood cells. Cells of connective tissues are usually farther apart than epithelial cells, and they have an abundance of materials between them (intercellular materials). This intercellular material consists of fibers and a thick gellike fluid called the matrix. The matrix is variable in type and amount, which is one of the main sources of difference between types of connective tissue. Connective tissue cells are able to reproduce. Most connective tissue have a good blood supply and are well nourished.

Major connective tissue cell types:

Fibroblasts - large star-shaped cells that are the most common connective tissue cell type. They function to produce white and yellow fibers. White fibers are composed of a protein called collagen. Collagen fibers are strong, flexible, but only slightly elastic. Yellow fibers are composed of a protein known as elastin, which has less strength than collagen fibers but is highly elastic. Fibroblasts will increase in number and active during tissue repair.

Mast cells - large cells that are widely distributed in connective tissue and are usually located near blood vessels. Mast cells contain heparin, an anticoagulant and histamine, a substance that promotes the inflqammatory response.

Mastophages (histiocytes) - almost as numerous as fibroblasts, they are usually attached to fibers. These cells play a role in immunity, they are specialized to carry out phagocytosis.

Types of connective tissue:

Loose (fibrous) connective tissue:
Cells of this tissue are mainly fibroblast that are scattered and separated by a jellylike intercellular matrix containing both yellow and white fibers. Loose connective tissue forms a thin delicate membrane throughout the body. It binds the skin to the underlying organs and fills spaces between muscles. It lies beneath most layers of epithelium, where its numerous blood vessels provide nourishment for epithelial cells. Areolar is another name for loose connective tissue.

1) **Adipose tissue** - is a specialized type of loose connective tissue that possesses an abundance of fat cells (adipocytes). Fat droplets stored in large vacuoles give the cells a swollen appearance. The cytoplasm forms a thin layer around the vacuole. Adipose tissue provides a protective cushion for internal organs, a protective insulating layer under the skin, and a storage area for energy reserves.

2) **Reticular tissue** - reticular fibers - thin delicate fibers - widely spread throughout the body, but the term reticular is restricted to areas where the fibers are associated with primitive reticular cells that give rise to macrophages. Reticular tissue forms the framework of lymphoid tissue, the liver, and bone marrow.

Dense Connective Tissue:

Dense connective tissue is composed of closely arranged arranged, tough collagenous and elastic fibers with fewer - closely arranged - cells (mostly fibroblasts) than loose connective tissue. Dense connective tissues are classified according to the arrangement of the fibers and the proportion of elastin and collagen present. Because white fibers are very strong, this type of tissue can withstand pulling forces, and it often functions to bind body parts together. The repair of tissue damage is slow, due to a relatively poor blood supply.

1) **Tendons** - connect muscle to bone

2) **Ligaments** - connect bone to bone at joints

Specialized Connective Tissue:

1) **Cartilage** - Cartilage has a firm matrix. Cells of cartilage, known as **chondrocytes**, are large and rounded with spherical nuclei and are clustered in small cavities called **lacunae**. Collagenous and elastic fibers are embedded in a solid matrix. Although cartilage lacks a direct blood supply, there are blood vessels in the connective tissue that surrounds it. Cartilage cells obtain nutrients from these blood cells by diffusion through the matrix. Repair of tissue damage is slow, due to the lack of direct blood supply. The three types of cartilage tissue are: **hytaline**, **elastic**, and **fibrocartilage**.

   a) **Hyaline Cartilage** - has a homogeneous matrix that gives a smooth glassy appearance and is white in color. It covers the ends of long bones where they articulate to form joints and supports the flexible part of the nose.
   b) **Elastic Cartilage** - yellow fibers are numerous in the matrix of elastic cartilage, making in more flexible than hyaline cartilage. It forms the framework of the external ear and the larynx.
   c) **Fibrocartilage** - the matrix contains dense fibers that makes this tissue tough and nonelastic. Fibrocartilage composes the intervertebral discs, which are cushionlike pads between the vertatebrae.

2) **Bone** - Bone is the hardest and most rigid of the connective tissue because of the large amount of calcium salts composing its matrix. The bone matrix is deposited by cells called **osteoblasts** in layers around tiny tubules known as **Haversian canals**. As the cells deposit calcium salts, they become trapped in lucunae by their own deposits. Once the matrix has been ossified by the calcium deposits, the cells within the lacunae are called **osteocytes**. In addition to the storage of calcium salts, bone provide support for the body, aids in locomotion, manufactures blood cells, and protects several vital organs.

3) **Blood** - Blood is composed of cells that are suspended in a fluid intercellular matrix called plasma. These cells include red blood cells, white blood cells, and some cellular fragments called platelets. A special tissue (hematopoitic) in bone marrow forms blood cells. Blood is a fluid tissue circulating through the body, carrying nutrients to cells and waste products away for removal.

CONNECTIVE TISSUES

TYPE	LOCATION	FUNCTION
Areolar (loose) connective tissue	Beneath the skin, between muscles, beneath most epithelial layers	Binds organs together holds tissue fluids
Adipose tissue	Beneath the skin, around the kidneys, behind the eyeballs, on the surface of the heart	Protection, insulation, and fat storage
Dense (Fibrous) connective tissue	Tendons, ligaments, skin	Binds organs together
Hyaline cartilage	Ends of bones, nose, rings in walls of respiratory passages	Support, protection provides framework
Elastic cartilage	Framework of external ear and part of the larynx	Support, protection provides framework
Fibrocartilage	Between bony parts of backbone, pelvic girdle, and knee	Support, protection
Bone	Bones of skeleton	Support, protection provides framework

Muscle Tissue:

Muscle tissues are contractile - their elongated cells or muscle fibers can change shape by becoming shorter and thicker. As they contract, the fibers pull at their attached ends and cause body parts to move. The three types of muscle tissue are: **1) Skeletal muscle**; **2) Smooth muscle**; and **3) Cardiac muscle**.

1) Skeletal muscle - is found attached to the bones of the body and can be controlled by conscious effort (voluntary). The cells are long and threadlike, with alternating light and dark cross-marking called striations. Each cell (muscle fiber) has many nuclei, located just below its plasma membrane. Skeletal muscles are responsible for moving the head, trunk, and limbs. And they are involved in such actions as chewing, swallowing, and breathing.

2) Smooth muscle - called smooth muscle because it lacks striations. This tissue is found in hollow internal (visceral) organs such as the stomach, intestines, urinary bladder, uterus, and blood vessels. Smooth muscle cannot be stimulated to contract by conscious efforts. Smooth muscle cells are shorter and thinner than skeletal muscle, and they each have a single, centrally located nucleus. Smooth muscles are responsible for movements that force food through the digestive tract, constrict blood vessels, and empty the urinary bladder.

3) Cardiac muscle tissue - occurs only in the heart. Its cells, which are striated, are joined end to end. Each cell has a single nucleus. At its ends, where it touches another cell, there is a specialized intercellular junction called an intercalated disc, which is unique to cardiac muscle. Cardiac, like smooth muscle is involuntary. Cardiac muscle is responsible for pumping blood through the heart chambers and the blood vessels.

Nervous Tissue:

Nerve tissue is found in the brain, spinal cord, and associated nerves. The basic unit of the nervous tissue is known as a neuron, which is a highly specialized cell that responds to environmental stimuli, transmits nerve impulses and coordinates and controls bodily functions.

In addition to neurons, nerve tissue contains neurogial cells. These cells function to support and bind the nerve tissue together, carry on phagocytosis, and aids in supplying nutrients to neurons by connecting them to blood vessels

Muscle & Nerve Tissues

Type	Location	Function
Skeletal (striated) Muscle tissues	Muscle attached to bone	Voluntary movements of skeletal parts
Smooth muscle tissue	Walls of hollow internal organs	Involuntary movements of internal organs
Cardiac Muscle tissue	Heart muscle	Heart movements
Nerve tissue	Brain, spinal cord, and nerve cords	Sensitivity and conduction of nerve impulses

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Specialization & Differentiation of Cells (cont.)

B) PLANT TISSUES

Plant tissues are identified and named according to their location and function. The four basic types (classes) of plant tissues are: **1) Meristematic, 2) Vascular, 3) Fundamental,** and **4) Epidermal.** These tissues makeup the organs of plants, such as leaves, stems, roots, and flowers. The arrangement of tissues in plant organs vary greatly.

1) Meristematic Tissue

Meristematic tissues in plants provide growth. All primary tissues of seed plants differentiate from a group of rapidly dividing cells known as apical meristems, located at stem and root tips. Cell division in these areas causes an increase in the plant's length and gives rise to the epidermis, cortex, pith, and some portions of the vascular tissues.

2) Epidermal Tissue

The protective covering of young plants is called the epidermis. Epidermal cells are flatten and multi-sided. They are generally a single cell layer thick forming a thin sheath. Both upper and lower epidermis of a leaf usually have a secreted cuticle of a waxy substance known as **cutin**, which aids in water retention. Many stems and leaves also possess tiny hairs which are outgrowths of epidermal cells. The epidermis also has tiny openings that regulate the exchange of water and gases with the environment. These openings, called stomta, are controlled by the shrinking or swelling of two adjacent cells (**Guard Cells**). The action of guard cells appear to be controlled by **osmotic pressure**.

3) Vascular Tissue

Vascular tissue are composed of tubelike cells that provide transport of certain fluids within the organism. The vascular tissues of plants are called **xylem** and **phloem**. Vascular bundles, which are groups of xylem and phloem, are scattered throughout the supportive tissues of the stem. Vascular bundles may also occur in the leaves and roots of plants.

a) Xylem - conducts water and minerals upwards from the roots. In this way leaves receive raw materials for use in photosynthesis. There are two types of xylem tissue; the conducting tubes called **tracheids** and those called **vessels**.

b) Phloem - conducts nutrient (sugar, amino acids, and other organic compounds) from the leaves to growing parts of the plant such as the roots and developing buds and flowers. Phloem cells are unique in that their end walls are perforated with many small openings. Phloem cells are also stacked end to end, known as **sieve tubes**.

4) Fundamental Tissue

Fundamental tissue include four basic tissue or cell type: **1) parenchyma cells, 2) collenchyma cells, 3) chlorenchyma cells** and **4) sclerenchyma cells**. The pith and cortex regions of stems are specialized for support and storage and are composed primarily of fundamental tissues. The cortex of a plant often include all three types, whereas the pith is composed of only parenchyma cells.

a) Parenchyma Cells - are found in unspecialized regions of all parts of the plant. Parenchyma cells vary in shape and generally contain a large central vacuole. They have uniformly thin cell walls pushed against each other. The functions of parenchyma cells include: food making, storage, and support. Parenchyma cells have retained the capacity for cellular division.

b) Collenchyma Cells - found beneath the epidermal layer, consists of cells with unevenly thickened walls in the corners where adjacent cells meet. these cells contain large amounts of **pectin** which gives them strength and elasticity. The cortex of growing stems and roots often contain collenchyma tissue. Collenchyma cells function in support.

c) Chlorenchyma Cells - In leaves, a different type of tissue is found under the epidermis, known as chlorenchyma cells. These cells are rectangular in shape with a high cloroplast content. The function of chlorenchyma cells is photosynthesis.

d) Sclerenchyma Cells - are much less flexible than collenchyma cells. The secondary cell walls of sclerenchyma are very thick and hard at maturity. At times the cells die and lose their cytoplasm. Sclerenchyma cells may occur in long bundles or sheath in the pith and cortex regions of plants. The function of sclerenchyma cells is protection.

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BIO K121

Laboratory Exercise 9

Photosynthesis: The Hill Reaction

****Note****

Some of the chemicals used in the following laboratory exercise may be **poisonous**. They are safe to use if **CARE** is taken in the laboratory. **DO NOT** allow chemicals to enter your mouth, or enter small cuts or scratches on your hands. **DO NOT** breathe in powders or allow them to blow around. **ALWAYS** wash your hands carefully after an experiment and follow the advice of your instructor regarding safety precautions.

Life on earth is dependent on **Photosynthesis**. Photosynthetic activity yields oxygen and carbon-containing energy molecules. Directly or indirectly, living organisms derive their carbon, hydrogen, and energy from photosynthetic green plants. This experiment will illustrate one aspect of photosynthesis - the splitting of water molecules by the chloroplasts spinach leaves in the presence of light.

In 1930, C. B. van Neil postulated that green plant photosynthesis was an oxidation-reduction process in which hydrogen was split from water (water is oxygenated) and is used to reduce carbon dioxide to a carbohydrate.

The postulated overall reaction was:

$$CO_2 + 2H_2O \text{ ----------> } CH_2O + O_2$$

This reaction requires two molecules of water for the reduction of carbon dioxide. One hydrogen pair is used to convert the carbon and one of the oxygens of CO_2 to H_2O. The oxygen atoms from the two molecules of water unite to form O_2 gas that is given off.

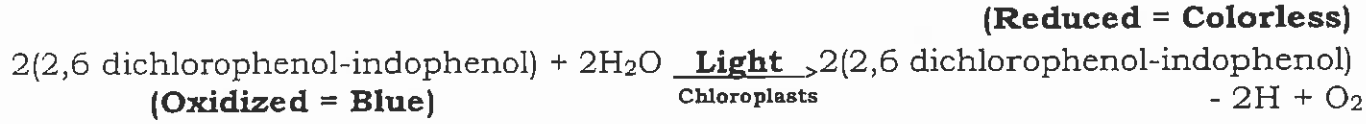
$$O{=}C{=}O + H\text{-}O\text{-}H + H\text{-}O\text{-}H \text{ --------> } \begin{matrix} & H \\ C{=}O + H\text{-}O\text{-}H + O{=}O & \\ & H \end{matrix}$$

This postulated mechanism of photosynthesis has now been experimentally confirmed by a number of different approaches. It is possible to determine the origin of O_2 in photosynthesis using isotopic tracer techniques which indicate that it comes from H_2O. In addition, it is possible to carry out this partial process of photosynthesis (the splitting of H_2O) in the laboratory.

This **photolysis** of H_2O takes place in the **photochemical** events of photosynthesis and can be carried out in the laboratory with isolated **chloroplasts**. The reaction was first demonstrated by R. Hill, and has thus become known as the Hill reaction.

The Hill reaction requires **chloroplasts** (highly organized, membrane bound organelles that specializes in photosynthesis). Isolated chloroplasts do not reduce carbon dioxide directly, a hydrogen acceptor must be supplied. The hydrogen acceptor chosen for this experiment is 2,6 diclhorophenol - indophenol which is blue in the oxidated form (hydrogens have been removed) and colorless when reduced (hydrogens have been added).

The reaction proceeds in the following manner:



Thus, by measuring the bleaching of the colored hydrogen acceptor, you may follow the course of the reaction.

Materials

250 ml Graduated cylinder	Spectrophotometer	Spinach leaves	Hot plate
Blender	Cheesecloth	Test tubes	Cuvettes
Centrifuge	Centrifuge tubes	Pipettes	60W light source
0.5M sucrose solution	10% propylene glycol	Ice bath	Glass rod

0.1% 2,6 dichlorophenol-indophenol
0.4M Potassium Phosphate buffer pH 6.5 containing 0.08M KCL

Procedure

READ ENTIRE PROCEDURE BEFORE BEGINNING !!

Hill Reaction Procedures:

Chloroplast Isolation

1) Thoroughly wash approximately 50g of **spinach leaves**. Remove all stems, including the large leaf veins, before weighing.

2) Homogenize approximately 30g of these leaves in 50ml of ice-cold **0.5M sucrose solution in a blender**. Continue to blend the mixture until it is a smooth, homogeneous, slurry with no recognizable leaf tissue present. Use short bursts of the blender. During the pauses push the leaf tissue back in contact with the blender's blades with a glass rod.

3) Filter the homogenate through two layers of **cheesecloth**. Squeezing the cheesecloth to increase the yield of filtered homogenate is appropriate. The filtrate can be collected in a beaker.

4) Distribute the filtered homogenate between two or more (depending on the yield) **centrifuge tubes** (cuvettes) and spin the suspensions at 1/2 maximum speed for 10 minutes.

5) Retain the SUPERNATANT by decanting it into fresh centrifuge tubes. Disregard the PELLET which contains a significant amount of the unhomogenized plant material.

6) Centrifuge at maximum speed for 10 minutes.

7) Discard the the supernatant.

8) Re-suspend the resulting pellet containing intact chloroplasts in 30ml ice cold **10% propylene glycol** using a glass rod. This will serve as the chloroplast suspension.

Preparation of the Experimental Tubes

1) Remove 10mL of the chloroplast suspension. Place it in a fresh tube and heat the tube to boiling. Boiling this sample of the chloroplast suspension destroys the chloroplast's functionality. This sample will be used in one of the control tubes described below. Allow the solution to return to room temperature before use.

2) Label four test tubes 1,2,3, and 4. Add the materials indicated (**Table 1**) to each tube.

	Tubes			
	1	**2**	**3**	**4**
0.4M Potassium Phosphate buffer pH 6.5 containing 0.08% KCL (ice cold)	9.0 mL	9.0 mL	9.0 mL	9.0mL
Boiled chloroplast Suspension	1.0 mL	-------	-------	--------
Chloroplast suspension	--------	1.0 mL	1.0 mL	1.0 mL

Table 1. The contents of the tubes used in this procedure. Note that 2,6-dichlorophenolindophenol (DPIP) will be added to each of these tubes later, as indicated in the following procedures.

Starting the Experiment

1) Add between 0.1 mL to 0.2mL of the 0.1% DPIP solution to tube 4 ONLY.

2) After the DPIP has been added to tube 4, add a FEW (very few) crystals of Dithionite to tube 4. Note: the addition of sodium dithionite reduces the DPIP and removes the blue color from the tube. Use this "reduced" tube 4 as a blank to set the spectrophotometer (0.0 optical density at 580 nm).

3) Place a test tube rack about 24 to 36 inches in front of a light source. Turn on the light source.

4) Add the same amount of DPIP that you added to tube 4 to the other three tubes. Add this substance quickly since those functional chloroplasts should start producing hydrogen that will reduce the DPIP even in weak room light.

5) As quickly as possible take a reading using the spectrophotometer for each of the three tubes and record this value as "Time Zero".

6) Place tubes 1 and 2 in a test tube rack in front of the light. Wrap tube 3 in aluminum foil. It can also be placed in front of the light.

7) At 4 minute intervals record the optical density of tubes 1 and 2 again. Leave tube 3 in dark until the end of the procedure.

8) Continue recording optical density at 580nm of tubes 1 and 2 until the density of tube 2 is approximately equal to the density of tube 4 or until the density of tube 2 does not change for two or three readings.

9) Remove tube 3 from its wrapper. Quickly read the density of this tube.

The Hill Reaction Data Sheet

Spectrophotometer Readings
Absorbance (nm)

Minutes	Tube 1	Tube 2	Tube 3
0			
04			
08			
12			
14			
16			
20			
24			
28			
32			

Plot the above data on a single sheet of graph paper. Plot absorbance on the y - axis and time in minutes on the x - axis.

Explain what happened in each of the three test tubes.

1) Thoroughly wash approximately 50g of **spinach leaves**. Remove all stems, including the large leaf veins, before weighing.

2) Homogenize approximately 30g of these leaves in 50ml of ice-cold **0.5M sucrose solution in a blender**. Continue to blend the mixture until it is a smooth, homogeneous, slurry with no recognizable leaf tissue present. Use short bursts of the blender. During the pauses push the leaf tissue back in contact with the blender's blades with a glass rod.

3) Filter the homogenate through two layers of **cheesecloth**. Squeezing the cheesecloth to increase the yield of filtered homogenate is appropriate. The filtrate can be collected in a beaker.

4) Distribute the filtered homogenate between two or more (depending on the yield) **centrifuge tubes** (cuvettes) and spin the suspensions at 1/2 maximum speed for 10 minutes.

5) Retain the SUPERNATANT by decanting it into fresh centrifuge tubes. Disregard the PELLET which contains a significant amount of the unhomogenized plant material.

6) Centrifuge at maximum speed for 10 minutes.

7) Discard the the supernatant.

8) Resuspend the resulting pellet containing intact chloroplasts in 30ml ice cold **10% propylene glycol** using a glass rod. This will serve as the chloroplast suspension.

7) Heat 10mL of the chloroplast suspension to boiling in a water. Cool immediately in an **ice bath**.

8) Label three test tubes 1,2, and 3, and make the following additions:

	Tubes 1	2	3
0.4M Potassium Phosphate buffer pH 6.5 containing 0.08% KCL (ice cold)	9.0 ml	9.0 ml	9.0 ml
Boiled chloroplast Suspension	1.0 ml	-------	-------

Chloroplast suspension	--------	1.0 ml	1.0 ml

9) At time zero, add 0.3 ml of 0.1% 2,6 dichlorophenol-indophenol to tube 1.

10) Transfer contents of tube 1 to a dry **spectrophotometer cuvette**.

11) Record the absorption of the solution with the spectrophotometer set at a 520 nm wavelength (green light frequency).

12) Then place tube 1 10 inches from a 60 watt light bulb. Angle the bulb so that it shines horizontally through the tube's contents.

13) Record the absorbance of tube 1 at 10 minute intervals for 40 minutes. Prior to making each reading, **shake** the tube to resuspend the clhoroplasts uniformily, then fill the cuvette.

14) Repeat steps 9 through 13 with tube 2.

15) Repeat steps 9 through 11 with tube 3, then place it in the dark. Record absorbance at 10 minute intervals for 40 minutes. Again, be sure to **shake** the tube each time **before** filling the cuvette.

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Exercise 8 - The Hill Reaction Data Sheet

Spectrophotometer Readings
Absorbance

Minutes	Tube 1	Tube 2	Tube 3
0			
10			
20			
30			

Plot the above data on a single sheet of graph paper. Plot absorbance on the y - axis and time in minutes on the x - axis.

Explain what happened in each of the three test tubes.

Extracting DNA from Onions

Introduction: Nucleic acids were first isolated from animal tissues in the late 1860's, but tremendous technological advances have occurred since then. Scientists using PCR enzymes can now extract usable DNA from scraps of hair or even fossilized insects millions of years old. In this lab we will use some fairly primitive techniques to isolate DNA from onion tissue.

Materials:

- piece of onion (approx 10 grams)
- 2 large test tubes
- mortar & pestle
- graduated cylinder (10 or 50 ml)
- 500 ml beaker, or mason jar
- bamboo kabob skewer or glass rods
- nylon netting, or small dip net, coffee filters or cheesecloth
- funnel
- small kitchen knife (or single-edge razor)
- cold ethanol
- ice bath (one per classroom may suffice)
- Detergent solution= 1 part table salt + 1 part generic shampoo concentrate + 8 parts water
- Enzyme solution= 1 part meat tenderizer powder + 19 parts water
- Plastic microfuge tubes or test tubes to save DNA

Instructions: Write detailed notes on <u>what you see and do</u> for each step below.

Methods:

1) Obtain a small piece of onion (about 10 cm^3) and chop it into tiny cubes (< 1 mm^3)

Why? The physical chopping breaks the plant's cell walls and allows the cytoplasm to leak out.

2) Place the chopped onion into the mortar and thoroughly grind it with the pestle.

Why? Grinding continues the physical breakdown of the tough cell walls.

3) Add about 10 ml of <u>detergent solution</u> and grind again.

Why the detergent? The soap breaks down the lipids (fats) in the phospholipid bi-layers of the cell membrane and nuclear membrane. This releases the nuclear material from the cell and the chromosomes containing DNA from the nucleus.

4) Filter the mixture through netting or cheesecloth into a large test tube.

Why? Filtering strains all the large cellular junk out of the mix. The DNA is so small it slips through with the liquid and into the test tube.

Caution! From this stage onward, you must be careful not to agitate the mixture.

Why? Any swirling, shaking, or turbulence may shear the fragile DNA strands!

---

5) Add about 3-4 ml of enzyme solution to the test tube.

Why? The enzymes denature (break down) the histone proteins that were keeping the DNA tightly coiled up on the chromosomes. As a result, the DNA is released and uncoils.

6) Let the mixture stand in a beaker of hot tap water for 10 minutes.

Why? Heat increases the rate of chemical reactions, and speeds the action of the enzymes.

7) Place your test tube in the ice bath to chill for several minutes.

Why? Cooling decreases the rate of chemical reactions, slowing the action of the enzymes before they destroy the DNA.

8) Carefully pour 10 ml ice-cold ethanol into test tube to form a separate layer on top. (You should see small wisps of gel forming at the boundary.)

Why? The polar/non-polar boundry layer causes the DNA to precipitate.

9) Using the bamboo skewer or glass rod, gently wind up the precipitated DNA. Show it to your instructor to verify that you have the DNA.

Why? The DNA is long and thin so it wraps around the toothpick like spaghetti on a fork!

10) You may save your DNA is a tube with some ethanol if you would like.

General Biology I
BIO K121
Summer
Genetics Lecture Note Supplement

Terms and Definitions

Gene - unit of inheritance (DNA). A short length of a chromosome, influencing a particular set of characteristics passed on through generations.

Genotype - the genetic make-up of an individual

Phenotype - the physical expression of a **gene**. Morphological, biochemical, or behavioral properties of an organism. It is possible for organisms to have the same **genotype**, but different phenotypes (environmentally-produced variation).

Allele - an alternate form of a **gene**. Two or more alternate forms of a gene at a given position (locus) on **homologous chromosomes**.

Locus (pl. Loci) - the particular site where a **gene** is found n a chromosome. **Homologous chromosomes** have corresponding **loci**.

Homologous Chromosomes - paired chromosomes that have the same kind of genes at the **loci** on each chromosome, the chromosomes are also identical in relation to their size, shape, and position of their centromeres. One **homologous chromosome** is inherited from each of the organisms parents.

Homozygous - having identical **alleles** for a given trait. When a **gene** and its allele produces the same effect on a trait; **AA** or **aa**.

Heterozygous - having different **alleles** for a given trait. When a **gene** and its allele produces different effects on the same trait; **Aa**.

Dominance or Dominate Allele - an **allele** whose expression masks the expression of its partner on the **homologous chromosome**. The **allele** that is fully expressed in its **phenotype**.

Recessive Allele - alleles that are not expressed in the presence of dominate alleles. Their trait cannot only be expressed in the homozygous (**AA** or **aa**) condition.

Epitasis - when a gene on one locus supresses the expression of a gene on another locus.

Aneuploidy - cells or gametes with chromosome numbers that differ from the normal.

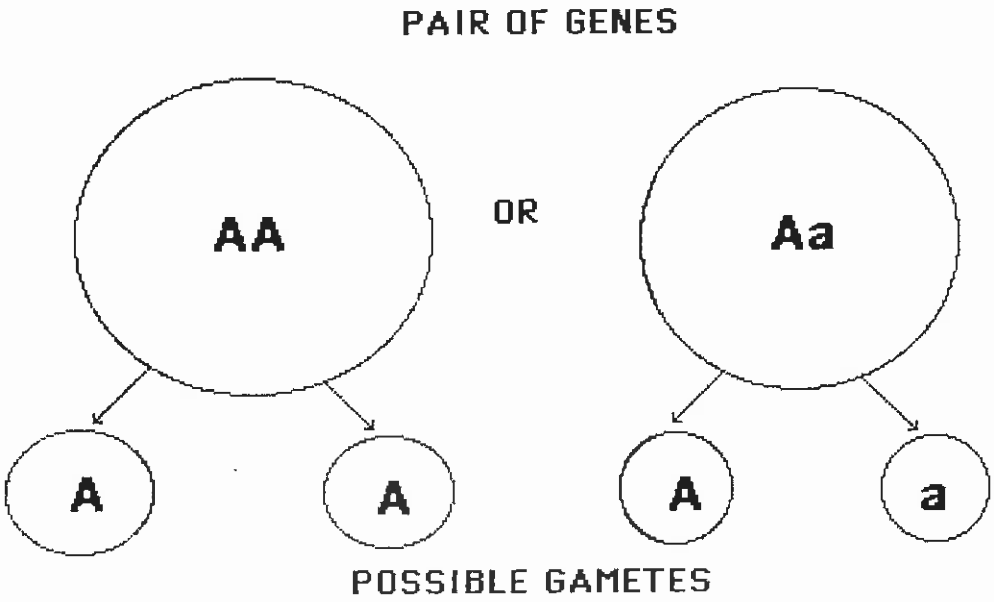
a) **Trisomic** - aneuploid cells or gametes having the normal diploid number plus one.

b) **Monosomic** - aneuploid cells or gametes that lack one chromosome.

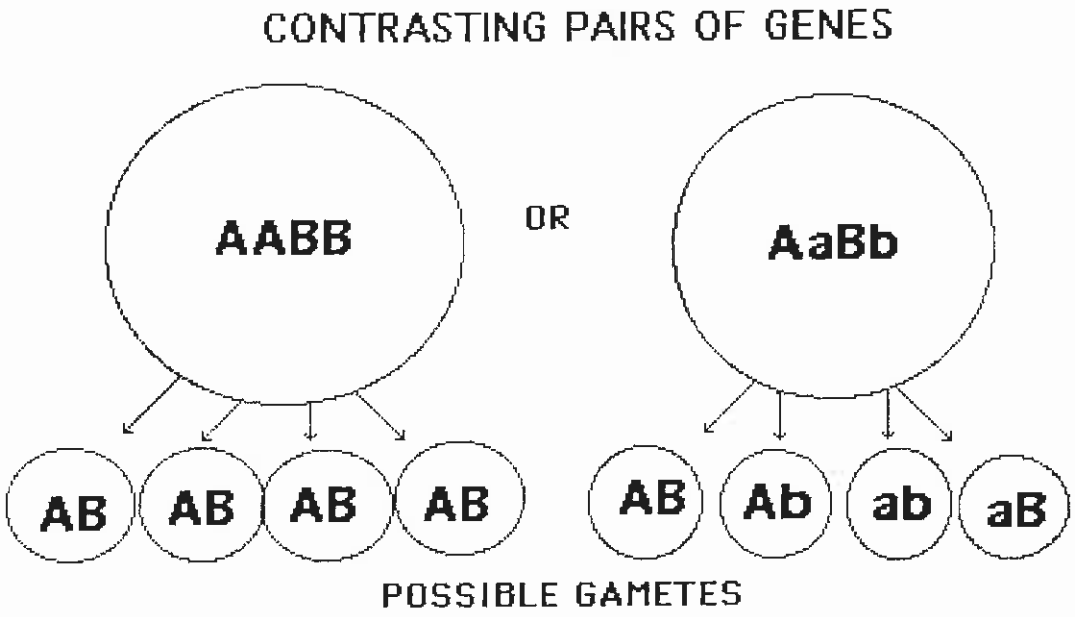
c) **Polyploid** - aneuploid cells or gametes that end up with three or more of each type of chromosome characteristic of the parental stock.

Important genetic concepts:

1) **Law of Segregation of Gametes** - Genes in an organism exist as pairs. When that organism produces gametes, there will be one and only one of each kind of gene in each gamete formed.



2) **Law of independent Assortment** - When two or more contrasting gene are within the individual, the genes from one pair will segregate from its member and go into the gametes independently of the segregation of the other pair of genes.



3) **Complimentary genes** - two independent pairs of genes acting on the same traits so that a dominant gene from both pairs is needed to express the trait.

ccEE	**X**	**CCee**	---------->	**CCEe**
(colorless)		(colorless)		(color)

One of the most common human genetic disorders arises from nondisjunction during gamete (usually ovum) formation. Down syndrome results from nondisjunction in one of the 23 pairs of human chromosomes, chromosome 21. An individual with Down syndrome has three copies of chromosome 21 instead of the normal two copies. While symptoms of this genetic disorder vary greatly, most individuals show moderate to severe mental impairment and a host of associated physical defects. Relatively few other human genetic disorders arise from nondisjunction, probably because the consequences of abnormal chromosome number are often lethal.

~~**Note: Remove marking ink from pop beads with 95% ethanol and tissues.**~~

2 Meiosis in Animal and Plant Cells (About 40 min)

Now that you have a conceptual understanding of meiosis, let's see the actual divisions as they occur in living organisms.

MATERIALS

Per lab room:

- set of demonstration slides of meiosis in animal testes and lily anther
- set of demonstration slides of meiosis in mammalian ovary

Per student pair:

- scissors
- tape or glue

PROCEDURE

A. Spermatogenesis in Male Animals

In animals, as mentioned previously, meiosis results in the production of gametes—ova in females and sperm in males.

1. Examine Figure 12-13, which depicts sperm formation in a seminiferous tubule within human testes. A diploid reproductive cell, the *spermatogonium,* first enlarges into a *primary spermatocyte.* The primary spermatocyte undergoes meiosis I to form two haploid *secondary spermatocytes.* After meiosis II, four haploid *spermatids* are produced, which develop flagella during differentiation into four *sperm cells.* This process is called *spermatogenesis.*
2. Examine the demonstration slide of spermatogenesis in animal testes. Under low power, note the many circular structures. These are the seminiferous tubules, where spermatogenesis takes place. See Figure 12-14.

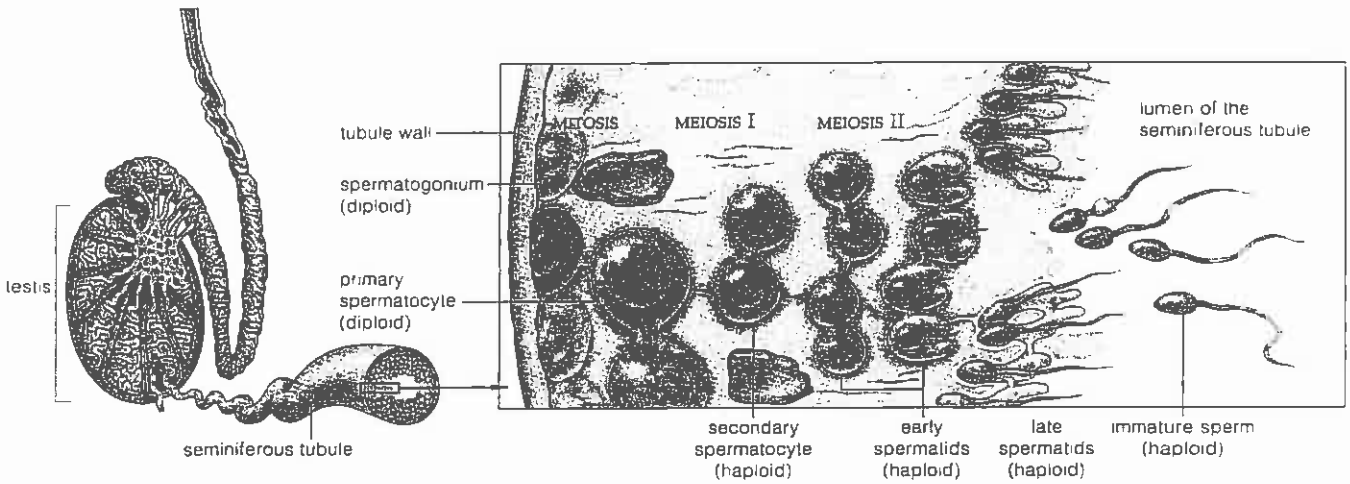


Figure 12-13 Spermatogenesis within testes in male animals. (After Starr, 2000.)

The diploid reproductive cell, called an *oogonium*, grows into a *primary oocyte*. The primary oocyte undergoes meiosis I, one product being the *secondary oocyte*, the other a *polar body*. Notice the difference in size of the secondary oocyte and the polar body. This is because the secondary oocyte ends up with nearly all of the cytoplasm after meiosis I.

In humans and other mammals, secondary oocytes are released from the ovary. If fertilization occurs, a sperm penetrates the secondary oocyte, which then continues through meiosis II. Following meiosis II, only the secondary oocyte becomes a mature, haploid *ovum;* depending on the species, the polar body may or may not undergo meiosis II. In any case, the polar bodies are extremely small and do not function as gametes.

2. Examine the demonstration slides of oogenesis in an animal. Identify the follicles within which oogenesis begins. Also identify oocytes that may be in various stages of development. (See Figures 12-17 and 12-18.)

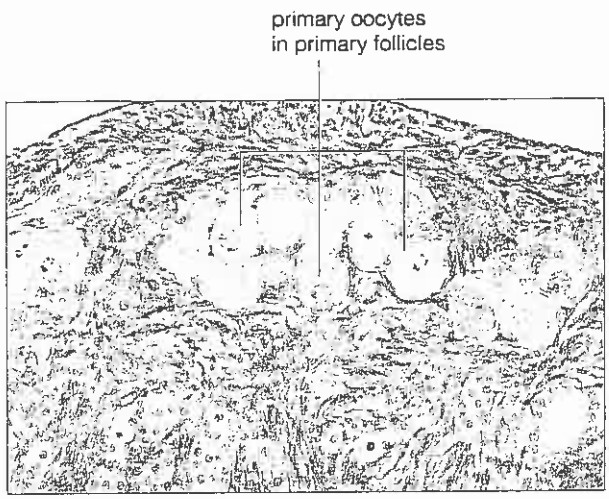


Figure 12-17 Section of mammalian ovary with primary follicles (220×). (Photo by D. Morton.)

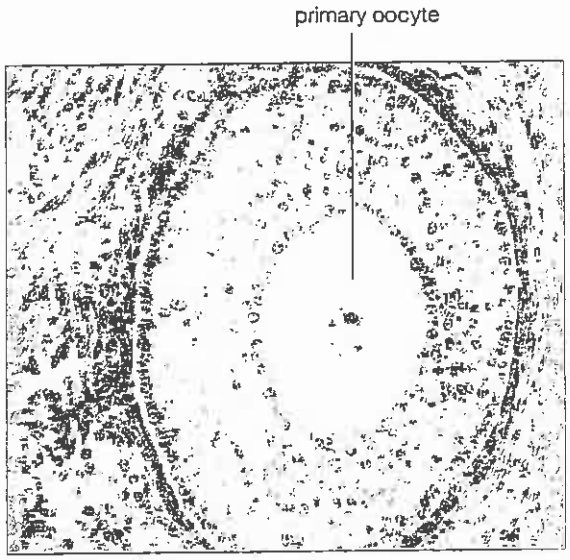
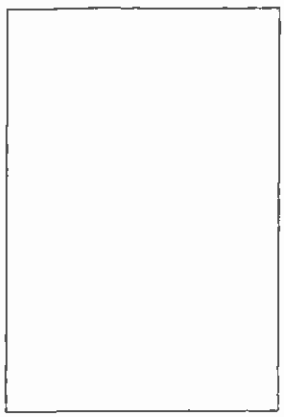


Figure 12-18 Section of mammalian ovary with primary oocyte (376 ·). (Photo by D. Morton.)

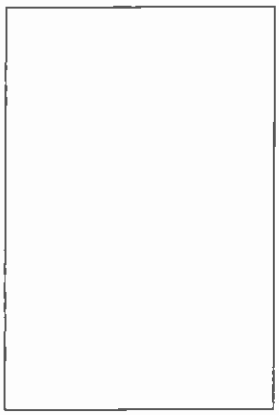
C. Meiosis in Plants

For the sake of brevity, we will only examine meiosis in the male reproductive structure of flowering plants. Recall from our earlier discussion that meiosis in plants results in spore production, not directly into gametes. The details of the life cycle of flowering plants is considered in Exercise 25.

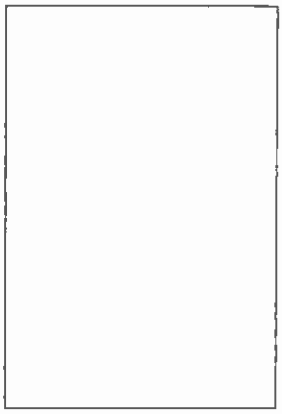
1. Examine the demonstration slides of meiosis beginning with the diploid *microsporocytes*. Microsporocytes are the cells within a flower that undergo meiosis to produce haploid *microspores*. Eventually these microspores develop into pollen grains, which in turn produce sperm.
2. As you examine the slides, cut out the photomicrographs on pages 175 and 177 and arrange them on Figure 12-19 to depict the meiotic events leading to microspore formation. Label each photo with the terms provided.
   (a) *Interphase.* During interphase, the *nucleus* of each diploid *microsporocyte* is distinct, containing granular-appearing chromatin. The cells are compactly arranged.
   (b) *Early prophase I.* Now the chromatin has begun to condense into discrete *chromosomes*, which have the appearance of fine threads within the nucleus.
   (c) *Mid-prophase I.* Additional condensation of the *chromosomes* has taken place. Pairing of homologous chromosomes is taking place.
   (d) *Late prophase I.* The chromosomes have condensed into short, rather fat structures. Synapsis and crossing over are taking place. Note that the nuclear envelope has disorganized.
   (e) *Metaphase I.* The homologous chromosomes lie in the region of the *spindle equator.* The *spindle*, composed of *spindle fibers*, can be discerned as fine lines running toward the *poles*. (Note the absence of centrioles in plant cells.)
   (f) *Early anaphase I.* Separation of homologous chromosomes is beginning to take place.
   (g) *Later anaphase I.* Homologous chromosomes have nearly reached the opposite poles. Reduction division has occurred.



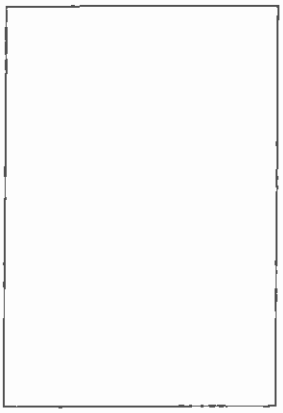
Interkinesis
Labels: nuclei, cell wall, daughter cells



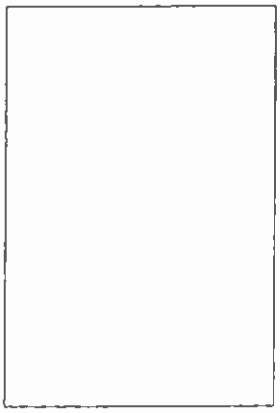
Prophase II
Labels: daughter cells, nuclei



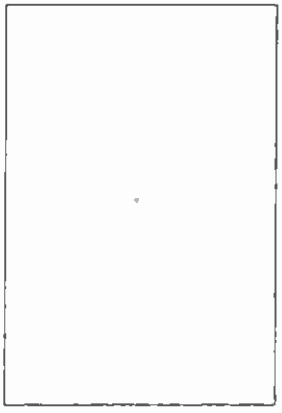
Metaphase II
Labels: chromosomes, spindle equator



Anaphase II
Labels: sister chromatids (unduplicated chromosomes)



Telophase II
Labels: cell plate, nuclei



Cytokinesis
Labels: cell plate, nuclei

(h) *Telophase I.* The homologous chromosomes have aggregated at opposite poles. The spindle remains visible.

(i) *Cytokinesis I.* The *cell plate* is forming in the midplane of the cell. Spindle fibers, which are aggregations of microtubules, are visible running perpendicularly through the cell plate. The microtubules are directing the movement of Golgi vesicles, which contain the materials that form the cell plate.

A nuclear envelope has re-formed about the chromosomes, resulting in a well-defined nucleus in each *daughter cell.*

(j) *Interkinesis.* In these plant cells, a short stage exists between meiosis I and II. Distinct nuclei are apparent in the two daughter cells. A cell wall has formed across the entirety of the midplane.

(k) *Prophase II.* The chromosomes in each nucleus of the two daughter cells condense again into distinct, threadlike bodies. As was the case at the end of prophase I, the nuclear envelope disorganizes.

(l) *Metaphase II.* Chromosomes consisting of sister chromatids line up on the spindle equator in both cells. (The photomicrograph shows the very early stages of separation of the chromatids.)

(m) *Anaphase II.* The sister chromatids (now more appropriately considered *unduplicated chromosomes*) are being drawn to their respective poles in each cell.

Name _____ Section Number _____

EXERCISE 12

Meiosis: Basis of Sexual Reproduction

POST-LAB QUESTIONS

Introduction

1. If a cell of an organism has 46 chromosomes before meiosis, how many chromosomes will exist in each nucleus after meiosis?

2. What basic difference exists between the life cycles of higher plants and higher animals?

3. In animals, meiosis results directly in gamete production, while in plants meiospores are produced. Where do the gametes come from in the life cycle of a plant?

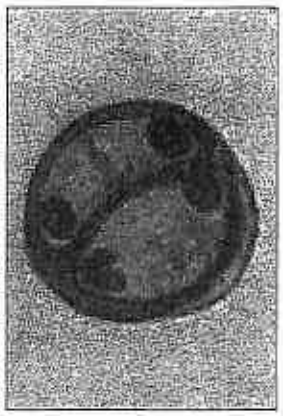
4. How would you argue that meiosis is the basis for sexual reproduction in plants, even though the *direct* result is a spore rather than a gamete?

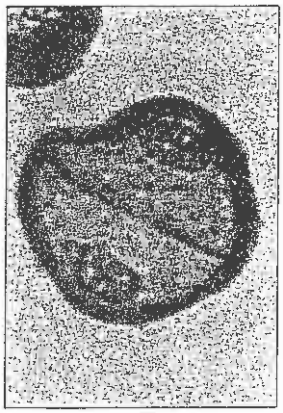
12.1 Demonstrations of Meiosis Using Pop Beads

5. Suppose one sister chromatid of a chromosome has the allele *H*. What allele will the other sister chromatid have? (Assume crossing over has not taken place.) _____

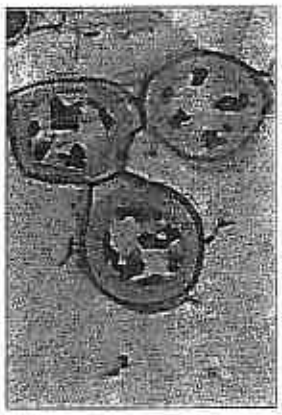
6. Suppose that two alleles on one homologous chromosome are *A* and *B*, and the other homologous chromosome's alleles are *a* and *b*.
   a. How many different genetic types of gametes would be produced *without* crossing over? _____
   b. What are the genotypes of the gametes? _____
   c. If crossing over were to occur, how many different genetic types of gametes could occur? _____
   d. List them. _____

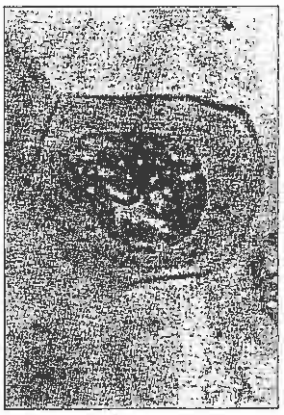
Photomicrographs for Figure 12-19 Meiosis in anther of a flowering plant. Cut from this page and arrange in proper sequence in Figure 12-19. (1200×) (Photos by J. W. Perry.) Continues on next page.





Photomicrographs for Figure 12-19 (continued) Meiosis in anther of a flowering plant. Cut from this page and arrange in proper sequence in Figure 12-19. (1200×) (Photos by J. W. Perry.)





Genetics Problems
Mendelian Genetics

1. In guinea pigs, short hair is dominant to long. A short haired (try all possibilities) guinea pig was mated to a long haired one. What proportion of the offspring will be:

a. homozygous long haired
b. homozygous short haired
c. heterozygous long haired
d. heterozygous short haired

2.A husband and wife both have normal skin pigmentation. Their first child is an albino. Give the genotypes of the parents and of the albino child. What is the chance that their second child will be albino. What is the chance that if they have a third child, it will be albino?

3. In humans, right handedness (R) is dominant over left handedness (r). A right handed man whose mother was left handed marries a right handed woman whose father and three of her sisters were left handed. What chances will the children of this marriage have of being left handed?

4. If two plants, both short, are mated the offspring is 75 short plants and 28 tall. Explain and diagram the cross. Which is dominant?

5. Two normal parents produce a child suffering from sickle cell anemia. What is the chance that their next child will also have this anemia?

6. What will the probable blood type be of a child if...

a. parents are AB and O?
b. parents are A and B?
c. parents are AB and B?
d. Parents are O and O?

7. Explain the following ratios...3:1 and 9:3:3:1

8. Determine the possible gametes produced by the following genotypes:

a. AaBb b. AaBbCcDd

9. In human, a type of blindness called aniridia (A) and migraine headache (M) are both dominant to the normal traits. What are the chances that two AaMm people both suffering from the diseases would produce a normal child with neither trait?

10. In peas, a cross between a yellow plant and a green plant yields 61 yellow and 57 green plants. Diagram the cross.

Epidemiology Laboratory

An epidemic is defined as a widespread outbreak of disease. When epidemics are worldwide, like HIV, they are called pandemics while diseases always present in society, like the common cold, are endemic. Epidemiologists study epidemics and must understand how and why an outbreak occurred. Many organizations, such as your local and state health departments, the Centers for Disease Control (CDC) and World Health Organization (WHO), are responsible for studying, tracking and preventing disease spread. They do this through education, identification of new or emerging diseases, disease treatment, tracking disease spread, vaccination, and conducting research. For example, the disease tuberculosis must be tracked when an outbreak occurs to be sure everyone exposed is treated, including health care workers, and that treatment is effective (often medication maybe given for 6 months).

For this laboratory, you will simulate an epidemic in the classroom. Each student will receive a test tube of "bodily fluids" with a number. Each student will then exchange "bodily fluids" with three students. Following the exchange, students will see the instructor for disease testing. A positive test will change from clear to pink.

Directions:

1. Each student should obtain one test tube and note the number.

2. By carefully mixing two test tubes together, exchange fluids with 3 other students. Each student should end up with approximately the same amount of fluid in each tube.

3. When exchanging, you should note the number of each student and the order of exchange. The order, 1st exchange, 2nd exchange and 3rd exchange is very important, please do not mix these up.

4. Following your exchanges, go to the instructor to get "tested". Note whether you have become positive (pink) or remained negative (clear or white).

5. Once you have exchanged with 3 students and been tested, put your data on the blackboard along with the entire class.

6. Examine the data and try to determine which student started the epidemic (only 1 person started the epidemic).

Hints of Faculty:

1. The 20 test tubes contain water (pH 7 or so) and 1 test tube has been contaminated with NaOH. The testing material is a pH indicator, phenolphthalein 5% in alcohol, that will turn positive in the presence of the base (pH 10 or so). For testing the tubes, simply add a few droppers of the phenolphthalein directly into the test tubes, a positive will turn pink immediately.

2. When students exchange, tell them to be cautious not to spill. They can mix with each other simply by pouring one tube into another.

3. Students must keep track of their number and the three numbers they exchanged with and put all data on the board. Similar to the table below.

4. Once the data is complete, the students can work to narrow the outbreak to the person who was initially infected. You can do this as a class, lab groups or have them analyze it for a laboratory report.

5. Follow the exercise with a discussion of how epidemiologists must control outbreaks by finding out how an outbreak began including whether it is a human or animal host, the first case, how it spreads {incubation period (short or long, symptomatic or asymptomatic, HIV spreads very effectively b/c of the long incubation period and asymptomatic early disease), mortality (high or low, Ebola stops spreading quickly b/c of the quick death), mode of transmission (airborne, direct contact, indirect contact, droplet etc)}, vaccination, effective treatment, length of treatment, knowledge of disease etc. You can begin the laboratory by defining these terms and follow up with the discussion.

Name/#	Positive?	Exchange # 1	Exchange # 2	Exchange # 3
# 1				
# 2				
# 3				
# 4				