

Advanced Placement Biology

Mrs. Lijek



Summer Assignment 2015

Welcome to AP Bio!

Our textbook for next year is "*Biology: the Unity and Diversity of Life*" by Starr and Taggart (11th edition). You have received it before the summer so you can begin to look through it and familiarize yourself with its structure. To get a proper head start on A.P. Biology in the fall, please do the following summer assignment:

On the school website Please find and print
the assignments described below:

<http://www.belmont.k12.ma.us/bhs/summer/>

I. **Cover your textbook** - keep them looking good, please! You can keep them at home during the year. *N.B.: We encourage (but don't require) AP Biology students to purchase a copy of the textbook for you to highlight and take notes in. Be sure to get the 11th edition to match with the class set!!

II. a.) Read three chapters in the textbook:

Chapter 45 - Population Ecology

Chapter 2 and 3 - Biochemistry

b.) Please do the study guides for chapters 3 and 45 (not ch.2). You do not need to answer the essay review questions at the end (but do the multiple choice questions!). The guides will be graded during the first week in September. If you prefer, you can take hand-written notes (at least 3 pages per chapter) instead of doing the study guides. HOWEVER, you must do the review quiz multiple choice questions at the end of each study guide.

III. **Perform the attached field activity** which asks you to collect data, graph and analyze it. These are important skills that are required for AP biology. The topic is connected to the material in Chapter 45.



Please email me with any questions you may have. I will respond to you as soon as possible (given vacation time, etc.) - slijek@belmont.k12.ma.us

I am looking forward to getting to know you and teaching you so much exciting biology in the coming year! Sincerely, Mrs. Lijek

Human Population Ecology

Advanced Placement Biology

Mrs. Lijek, Belmont High School

(adapted from Dr. Bruce W. Grant, Widener University)



Synopsis of the Lab

You will visit a cemetery of your choosing (outside Belmont is encouraged!) and record dates of births and deaths etched on the headstones. You will create graphs of the data to help you interpret them. You will examine demographic parameters such as survivorship and mortality of males and females during two time intervals: deaths pre-1950 or post-1950. You will compare the data and suggest some causes for the results.

Objectives for the Lab

- (1) You will understand some of the basic concepts of population demography - survivorship and mortality.
- (2) You will work with real data to learn how to graphically analyze the data.
- (3) You will understand how cultural factors may have affected the human demography of the people buried in your cemetery over the past 150 years.
- (4) You will be able to use this type of information to understand how scientists learn about human impacts on other animals.

What Is Due from This Activity? (Neatly bound together, descriptive overall title, each section titled (see below), typed, 1 $\frac{1}{2}$ spacing, with a table of contents using the order below, with page numbers, footnote resources (at least 4), 3-hole punched!)

(1) **Abstract:** Summarize your fieldwork and analysis in $\frac{1}{2}$ - 1 page. Interpret the data by incorporating the demographics for your population with the cultural issues of their time. Include your **conclusions** about the results. Summarize what you have learned and its value to you. Suggest any improvements to this activity and provide your **opinion** of this activity.

(2) **Introduction:** Describe where you went and **research** what types of demographics are found in the cemetery (relative wealth of the population, other socio-economic/cultural information, etc.)

(3) **Graphs:** 1) Survivorship Curve (curved best-fit line, not linear regression) showing the male/female survivorship by age interval for both time periods (4 lines) on the same graph, and 2) a survivorship graph (curved best-fit line) of the human data in your textbook (p.808).

(4) Typed *questions* and answers to all questions at the end of this handout (be sure to research your answers).

(5) Your original data (Data Sheet #1) with at least **200** data points (100 points for each time interval), which you collected at the cemetery. Feel free to collect more data points! (You will need to make copies of the provided blank data sheets or type your own.)

(6) Your "Calculations of Survivorship" table of your data (Data Sheet #2).

(7) Resources cited (MLA or APA format) and **annotated** that support your ideas.

Introduction

Local cemeteries are an excellent place to study human demography. Etched in the gravestones are the dates of birth and death of the person below, at least in most cases. From these data, we can calculate death rates and draw survivorship curves. A survivorship curve is simply a graphical representation of the chance that an individual will survive from birth to any particular age. By comparing survivorship curves for different periods of time we may look for historical trends in demography over the decades. Also, different cemeteries may represent different socio-economic cross-sections of the population, and comparing data among cemeteries may reveal different patterns of mortality.

Over the last few centuries, advances in health care and large-scale global political conflict have left rather opposing marks on the demographics of the U.S. population. Two major time intervals stand out: before 1950 and from 1950 to the present. Firstly, the time interval before 1950 includes the industrial revolution, the ravaging effects of polio, the 1918 influenza pandemic, infections and other presently curable diseases, as well as World Wars I and II. Following 1950, numerous vaccines and antibiotics were widely used and, with the exception of the Korean, Vietnam, and Gulf Wars (not to mention a few other incidents...), this has been an era of relative peace in North America. However, new pandemics have emerged such as AIDS. What are your predictions about how the demographics of the United States population have changed during these two time periods?

In order to study the demography of a population, we would have to study all of the local cemeteries and assume that no one emigrated from the area and was buried elsewhere. Neither is likely. Thus for now, we will assume that the cemeteries you will visit are representative of all humans in the area, although we should be aware of these sorts of biases in the data.

Methods for the Lab

Study Sites: Choose a cemetery to visit. Be creative with your choice! Consider using a cemetery where you vacation. Record its name and location on Data Sheet #1.

Data Collection: Collect data from headstones in the following categories: (200+ total)

Time Period 1: FEMALES WHO DIED BEFORE 1950 - 50 headstones

Time Period 1: MALES WHO DIED BEFORE 1950 - 50 headstones

Time Period 2: FEMALES WHO DIED AFTER Jan. 1, 1950 - 50 headstones

Time Period 2: MALES WHO DIED AFTER Jan 1, 1950 - 50 headstones

PLEASE DO NOT DUPLICATE DATA WITH ANY OTHER CLASS MEMBER, although it's fine if you visit the same cemetery together. Also, if you visit a cemetery, at all times behave with respect and restraint when collecting these data. It is customary to avoid, where possible, walking on top of the graves. Most cemeteries do not allow picnics on the grounds.

Data Analysis

To estimate demographic characteristics of a population, we need to know the ages of people when they died for each sex and time interval. To get this, examine your field data sheets (Data Sheet #1), and count the number of people who died in 10 year intervals, 0-9, 10-19, etc.

Use Data Sheet #2 to guide you through the calculations to estimate the survivorship for each age interval. Plot the data on graph paper or on the computer. (Do NOT use plain, unlined paper.)

Steps for Data Analysis (see sample table for help)

1. On top of each Data Sheet #2, record the type of data for each page (MALES or FEMALES, DIED BEFORE or AFTER 1950).
2. **Column A:** Record the number of people who died for each 10-year age interval listed (0-9, 10-19, etc.) from your data set from Data Sheet #1.
3. At the bottom of the table, write down the total number of people who died in this data set (i.e., add all of the numbers in the column= N_1).
4. **Column B:** Determine the number of people living at the start of each interval (people who survived the previous age interval). Age interval 0-9 will be the N_1 number. To determine the numbers below it, take the number above and subtract the deaths from the same row (above).
5. **Column C:** Determine the cumulative number of survivors at the end of each interval by subtracting the number who died from the survivors in that interval. ($N-D$). This number will be the same as those in column B but off by one line.
6. **Column D:** The chance of surviving each time interval is determined by dividing the survivors (column C) by the number of living in the time interval (column B). [*Example from Sample Sheet:* if you survive to age 50, there is a 100% chance of reaching age 59.]
7. **Column E:** To determine cumulative SURVIVORSHIP (chance of surviving from birth to age 109), divide the number in column C by the total that you found at the bottom of column A (N_1).
8. Use graph paper or the computer (NOT plain paper) to plot the SURVIVORSHIP from column E as a function of age interval from your data for each group. Your graph will be graded on the accuracy, neatness, and conforming to the rules for making graphs.
9. Make a graph of the "Life Table for the U.S. Population in 2001" in your textbook (p.808). You will need to calculate the cumulative survivorship for this table before making the graph of survivorship.

Questions to Answer
After You Have Collected and Graphed Your Data
(be sure to type *questions* as well)

I. Data Interpretation

Q #1: Which *time interval/s* individuals had the best chance of surviving to the age of:
 a) 0-10 years b) 11-20 years c) 31-40 years d) 71-80 years

Q#2: Which *sex* had the greater chance of surviving to the age of:
 a) 0-10 years b) 11-20 years c) 31-40 years d) 71-80 years

Q #3: Find at least 2 sources (reference in the body of your answer) and explain some reasons for the differences in survivorship trends you noticed above.

Q #4: Using your data, estimate (don't graph actual data) and *sketch* what an age structure diagram would look like (see samples in text, p. 815) for the two time intervals. Describe what type of growth each time period displays. Explain why you think this. What do you think the most recent diagram predicts about the future population growth of the U.S.?

If your data are from outside the U.S., how do your graphs/age structure diagrams compare to that of the U.S. (from your text)? Research and reference at least 2 sources to explain any differences you notice between the two countries. What do you think the most recent diagram predicts about the future population growth for the country of your data?

II. Analysis and Conclusions

Q #5: Why might data that you have collected be useful to a life insurance company? Include information about what an "actuary" does.

How would this information affect a health insurance company? Many people carry recessive and hidden genetic defects that sometimes pre-dispose the carrier population to a curve of higher disease incidence and mortality. Even though carriers of such defects may have no physical symptoms, what do you think would happen to his or her health insurance premium if his or her insurance company found out about the hidden genetic defect? Do you believe that this is fair to the individual? to the insurance company? Learn about GINA and explain the impact of this legislation.

Q#6: Give specific examples of the types of information that human survivorship curves and age structure diagrams reveal for different cultures. Discuss, using two examples, why this type of data collection and analysis is valuable to a culture/country in the long term.

Q#7: Many people regard the rapid population growth of developing countries as our most serious environmental problem. Others think that the population growth in developed countries, though smaller, is actually a greater threat to the environment. What kinds of problems results from population growth in a) developing countries and b) the industrialized world? Which do you think is the greater threat? Why?

Q#8: The mountain gorilla, spotted owl, giant panda, snow leopard, and grizzly bear are all endangered by human encroachment on their environments. Another thing these animals have in common is that they all have equilibrial life histories. Why might they be more easily endangered than animals with opportunistic life histories? What general type of survivorship curve would you expect these species to exhibit? Explain your answer.

these species to exhibit? Explain your answer.

DATA SHEET 1: RAW DATA

HEADSTONES YOU NEED TO FIND: _____

(above write MALES or FEMALES, DIED BEFORE or AFTER 1950)

Range of Death years:

death year - birth year _____ = age at death	death year - birth year _____ = age at death	death year - birth year _____ =age at death
death year - birth year _____ = age at death	death year - birth year _____ = age at death	death year - birth year _____ = age at death
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DATA SHEET 2: Calculations of Survivorship

Type of Headstones You Found: _____

(above write: MALES or FEMALES, DIED BEFORE or AFTER 1950)

	A	B	C	D	E
Age Interval (in years)	Number of Deaths per Age Interval	Number Living at Start of Interval	Cumulative Survivors at End of Interval	Chance of Surviving Each Time Interval	Cumulative Chance of Surviving to End of Interval $(N-D)/N_1^*$
	(D)	(N)	(N - D)	(N-D)/N	
0-9					
10-19					
20-29					
30-39					
40-49					
50-59					
60-69					
70-79					
80-89					
90-99					
100-109					

* N_1 = total data points on this table (number of headstones you found in this category)

45

POPULATION ECOLOGY

INTRODUCTION

This chapter introduces the principles by which biologists study populations of a species. It is important as you progress through the chapter that you distinguish between the many terms associated with describing populations, such as size, density, and structure. The final sections of the chapter apply the knowledge of population structure to humans, and discuss some of the challenges facing human population growth.

FOCAL POINTS

- Figure 45.5 [p.804] and Figure 45.8 [p.807] together illustrate a key concept, the difference between exponential and logistic population growth models.
- Figure 45.11 [p.809] explains the differences between the three forms of survivorship curves.
- Figure 45.17 [p.815] illustrates the different forms of age structure in populations based on their rate of growth.

Interactive Exercises

The Numbers Game [pp.800–801]

45.1. CHARACTERISTICS OF POPULATIONS [p.802]

45.2. ELUSIVE HEADS TO COUNT [p.803]

45.3. POPULATION SIZE AND EXPONENTIAL GROWTH [pp.804–805]

Selected Words: *pre-reproductive*, *reproductive*, and *post-reproductive* ages [p.802], *habitat* [p.802], *crude density* [p.802], *interspecific* interactions [p.802], *capita* [p.804]

Boldfaced, Page-Referenced Terms

[p.801] ecology _____

[p.802] demographics _____

[p.802] population size _____

[p.802] age structure _____

[p.802] reproductive base _____

[p.802] population density _____

[p.802] population distribution _____

[p.803] quadrats _____

[p.803] capture-recapture methods _____

[p.804] immigration _____

[p.804] emigration _____

[p.804] migration _____

[p.804] zero population growth _____

[p.804] per capita _____

[p.804] net reproduction per individual per unit time (r) _____

[p.805] exponential growth _____

[p.805] doubling time _____

[p.805] biotic potential _____

Matching

Choose the most appropriate statement for each term. [p.802]

- | | |
|---|---|
| 1. ____ demographics | A. Includes pre-reproductive and reproductive age categories |
| 2. ____ population size | B. The general pattern in which the individuals of the population are dispersed through a specified area |
| 3. ____ population density | C. When individuals of a population are more evenly spaced than they would be by chance alone |
| 4. ____ habitat | D. The number of individuals in some specified area or volume of a habitat |
| 5. ____ population distribution | E. Occurs only when individuals of a population neither attract nor avoid one another when conditions are fairly uniform through the habitat, and when resources are available all the time |
| 6. ____ age structure | F. The number of individuals in each of several to many age categories |
| 7. ____ reproductive base | G. The measured number of individuals in a specified area |
| 8. ____ crude density | H. The number of individuals that contribute to a population's gene pool |
| 9. ____ pre-reproductive, reproductive, and post-reproductive | I. The type of place where a species normally lives |
| 10. ____ clumped dispersion | J. Categories of a population's age structure |
| 11. ____ nearly uniform dispersion | K. The vital statistics of a population |
| 12. ____ random dispersion | L. Individuals of a population form aggregations at specific habitat sites; most common dispersion pattern |

Short Answer

13. A zoologist wishes to estimate the population size of a species of salamander. Initially, 10 salamanders are caught and marked with an orange, waterproof dye. After six months the scientist returns and captures 5 marked salamanders out of a total catch of 50. What is the population size of the salamanders? [p.803]

14. List three variables that may have caused error in the above estimate of population size. [p.803]

Matching

Match each of the following statements to the correct term. [pp.804–805]

- | | |
|--|---------------------------|
| 15. ____ Growth at a proportional rate, such as a fixed percentage of the population per year. | A. per capita rates |
| 16. ____ The departure of individuals from a population | B. r |
| 17. ____ Net reproduction per individual per unit time | C. zero population growth |
| 18. ____ A balanced number of births and deaths | D. biotic potential |
| 19. ____ Rates per individual | E. doubling time |
| 20. ____ The arrival of new individuals from other populations | F. exponential growth |
| 21. ____ The maximum rate of increase per individual under ideal conditions | G. emigration |
| 22. ____ The time it takes for a population to double its size | H. immigration |

Problems

23. Consider the equation $G = rN$, where G = the population growth rate per unit time, r = the net population growth rate per individual per unit time, and N = the number of individuals in the population. Assume that r remains constant at 0.2. [p.805]

a. As the value of G increases, what happens to the value of N ?

b. If the value of G is negative, what happens to the value of N ?

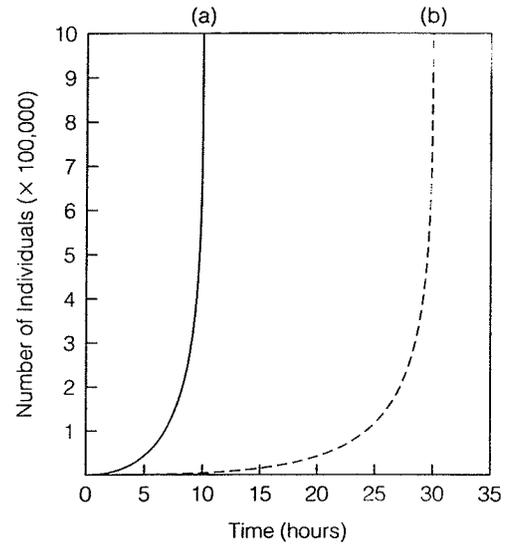
c. If the net reproduction per individual stays the same and the population grows faster, then what must happen to the number of individuals in the population?

24. Look at line (a) in the accompanying graph. After seven hours have elapsed, approximately how many individuals are in the population? [p.805]

25. Look at line (b) in the same graph.

a. After 24 hours have elapsed, approximately how many individuals are in the population? [p.805]

b. After 28 hours have elapsed, approximately how many individuals are in the population? [p.805]



45.4. LIMITS ON THE GROWTH OF POPULATIONS [pp.806–807]

45.5. LIFE HISTORY PATTERNS [pp.808–809]

45.6. NATURAL SELECTION AND LIFE HISTORIES [pp.810–811]

Selected Words: sustainable supply of resources [p.806], “survivorship” [p.808], Type I curves [p.809], Type II curves [p.809], Type III curves [p.809]

Boldfaced, Page-Referenced Terms

- [p.806] limiting factor _____

- [p.806] carrying capacity _____

- [p.806] logistic growth _____

- [p.807] density-dependent controls _____

- [p.807] density-independent factors _____

- [p.808] life history pattern _____

- [p.808] cohort _____

- [p.809] survivorship curve _____

Matching

Match each of the following terms to the most appropriate statement.

- | | |
|---|--|
| 1. _____ limiting factor [p.806] | A. An essential resource that is in short supply. |
| 2. _____ life history patterns [p.808] | B. The maximum number of individuals of a population that the environment can sustain. |
| 3. _____ carrying capacity [p.806] | C. A set of adaptations that influence survival, fertility, and age at first reproduction. |
| 4. _____ survivorship curve [p.809] | D. A small population that initially grows slowly, then rapidly, and then the numbers level off. |
| 5. _____ logistic growth [p.806] | E. Graph line of the age-specific survival of a cohort in a habitat. |
| 6. _____ density-dependent control [p.807] | F. Biotic or abiotic factors that reduce the odds for individual survival during overcrowding. |
| 7. _____ density-independent factor [p.807] | G. Causes changes in population size regardless of density. |

Choice

Choose the most appropriate form of survivorship curve for each of the following descriptions. [p.809]

a. Type I b. Type II c. Type III

8. _____ Constant death rate at all ages.
9. _____ Highest death rate at an early age.
10. _____ High survivorship until late in life.
11. _____ Most human populations follow this survivorship curve.
12. _____ The survivorship of sea stars is an example.
13. _____ Lizards and small mammals follow this pattern.

45.7. HUMAN POPULATION GROWTH [pp.812–813]

45.8. FERTILITY RATES AND AGE STRUCTURE [pp.814–815]

45.9. POPULATION GROWTH AND ECONOMIC EFFECTS [pp.816–817]

45.10. SOCIAL IMPACT OF NO GROWTH [p.817]

Selected Words: *preindustrial stage* [p.816], *transitional stage* [p.816], *industrial stage* [p.816], *postindustrial stage* [p.816], *postpone* [p.817]

Boldfaced, Page-Referenced Terms

[p.814] total fertility rate (TFR) _____

[p.816] demographic transition model _____

Fill-in-the-Blanks

Early humans evolved in (1) _____ [p.812], then in savannas. They were (2) _____ [p.812], mostly, but they also scavenged bits of meat. Bands of hunter-gatherers moved out of Africa about (3) _____ [p.812] million years ago. By 40,000 years ago, their descendants were established in much of the world.

Starting about 11,000 years ago or so, many hunter-gatherer bands shifted to (4) _____ [p.812]. Instead of simply following (5) _____ [p.812] game herds, they settled in fertile valleys and other regions that favored seasonal harvesting of fruits and (6) _____ [p.812]. In this way, they developed a more dependable basis for life. A pivotal factor was the domestication of wild (7) _____ [p.812], including species ancestral to modern (8) _____ [p.812] and (9) _____ [p.812]. People harvested, stored, and planted seeds in one place. They domesticated

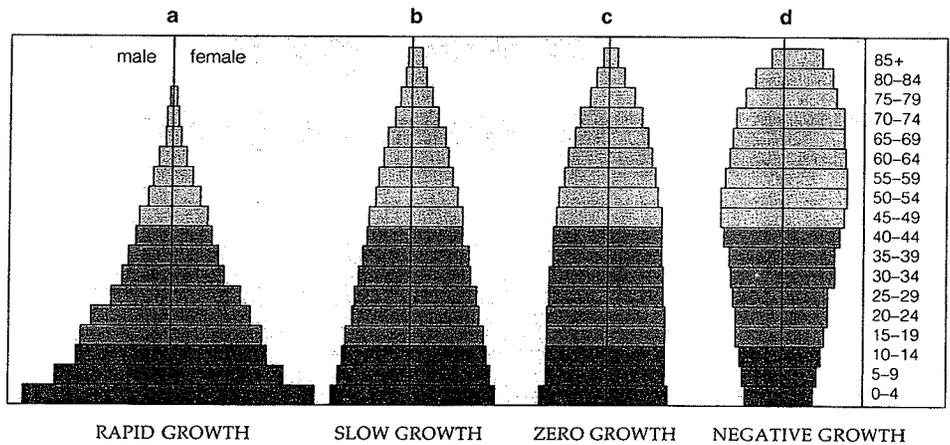
(10) _____ [p.812] for food and pulling plows. They dug (11) _____ [p.812] ditches to divert water to croplands.

Until about 300 years ago, poor (12) _____ [p.812], malnutrition, and infectious (13) _____ [p.813] kept death rates high enough to more or less balance (14) _____ [p.813] rates. Infectious diseases became density-(15) _____ [p.813] controls. Epidemics swept through overcrowded settlements and cities were infested with fleas and (16) _____ [p.813]. Then came plumbing and new methods of (17) _____ [p.813] treatment. Over time, vaccines, (18) _____ [p.813], and other drugs were developed as weapons against pathogens. The (19) _____ [p.813] rates dropped sharply. Birth rates began to exceed death rates—and rapid population growth was under way.

Choice

For each of the following, choose the appropriate age structure diagram from the accompanying figure. [p.815]

- 20. _____ United States
- 21. _____ China
- 22. _____ Canada
- 23. _____ Mexico
- 24. _____ Australia
- 25. _____ India



Sequence

Arrange the following stages of the demographic transition model in correct chronological sequence. Write the letter of the first step next to 26, the letter of the second step next to 27, and so on. [p.816]

- 26. _____
 - 27. _____
 - 28. _____
 - 29. _____
- A. *Industrial stage*: population growth slows and industrialization is in full swing
 - B. *Preindustrial stage*: harsh living conditions, high birth and death rates, slow population growth
 - C. *Postindustrial stage*: zero population growth is reached; then birth rate falls below death rate, and population size slowly decreases
 - D. *Transitional stage*: industrialization begins, food production rises, and health care improves; death rates drop, birth rates remain high, resulting in rapid population growth

Self-Quiz

- _____ 1. The number of individuals that contribute to a population's gene pool is _____. [p.802]
- the population density
 - the population growth
 - the population birth rate
 - the population size
- _____ 2. The number of individuals in a given area or volume of a habitat is _____. [p.802]
- the population density
 - the population growth
 - the population birth rate
 - the population size
- _____ 3. A population that is growing exponentially in the absence of limiting factors can be illustrated accurately by a(n) _____. [p.804]
- S-shaped curve
 - J-shaped curve
 - curve that terminates in a plateau phase
 - tolerance curve
- _____ 4. Assuming the birth rate and death rate remain constant, both can be combined into a single variable, r , or _____. [p.804]
- the per capita rate
 - the minus migration factor
 - exponential growth
 - the net reproduction per individual per unit time
- _____ 5. _____ is a way to express the growth rate of a given population. [p.805]
- Doubling time
 - Population density
 - Population size
 - Carrying capacity
- _____ 6. The maximum rate of increase per individual under ideal conditions is called the _____. [p.805]
- biotic potential
 - carrying capacity
 - doubling time
 - population size
- _____ 7. The maximum number of individuals of a population (or species) that a given environment can sustain indefinitely defines _____. [p.806]
- the carrying capacity of the environment
 - exponential growth
 - the doubling time of a population
 - density-independent factors
- _____ 8. Which of the following is *not* characteristic of logistic growth? [p.806]
- S-shaped curve
 - leveling off of growth as carrying capacity is reached
 - unrestricted growth
 - slow growth of a low-density population followed by rapid growth
- _____ 9. The beginning of industrialization, a rise in food production, improvement of health care, rising birth rates, and declining death rates describes the _____ stage of the demographic transition model. [p.816]
- preindustrial
 - transitional
 - industrial
 - postindustrial
- _____ 10. The survivorship curve typical of industrialized human populations is Type _____. [p.809]
- I
 - II
 - III
 - none of the above types

Chapter Objectives/Review Questions

1. Define the term *ecology*. [p.801]
2. Define the following terms: *demographics, habitat, population size, population density, population distribution, age structure, and reproductive base*. [p.802]
3. List and describe the three patterns of dispersion illustrated by populations in a habitat. [p.802]
4. Given data on a capture–recapture experiment, estimate the population size of the species. [p.803]
5. Distinguish immigration from emigration and define the term *migration*. [p.804]
6. Define *zero population growth* and describe how achieving it would affect population size. [p.804]
7. Explain how $G = rN$ can be used to predict population growth. [p.805]
8. Explain the relationship between exponential growth and doubling time. [p.805]
9. Explain what is meant by *biotic potential*. [p.805]
10. List several examples of limiting factors, and explain how they influence population curves. [p.806]
11. Explain what is meant by *carrying capacity*. [p.806]
12. Explain the meaning of the logistic growth equation. [p.806]
13. Compare logistic and exponential growth. [pp.805–806]
14. Define the term *density-dependent controls on growth* of populations; cite one example. [p.807]
15. Define the term *density-independent factors* and list two examples; indicate how such factors affect populations. [p.807]
16. Explain what is meant by a life history pattern. [p.808]
17. Explain the three survivorship curves. [p.809]
18. Guppy populations targeted by killifish tend to be larger, less streamlined, and more brightly colored, and guppy populations targeted by pike-cichlids tend to be smaller, more streamlined, and duller in color patterning. Other life history pattern differences exist between the two groups. After consideration of the research results obtained by Reznick and Endler, provide an explanation for these differences. [pp.810–811]
19. List three possible reasons why growth of the human population is out of control. [pp.812–813]
20. Define the term *total fertility rate*. [p.814]
21. Be able to analyze age structure diagrams to determine patterns of growth. [p.815]
22. List and describe the four stages of the demographic transition model. [p.816]

Integrating and Applying Key Concepts

1. Assume that the world has reached zero population growth. The year is 2110, and there are 10.5 billion individuals of *Homo pollutans* on Earth. You have seen stories on the community television screen about how people used to live 120 years ago. List the ways that life has changed, and comment on the events that no longer happen because of the enormous human population.
2. The capture–recapture method of estimating population is widely recognized as being inaccurate. If given the resources, how would you go about estimating the size of a population without counting every individual in the population?
3. How would changes in immigration laws in the United States influence the age structure diagrams? What are the long-term consequences of these decisions? Why would countries like Canada and Australia be actively increasing immigration?

3

MOLECULES OF LIFE

INTRODUCTION

Often students question why a course in the biological sciences needs to start with a discussion of chemistry. Yet, chemistry is the foundation of life. Your body is powered by chemical reactions that convert food into energy and raw materials for the building of cells and tissues. In this chapter you will examine the basic principles of organic chemistry, which focuses on the element carbon. You will then examine the biologically important organic compounds, namely the carbohydrates, fats, proteins, and nucleic acids.

FOCAL POINTS

- Figure 3.6 [p.37] illustrates condensation and hydrolytic reactions, which are the cornerstone of biochemistry. The principles are the same for all of the biologically important molecules.
- Figure 3.16 [p.43] shows the different levels of protein structure and how they contribute to a three-dimensional molecule. Proteins are the working molecules of the cell. Their function is based on their shape.
- Table 3.1 [p.48] provides an excellent summary of the chapter.

Interactive Exercises

Science or the Supernatural? [pp.32–33]

3.1. MOLECULES OF LIFE—FROM STRUCTURE TO FUNCTION [pp.34–35]

3.2. HOW DO CELLS BUILD ORGANIC COMPOUNDS? [pp.36–37]

Selected Words: “organic” substances [p.34], “inorganic” substances [p.34], *hydroxyl* groups [p.36], *carbonyl* groups [p.37], *carboxyl* groups [p.37], *phosphate* groups [p.37], *sulfhydryl* groups [p.37], *functional-group transfer* [p.37], *electron transfer* [p.37], *rearrangement* [p.37], *condensation* [p.37], *cleavage* [p.37]

Boldfaced, Page-Referenced Terms

[p.34] organic compounds

[p.34] hydrocarbons _____

[p.34] functional groups _____

[p.36] monomers _____

[p.36] polymers _____

[p.36] alcohols _____

[p.37] enzymes _____

[p.37] condensation reaction _____

[p.37] hydrolysis _____

Fill-in-the-Blanks

The molecules of life are (1) _____ [p.34] compounds, which are defined as containing the element (2) _____ [p.34] and at least one (3) _____ [p.34] atom. The term is a holdover from a time when chemists thought "organic" substances were the ones made naturally in living (4) _____ [p.34] only, as opposed to (5) " _____ " [p.34] substances that formed abiotically. The term persists, although scientists now synthesize organic compounds in (6) _____ [p.34] and have reason to believe that organic compounds were present on Earth before organisms were.

The (7) _____ [p.34] consist only of hydrogen atoms (8) _____ [p.34] bonded to (9) _____ [p.34]. Examples are (10) _____ [p.34] and other fossil fuels. Like other organic compounds, each has a specific number of (11) _____ [p.34] that are arranged in specific ways. Each organic compound has one or more (12) _____ [p.34] groups, which are particular atoms or clusters of atoms covalently bonded to (13) _____ [p.34].

Carbon's importance to life starts with its versatile (14) _____ [p.34] behavior. Each carbon atom can covalently bond with as many as (15) _____ [p.34] other atoms. Such bonds, in which two atoms share one, two, or three pairs of electrons, are relatively (16) _____ [p.34]. They join together carbon atoms as a(n) (17) _____ [p.34] to which hydrogen, oxygen, and other elements are attached. In those configurations we find clues to how the different molecules of life will function and what their (18) _____ [p.34]-dimensional shape will be.

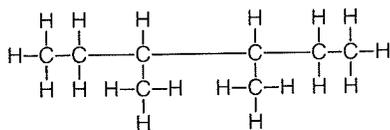
Matching

Match each of the following functional groups with its correct description. [pp.36–37]

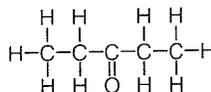
19. ____ sulfhydryl group
20. ____ hydroxyl group
21. ____ carbonyl group
22. ____ phosphate group
23. ____ carboxyl group
- A. Stabilizes the structure of proteins
B. Found within the structure of ATP and DNA
C. The functional group of the alcohols
D. Used in the building of fats and carbohydrates
E. A key component of the amino acids and fatty acids

Labeling

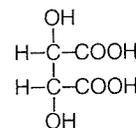
For each of the following molecules, shade in all of the atoms associated with the indicated functional group. Use Figure 3.4 [p.36] as a reference.



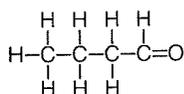
24. methyl



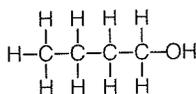
25. carbonyl



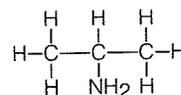
26. carboxyl



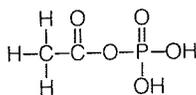
27. carbonyl



28. hydroxyl



29. amino



30. phosphate

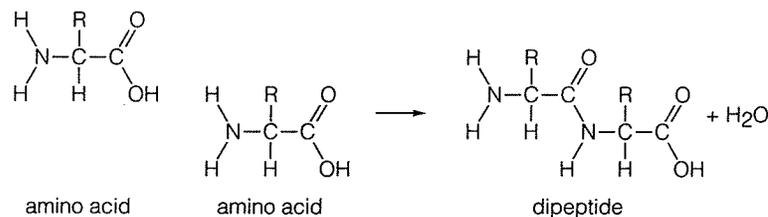
Matching

Choose the most appropriate answer for each term.

31. ____ enzymes [p.37]
32. ____ condensation reaction [p.37]
33. ____ monomers [p.36]
34. ____ hydrolysis [p.37]
35. ____ polymers [p.36]
36. ____ functional-group transfer [p.37]
37. ____ cleavage [p.37]
38. ____ rearrangement [p.37]
39. ____ electron transfer [p.37]
- A. A class of proteins that make chemical reactions occur faster
B. A type of reaction that splits molecules using water
C. The individual subunits of organic molecules
D. Any reaction that splits a molecule into two smaller molecules
E. The type of chemical reaction that moves electrons between molecules
F. The movement of functional groups between molecules
G. The formation of a covalent bond by the removal of $-OH$ and H^+ functional groups, forming water
H. Long chains of subunits, sometimes consisting of millions of individual subunits
I. A change in the internal bond structure of a molecule

Identification

40. Study the structural formulas of the two adjacent amino acids. Identify the enzyme action causing formation of a covalent bond and a water molecule (through a condensation reaction) by circling an H atom from one amino acid and an -OH group from the other amino acid. Also circle the covalent bond that formed the dipeptide [pp.37,42].

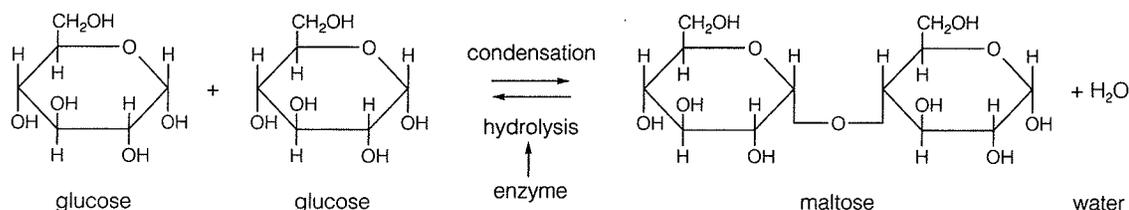


3.3. THE MOST ABUNDANT ONES—CARBOHYDRATES [pp.38–39]

Selected Words: “saccharide” [p.38], *monosaccharide* [p.38], *oligosaccharide* [p.38], *disaccharides* [p.38], “complex” carbohydrates [p.38], *polysaccharides* [p.38]

Identification

1. In the diagram, identify condensation reaction sites between the two glucose molecules by circling the components of the water molecule whose removal allows a covalent bond to form between the glucose molecules (text Figure 3.7, p.38). Note that the reverse reaction is hydrolysis and that both condensation and hydrolysis reactions require enzymes in order to proceed efficiently. [p.37]



Choice

Choose the class of carbohydrates (a–c) associated with the terms in items 2–9.

- a. oligosaccharides [p.38] b. polysaccharides [pp.38–39] c. monosaccharides [p.38]
2. _____ “complex” carbohydrates
 3. _____ chitin
 4. _____ disaccharides
 5. _____ ribose and deoxyribose
 6. _____ lactose, sucrose, and maltose
 7. _____ glucose and fructose
 8. _____ starch and glycogen
 9. _____ cellulose

Matching

Match each of the following carbohydrates with its correct function. [pp.38–39]

- | | |
|--------------------|---|
| 10. ____ sucrose | A. Instant energy source for most organisms; precursor of many organic molecules; serves as building block for larger carbohydrates |
| 11. ____ chitin | B. Storage form for photosynthetically produced sugars |
| 12. ____ glucose | C. Most plentiful sugar in nature, formed from glucose and fructose |
| 13. ____ ribose | D. Animal starch that is stored in liver and muscle tissue of mammals |
| 14. ____ cellulose | E. Main structural material in some external skeletons and other hard body parts of some animals and fungi |
| 15. ____ starch | F. Structural material of plant cell walls |
| 16. ____ glycogen | G. Five-carbon sugar occurring in DNA and RNA |

3.4. GREASY, OILY—MUST BE LIPIDS [pp.40–41]

Selected Words: *unsaturated* [p.40], *saturated* [p.40], “vegetable oils” [p.40], *neutral fats* [p.40]

Boldfaced, Page-Referenced Terms

[p.40] lipids _____

[p.40] fats _____

[p.40] fatty acid _____

[p.40] triglycerides _____

[p.41] phospholipids _____

[p.41] waxes _____

[p.41] sterols _____

3.5. PROTEINS—DIVERSITY IN STRUCTURE AND FUNCTION [pp.42–43]

3.6. WHY IS PROTEIN STRUCTURE SO IMPORTANT? [pp.44–45]

Selected Words: peptide bond [p.43], primary structure [p.43], secondary structure [p.43], “domain” [p.43], tertiary structure [p.43], quaternary structure [p.43], glycoprotein [p.43], lipoproteins [p.43], sickle-cell anemia [p.44]

Boldfaced, Page-Referenced Terms

[p.42] amino acid _____

[p.43] polypeptide chain _____

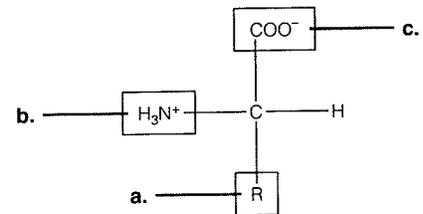
[p.44] heme _____

[p.44] denaturation _____

Labeling

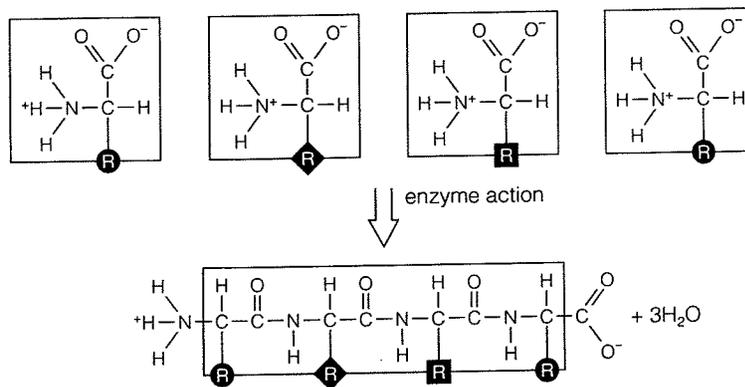
1. In the following model of an amino acid, label the R group, amino group, and carboxyl group. [p.42]

- a. _____
- b. _____
- c. _____



Identification

2. The following diagram illustrates four ionized amino acids (in cellular solution) forming a polypeptide chain. In the upper section, circle the atoms from each amino acid that are involved in the formation of a peptide bond. On the polypeptide chain (lower section), circle the location of the resulting peptide bonds. [p.42]



Matching

Choose the most appropriate statement for each term.

- | | |
|---------------------------------------|---|
| 3. _____ amino acid [p.42] | A. Coils or twists in amino acids caused by hydrogen bonds. |
| 4. _____ peptide bond [p.43] | B. Three or more amino acids joined in a linear chain. |
| 5. _____ polypeptide chain [p.43] | C. Proteins with linear or branched oligosaccharides covalently bonded to them. Often found on cell surfaces. |
| 6. _____ primary structure [p.43] | D. The type of covalent bond linking one amino acid to another. |
| 7. _____ secondary structure [p.43] | E. Globular proteins and hemoglobin are examples of this level of protein structure. |
| 8. _____ tertiary structure [p.43] | F. The unwinding of protein structure causing a change in shape. |
| 9. _____ domain [p.43] | G. The lowest level of protein structure consisting of a linear, unique sequence of amino acids. |
| 10. _____ quaternary structure [p.43] | H. A small organic compound having an amino group, an acid group, a hydrogen atom, and an R group. |
| 11. _____ lipoproteins [p.43] | I. The level of organization determined by interacting domains. |
| 12. _____ glycoproteins [p.43] | J. These transport triglycerides and cholesterol in the body. |
| 13. _____ denaturation [p.44] | K. A structurally stable unit of a polypeptide chain. |

Fill-in-the-Blanks

What is the take-home lesson? A protein's (14) _____ [p.45] dictates its function. Hemoglobin, hormones, (15) _____ [p.45], transporters—such proteins help us survive. Twists and folds in their (16) _____ [p.45] chains form anchors, or (17) _____ [p.45]-spanning barrels, or jaws that grip enemy agents in the body. (18) _____ [p.45] can alter the chains enough to block or enhance an anchoring, transport, or defensive function. Sometimes the consequences are awful. Yet changes in sequences and functional (19) _____ [p.45] also give rise to variation in (20) _____ [p.45]—the raw material for (21) _____ [p.45].

3.7. NUCLEOTIDES, DNA, AND THE RNAS [pp.46-47]

Selected Words: "base pairing" [p.46]

Boldfaced, Page-Referenced Terms

[p.46] ATP _____

[p.46] coenzymes _____

[p.46] nucleic acids _____

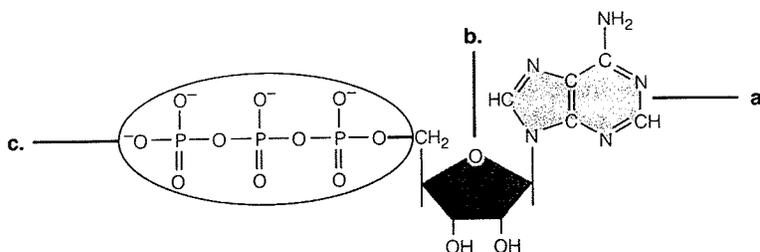
[p.46] DNA _____

[p.47] RNAs _____

Labeling

1. In the following diagram of a nucleotide, label the phosphate groups, nitrogenous base, and five-carbon sugar subunits. [p.46]

- a. _____
- b. _____
- c. _____



Matching

Choose the most appropriate answer for each term.

- | | |
|---------------------------------------|---|
| 2. ____ adenosine triphosphate [p.46] | A. A molecule that can transfer phosphate groups, making molecules reactive |
| 3. ____ coenzymes [p.46] | B. Single-stranded molecules made of ribonucleotides |
| 4. ____ base pairs [p.46] | C. Enzyme assistants; examples are NAD ⁺ and FAD ⁺ |
| 5. ____ RNAs [p.47] | D. The signature molecule of life, made from deoxyribonucleotides |
| 6. ____ DNA [p.46] | E. Two nucleotides linked together by hydrogen bonds |

Self-Quiz

Choice

For questions 1–10, choose the class of organic molecule to which the item belongs. Some answers may be used more than once.

- a. lipids [pp.40–41] b. nucleic acids [pp.46–47] c. proteins [pp.42–45]
d. carbohydrates [pp.38–39]

- 1. ____ glycoproteins
- 2. ____ phospholipids
- 3. ____ glycogen
- 4. ____ adenosine triphosphate
- 5. ____ sucrose and maltose
- 6. ____ triglycerides
- 7. ____ DNA and RNA
- 8. ____ cholesterol
- 9. ____ glycogen and starch
- 10. ____ waxes

Multiple Choice

- _____ 11. Amino acids are linked by _____ bonds to form the primary structure of a protein. [p.43]
- disulfide
 - hydrogen
 - ionic
 - peptide
- _____ 12. Proteins _____. [pp.42–43]
- are weapons against disease-causing bacteria and other invaders
 - are composed of amino acid subunits
 - may act as hormones
 - may function as enzymes
 - all of the above
- _____ 13. Which of the following does not belong to the lipid class of organic molecules? [p.43]
- sterols
 - waxes
 - phospholipids
 - glycoproteins
 - triglycerides
- _____ 14. DNA _____. [p.46]
- is one of the adenosine phosphates
 - is one of the nucleotide coenzymes
 - is double-stranded
 - is composed of monosaccharides
- _____ 15. Denaturation is a change in _____ shape. [p.44]
- lipid
 - carbohydrate
 - protein
 - nucleic acid
- _____ 16. Carbon is part of so many different substances because _____. [p.34]
- carbon generally forms two covalent bonds with a variety of other atoms
 - a carbon atom generally forms four covalent bonds with a variety of atoms
 - carbon ionizes easily
 - carbon is a polar compound
- _____ 17. Which of the following levels of protein structure is not correctly linked to its description? [p.43]
- Primary—the linear sequence of amino acids
 - Secondary—coiling of a polypeptide due to the action of hydrogen bonds
 - Tertiary—interactions between the domains of a protein
 - Quaternary—chemical interactions between multiple polypeptide chains
 - All of the above are correct
- _____ 18. _____ are molecules used by cells as structural materials, as energy transport molecules, or as storage forms of energy. [pp.38–39]
- Lipids
 - Nucleic acids
 - Carbohydrates
 - Proteins
- _____ 19. Hydrolysis could be correctly described as the _____. [p.37]
- heating of a compound in order to drive off its excess water and concentrate its volume
 - breaking of a long-chain compound into its subunits by adding water molecules to its structure between the subunits
 - linking of two or more molecules by the removal of one or more water molecules
 - constant removal of hydrogen atoms from the surface of a carbohydrate
 - prime example of a condensation class of reactions