CollegeBoard

AP Biology Practice Exam

From the 2013 Administration

This is a modified version of the 2013 AP Biology Exam.

Contents

Note: This publication shows the page numbers that appeared in the *2012–13 AP Exam Instructions* **book and in the actual exam. This publication was not repaginated to begin with page 1.**

Exam Instructions

The following contains instructions taken from the *2012–13 AP Exam Instructions* book.

AP® Biology Exam

Regularly Scheduled Exam Date: Monday morning, May 13, 2013
Late-Testing Exam Date: Friday afternoon, May 24, 2013

Section I: At a Glance

Total Time:
1 hour, 30 minutes
Number of Questions:
69
Percent of Total Score:
50%
Writing Instrument:
Pencil required
Electronic Device:
Four-function calculator (with square root) allowed for all sections

Section II: At a Glance

Total Time:
1 hour, 30 minutes
Number of Questions:
8
Percent of Total Score:
50%
Writing Instrument:
Pen with black or dark blue ink
Electronic Device:
Four-function calculator (with square root) allowed for all sections
Reading Period Time:
10 minutes
Use this time to read the questions and plan your answers.
Writing Period Time:
1 hour, 20 minutes
Suggested Time:
Approximately 22 minutes per long question, 6 minutes per short question
Weight:
Approximate weights
Questions 1 and 2: 25% each
Questions 3 – 5:   10% each
Questions 6 – 8:   7% each

Section I: Multiple Choice Booklet Instructions

Section I of this exam contains 69 questions. Fill in only the circles for numbers 1 through 63 and numbers 121 through 126 of the answer sheet. Indicate all of your answers to the Section I questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work.

For questions 1 through 63, after you have decided which of the suggested answers is best, completely fill in the corresponding circle on the answer sheet. Because this section offers only four answer options for each question, do not mark the (E) answer circle for any question.

Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely.

For questions 121 through 126, follow the instructions at the beginning of Part B to enter your numeric answers. Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on Section I is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

Section II: Free Response Booklet Instructions

The questions for Section II are printed in this booklet. You may use the unlined pages to organize your answers and for scratch work, but you must write your answers on the labeled pages provided for each question.

The proctor will announce the beginning and end of the reading period. You are advised to spend the 10-minute period reading all the questions, and to use the unlined pages to sketch graphs, make notes, and plan your answers. Do NOT begin writing on the lined pages until the proctor tells you to do so.

Each answer should be written out in paragraph form; outline form is not acceptable. Do not spend time restating the questions or providing more than the number of examples called for. For instance, if a question calls for two examples, you can earn credit only for the first two examples that you provide. Labeled diagrams may be used to supplement discussion, but unless specifically called for by the question, a diagram alone will not receive credit. Write clearly and legibly. Begin each answer on a new page. Do not skip lines. Cross out any errors you make; crossed-out work will not be scored.

Manage your time carefully. You may proceed freely from one question to the next. You may review your responses if you finish before the end of the exam is announced.

What Proctors Need to Bring to This Exam

- Exam packets
- Answer sheets
- AP Student Packs
- *2012-13 AP Coordinator's Manual*
- This book — *AP Exam Instructions*
- School Code and Home-School/Self-Study Codes
- Extra Calculators
- Pencil sharpener

- Extra No. 2 pencils with erasers
- Extra pens with black or dark blue ink
- Lined paper
- Stapler
- Watch
- Signs for the door to the testing room
  - "Exam in Progress"
  - "Cell phones are prohibited in the testing room"

SECTION I: Multiple Choice

Students are allowed to use four-function (with square root) calculators throughout the entire AP Biology Exam. Graphing calculators and scientific calculators are not permitted for use on the AP Biology Exam. See pages 39–42 of the *2012-13 AP Coordinator's Manual* for more information.

Before starting the exam administration, make sure each student has an appropriate calculator. If a student does not have a calculator, you may provide one from your supply. If the student does not want to use the calculator you provide or does not want to use a calculator at all, he or she must hand copy, date, and sign the release statement on page 40 of the *2012-13 AP Coordinator's Manual*. Students may have no more than two calculators on their desks. Calculators may not be shared.

■ **Do not begin the exam instructions below until you have completed the appropriate**
● **General Instructions for your group.**

Make sure you begin the exam at the designated time.

If you are giving the regularly scheduled exam, say:

> **It is Monday morning, May 13, and you will be taking the AP Biology Exam.**

If you are giving the alternate exam for late testing, say:

> **It is Friday afternoon, May 24, and you will be taking the AP Biology Exam.**

> **In a moment, you will open the packet that contains your exam materials. By opening this packet, you agree to all of the AP Program's policies and procedures outlined in the *2012-13 Bulletin for AP Students and Parents*. You may now remove the shrinkwrap from your exam packet and take out the Section I booklet, but do not open the booklet or the shrinkwrapped Section II materials. Put the white seals aside. . . .**
>
> **Carefully remove the AP Exam label found near the top left of your exam booklet cover. Now place it on page 1 of your answer sheet on the dark blue box near the top right-hand corner that reads "AP Exam Label."**

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If students accidentally place the exam label in the space for the number label or vice versa, advise them to leave the labels in place. They should not try to remove the label; their exam will be processed correctly.

> **Read the statements on the front cover of Section I and look up when you have finished. . . .**
>
> **Sign your name and write today's date. Look up when you have finished. . . .**
>
> **Now print your full legal name where indicated. Are there any questions? . . .**
>
> **Turn to the back cover and read it completely. Look up when you have finished. . . .**
>
> **Are there any questions? . . .**
>
> **Section I is the multiple-choice portion of the exam. Mark all of your responses beginning on page 2 of your answer sheet, one response per question. If you need to erase, do so carefully and completely. Your score on the multiple-choice section will be based solely on the number of questions answered correctly. Four-function calculators (with square root) are allowed.**
>
> **This section also contains grid-in questions for which there are no answer choices. You will solve each problem and write your final numeric answer in the boxes at the top of the grid and fill in the corresponding circles. You will receive credit <u>only</u> if the circles are filled in correctly. Please pay close attention to the directions in your exam booklet for completing the grid-in questions.**
>
> **Are there any questions? . . .**
>
> **You have 1 hour and 30 minutes for this section. Open your Section I booklet and begin.**

Note Start Time here _____. Note Stop Time here _____. Check that students are marking their answers in pencil on their answer sheets, and that they are not looking at their shrinkwrapped Section II booklets. After 1 hour and 30 minutes, say:

> **Stop working. Close your booklet and put your answer sheet on your desk, face up. Make sure you have your AP number label and an AP Exam label on page 1 of your answer sheet. I will now collect your answer sheet.**

Collect an answer sheet from each student. Check that each answer sheet has an AP number label and an AP Exam label. Then say:

> **Now you must seal your exam booklet. Remove the white seals from the backing and press one on each area of your exam booklet cover marked "PLACE SEAL HERE." Fold each seal over the back cover. When you have finished, place the booklet on your desk, face up. I will now collect your Section I booklet. . . .**

Collect a Section I booklet from each student. Check that each student has signed the front cover of the sealed Section I booklet.

There is a 10-minute break between Sections I and II. When all Section I materials have been collected and accounted for and you are ready for the break, say:

> **Please listen carefully to these instructions before we take a 10-minute break. Everything you placed under your chair at the beginning of the exam must stay there. Leave your shrinkwrapped Section II packet on your desk during the break. You are not allowed to consult teachers, other students, or textbooks about the exam during the break. You may not make phone calls, send text messages, use your calculators, check email, use a social networking site, or access any electronic or communication device. Remember, you are not allowed to discuss the multiple-choice section of this exam. If you do not follow these rules, your score could be canceled. Are there any questions? . . .**
>
> **You may begin your break. Testing will resume at _____.**

SECTION II: Free Response

After the break, say:

> **May I have everyone's attention? Place your Student Pack on your desk. . . .**
>
> **You may now remove the shrinkwrap from the Section II packet, but do not open the exam booklet until you are told to do so. . . .**
>
> **Read the bulleted statements on the front cover of the exam booklet. Look up when you have finished. . . .**
>
> **Now place an AP number label on the shaded box. If you don't have any AP number labels, write your AP number in the box. Look up when you have finished. . . .**
>
> **Read the last statement. . . .**
>
> **Using your pen, print the first, middle and last initials of your legal name in the boxes and print today's date where indicated. This constitutes your signature and your agreement to the statements on the front cover. . . .**
>
> **Turn to the back cover and complete Item 1 under "Important Identification Information." Print the first two letters of your <u>last</u> name and the first letter of your <u>first</u> name in the boxes. Look up when you have finished. . . .**
>
> **In Item 2, print your date of birth in the boxes. . . .**
>
> **In Item 3, write the school code you printed on the front of your Student Pack in the boxes. . . .**
>
> **Read Item 4. . . .**
>
> **Are there any questions? . . .**
>
> **I need to collect the Student Pack from anyone who will be taking another AP Exam. You may keep it only if you are not taking any other AP Exams this year. If you have no other AP Exams to take, place your Student Pack under your chair now. . . .**

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> **While Student Packs are being collected, read the information on the back cover of the exam booklet. Do not open the booklet until you are told to do so. Look up when you have finished. . . .**

Collect the Student Packs. Then say:

> **Are there any questions? . . .**
>
> **Section II begins with a 10-minute reading period. During the reading period, you will read the questions and plan your answers to the questions. You may use the unlined pages of this booklet to organize your answers and for scratch work, but you must write your answers on the lined pages provided for each question. Answers must be written in ink. Are there any questions? . . .**
>
> **You may now open the Section II booklet and begin the 10-minute reading period.**

🕐 Note Start Time here _____. Note Stop Time here _____. Check that students are writing any notes in the appropriate areas in the Section II booklet. If any students begin writing their responses during this time, remind them that the reading period is not yet over, and that the reading period is designed to provide students with time to develop better organized, higher scoring responses. If the students choose to continue writing responses, take no further action. After 10 minutes, say:

> **Stop. The reading period is over. You have 1 hour and 20 minutes to answer the questions. You are responsible for pacing yourself, and may proceed freely from one question to the next. If you need more paper during the exam, raise your hand. At the top of each extra piece of paper you use, be sure to write only your AP number and the number of the question you are working on. Do not write your name. Are there any questions? . . .**
>
> **You may begin.**

🕐 Note Start Time here _____. Note Stop Time here _____. Check that students are using pens to write their answers in their exam booklets. After 1 hour and 10 minutes, say:

> **There are 10 minutes remaining.**

After 10 minutes, say:

> **Stop working and close your exam booklet. Place it on your desk, face up.**

If any students used extra paper for the free-response section, have those students staple the extra sheet/s to the first page corresponding to that question in their exam booklets. Then say:

> **Remain in your seat, without talking, while the exam materials are collected. . . .**

Collect a Section II exam booklet from each student. Check for the following:

- Exam booklet front cover: The student placed an AP number label on the shaded box, and printed his or her initials and today's date.
- Exam booklet back cover: The student completed the "Important Identification Information" area.

When all exam materials have been collected and accounted for, return to students any electronic devices you may have collected before the start of the exam.

If you are giving the regularly scheduled exam, say:

> **You may not discuss these specific free-response questions with anyone unless they are released on the College Board website in about two days. Your AP score results will be delivered online in July.**

If you are giving the alternate exam for late testing, say:

> **None of the questions in this exam may ever be discussed or shared in any way at any time. Your AP score results will be delivered online in July.**

If any students completed the AP number card at the beginning of this exam, say:

> **Please remember to take your AP number card with you. You will need the information on this card to view your scores and order AP score reporting services online.**

Then say:

> **You are now dismissed.**

All exam materials should be put in secure storage until they are returned to the AP Program after your school's last administration. Before storing materials, check the "School Use Only" section on page 1 of the answer sheet and:

- Fill in the appropriate section number circle in order to access a separate AP Instructional Planning Report (for regularly scheduled exams only) or subject score roster at the class section or teacher level. See "Post-Exam Activities" in the *2012-13 AP Coordinator's Manual*.
- Check your list of students who are eligible for fee reductions and fill in the appropriate circle on their registration answer sheets.

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Student Answer Sheet for the Multiple-Choice Section

AP

Answer Sheet
2013

AP Number Label
(from Student Pack)

AP Exam Label
(from Section I Booklet)

B123456789T

COMPLETE THIS AREA AT EVERY EXAM.   USE NO. 2 PENCIL ONLY

To maintain the security of the exam and the validity of my AP score, I will allow no one else to see the multiple-choice questions. I will not discuss these questions with anyone at any time after completing the multiple-choice booklet when asked to do so. and I am aware of and agree to the AP Program's policies and procedures as outlined in the *2012-13 Bulletin for AP Students and Parents*, including using testing accommodations (e.g., extended time, computer, etc.) only if I have been preapproved by College Board Services for Students with Disabilities.

A. SIGNATURE
Sign your legal name as it will appear on your college applications.   Date

B. LEGAL NAME   Omit apostrophes, Jr., II.

Legal Last Name — First 15 Letters
Legal First Name — First 12 Letters
MI

H. AP EXAM I AM TAKING USING THIS ANSWER SHEET
Exam Name:
Form: Form Code:
Exam Code:

768252

SCHOOL USE ONLY
Section Number   ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
Fee Reduction Granted   ① Option 1   ② Option 2

C. YOUR AP NUMBER

D. EXAM DATE   Month   Day

E. EXAM START TIME   AM   PM

F. MULTIPLE-CHOICE BOOKLET SERIAL NUMBER
S

G. ONLINE PROVIDER CODE

COMPLETE THIS AREA ONLY ONCE.

I. AREA CODE AND PHONE NUMBER
INTERNATIONAL PHONE

J. SCHOOL YOU ATTEND
SCHOOL CODE
School Name
City
State
Country

K. DATE OF BIRTH
Month   Day   Year
Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec

L. SOCIAL SECURITY NUMBER (Optional)

M. COLLEGE TO RECEIVE YOUR AP SCORE REPORT
COLLEGE CODE   Using the college code listed in the AP Student Pack, indicate the ONE college that you want to receive your AP score report.
College Name
City
State
Country

N. CURRENT GRADE LEVEL
Not yet in 9th grade
9th
10th
11th
12th
No longer in high school

O. STUDENT SEARCH SERVICE®
Yes   No

COMPLETE THIS AREA AT EACH EXAM (IF APPLICABLE)

P. SURVEY QUESTIONS — Answer the survey questions in the AP Student Pack. Do not put responses to exam questions in this section.

1 (A)(B)(C)(D)(E)(F)(G)(H)(I)
2 (A)(B)(C)(D)(E)(F)(G)(H)(I)
3 (A)(B)(C)(D)(E)(F)(G)(H)(I)

4 (A)(B)(C)(D)(E)(F)(G)(H)(I)
5 (A)(B)(C)(D)(E)(F)(G)(H)(I)
6 (A)(B)(C)(D)(E)(F)(G)(H)(I)

7 (A)(B)(C)(D)(E)(F)(G)(H)(I)
8 (A)(B)(C)(D)(E)(F)(G)(H)(I)
9 (A)(B)(C)(D)(E)(F)(G)(H)(I)

Q. LANGUAGE — Do not complete this section unless instructed to do so.

If this answer sheet is for the French Language and Culture, German Language and Culture, Italian Language and Culture, Spanish Language, or Spanish Literature and Culture Exam, please answer the following questions. Your responses will not affect your score.

1. Have you lived or studied for one month or more in a country where the language of the exam you are now taking is spoken?

◯ Yes   ◯ No

2. Do you regularly speak or hear the language at home?

◯ Yes   ◯ No

QUESTIONS 1–75

Indicate your answers to the exam questions in this section (pages 2 and 3). Use a No. 2 pencil only. Mark only one response per question. If a question has only four answer options, do not mark option E. Answers written in the multiple-choice booklet will not be scored.

Your answer sheet will be scored by machine. Any improper gridding may affect your score.
- Completely fill in the circle for your response next to the number of the question you are answering.
- Erase carefully and completely. Stray marks and smudges could be read as answers.

1 (A)(B)(C)(D)(E)
2 (A)(B)(C)(D)(E)
3 (A)(B)(C)(D)(E)
4 (A)(B)(C)(D)(E)
5 (A)(B)(C)(D)(E)
6 (A)(B)(C)(D)(E)
7 (A)(B)(C)(D)(E)
8 (A)(B)(C)(D)(E)
9 (A)(B)(C)(D)(E)
10 (A)(B)(C)(D)(E)
11 (A)(B)(C)(D)(E)
12 (A)(B)(C)(D)(E)
13 (A)(B)(C)(D)(E)
14 (A)(B)(C)(D)(E)
15 (A)(B)(C)(D)(E)
16 (A)(B)(C)(D)(E)
17 (A)(B)(C)(D)(E)
18 (A)(B)(C)(D)(E)
19 (A)(B)(C)(D)(E)
20 (A)(B)(C)(D)(E)
21 (A)(B)(C)(D)(E)
22 (A)(B)(C)(D)(E)
23 (A)(B)(C)(D)(E)
24 (A)(B)(C)(D)(E)
25 (A)(B)(C)(D)(E)

26 (A)(B)(C)(D)(E)
27 (A)(B)(C)(D)(E)
28 (A)(B)(C)(D)(E)
29 (A)(B)(C)(D)(E)
30 (A)(B)(C)(D)(E)
31 (A)(B)(C)(D)(E)
32 (A)(B)(C)(D)(E)
33 (A)(B)(C)(D)(E)
34 (A)(B)(C)(D)(E)
35 (A)(B)(C)(D)(E)
36 (A)(B)(C)(D)(E)
37 (A)(B)(C)(D)(E)
38 (A)(B)(C)(D)(E)
39 (A)(B)(C)(D)(E)
40 (A)(B)(C)(D)(E)
41 (A)(B)(C)(D)(E)
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67 (A)(B)(C)(D)(E)
68 (A)(B)(C)(D)(E)
69 (A)(B)(C)(D)(E)
70 (A)(B)(C)(D)(E)
71 (A)(B)(C)(D)(E)
72 (A)(B)(C)(D)(E)
73 (A)(B)(C)(D)(E)
74 (A)(B)(C)(D)(E)
75 (A)(B)(C)(D)(E)

DO NOT WRITE IN THIS AREA

Be sure each mark is dark and completely fills the circle. If a question has only four answer options, do not mark option E.

76 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
77 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
78 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
79 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
80 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
81 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
82 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
83 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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87 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
88 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
89 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
90 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

91   Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
92   Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
93   Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
94   Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
95   Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
96   Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
97   Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
98   Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
99   Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
100 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
101 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
102 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
103 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
104 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
105 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

106 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
107 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
108 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
109 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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114 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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116 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
117 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
118 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
119 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
120 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

For Students Taking AP Biology

Write your answer in the boxes at the top of the griddable area and fill in the corresponding circles.
Mark only one circle in any column. You will receive credit only if the circles are filled in correctly.

121 122 123 124 125 126

(griddable answer grids with digits 0–9 for each column)

ETS USE ONLY

SELECTED MEDIA EXAMS	R	W	O	OTHER EXAMS	R	W	O
PT02				TOTAL			
PT03				Subscore (if applicable)			
PT04				Subscore (if applicable)			

Exam ⓪①②③④⑤⑥⑦⑧⑨
      ⓪①②③④⑤⑥⑦⑧⑨
Exam ⓪①②③④⑤⑥⑦⑧⑨
      ⓪①②③④⑤⑥⑦⑧⑨

DO NOT WRITE IN THIS AREA

COMPLETE THIS AREA ONLY ONCE.

V. SEX

○ Female
○ Male

W. WHICH LANGUAGE DO YOU KNOW BEST?

○ English
○ English and another language about the same
○ Another language

R. YOUR MAILING ADDRESS

Use the address abbreviations from your AP Student Pack. Fill in only one circle per column. Indicate a space in your address by leaving a blank box; do not grid that column.

STREET ADDRESS (include street number, street name, apartment number, etc.)

CITY

ZIP OR POSTAL CODE

COUNTRY CODE

(Lettered and numbered bubble grid columns for street address, city, ZIP or postal code, and country code.)

X. ETHNICITY/RACE

○ American Indian or Alaska Native
○ Asian, Asian American or Pacific Islander
○ Black or African American
○ Mexican or Mexican American
○ Puerto Rican
○ Other Hispanic, Latino or Latin American
○ White
○ Other

Y. PARENTAL EDUCATION LEVEL

Father/ Male Guardian	Mother/ Female Guardian	
○	○	Grade school
○	○	Some high school
○	○	High school diploma or equivalent
○	○	Business or trade school
○	○	Some college
○	○	Associate or two-year degree
○	○	Bachelor's or four-year degree
○	○	Some graduate or professional school
○	○	Graduate or professional degree

STATE

○ AK	○ HI	○ MI	○ NY	○ VT
○ AL	○ IA	○ MN	○ OH	○ WA
○ AR	○ ID	○ MO	○ OK	○ WI
○ AZ	○ IL	○ MS	○ OR	○ WV
○ CA	○ IN	○ MT	○ PA	○ WY
○ CO	○ KS	○ NC	○ RI	○ Puerto Rico
○ CT	○ KY	○ ND	○ SC	○ AA
○ DC	○ LA	○ NE	○ SD	○ AE
○ DE	○ MA	○ NH	○ TN	○ AP
○ FL	○ MD	○ NJ	○ TX	○ Other
○ GA	○ ME	○ NM	○ UT	
		○ NV	○ VA	

T. STUDENT IDENTIFIER (Student ID Number)

(Numbered bubble grid)

S. FOR STUDENTS OUTSIDE THE UNITED STATES ONLY

○ If your address does not fit in the spaces provided in Item R, fill in as many circles as you can, then fill in the circle in Item S and print the remainder of your address in the spaces provided.

Address

City   State or Province   ZIP or Postal Code

Country

U. EMAIL ADDRESS

By providing your email address, you are granting the College Board permission to use your email in accordance with the policies in the *2012-13 Bulletin for AP Students and Parents.*

Section I: Multiple-Choice Questions

This is the multiple-choice section of the 2013 AP exam. It includes cover material and other administrative instructions to help familiarize students with the mechanics of the exam. (Note that future exams may differ in look from the following content.)

AP® Biology Exam

SECTION I: Multiple Choice and Grid-In

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
1 hour, 30 minutes
Number of Questions
58
Percent of Total Score
50%
Writing Instrument
Pencil required
Electronic Device
Four-function calculator
(with square root)

Instructions

Section I of this exam contains 53 multiple-choice questions and 5 grid-in questions. Indicate all of your answers to the Section I questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work.

For questions 1–53, after you have decided which of the suggested answers is best, completely fill in the corresponding circle on the answer sheet. Fill in only the circles for questions 1–53. Because this section offers only four answer options for each question, do not mark the (E) answer circle for any question.

Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely. Here is a sample question and answer.

Sample Question   Sample Answer

Chicago is a   Ⓐ ● Ⓒ Ⓓ Ⓔ
(A) state
(B) city
(C) country
(D) continent

For questions 121–125, follow the instructions after question 53 to enter your numeric answers. Write your numeric answer in the boxes at the top of the grid and fill in the corresponding circles for questions 121–125.

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the questions.

Your total score on Section I is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

AP® BIOLOGY EQUATIONS AND FORMULAS

Statistical Analysis and Probability

Mean uuu

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Standard Deviation

$$S = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

Standard Error of the Mean

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

Chi-Square

$$\chi^2 = \sum \frac{(o-e)^2}{e}$$

$\bar{x}$ = sample mean

n = size of the sample

s = sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population)

o = observed results

e = expected results

Degrees of freedom are equal to the number of distinct possible outcomes minus one.

Chi-Square Table

p value	Degrees of Freedom							
	1	2	3	4	5	6	7	8
0.05	3.84	5.99	7.82	9.49	11.07	12.59	14.07	15.51
0.01	6.64	9.21	11.34	13.28	15.09	16.81	18.48	20.09

Laws of Probability

If A and B are mutually exclusive, then:

$$P(A \text{ or } B) = P(A) + P(B)$$

If A and B are independent, then:

$$P(A \text{ and } B) = P(A) \times P(B)$$

Hardy-Weinberg Equations

$p^2 + 2pq + q^2 = 1$

$p + q = 1$

p = frequency of the dominant allele in a population

q = frequency of the recessive allele in a population

Metric Prefixes

Factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Mode = value that occurs most frequently in a data set

Median = middle value that separates the greater and lesser halves of a data set

Mean = sum of all data points divided by number of data points

Range = value obtained by subtracting the smallest observation (sample minimum) from the greatest (sample maximum)

Rate and Growth

Rate
$$\frac{dY}{dt}$$

Population Growth
$$\frac{dN}{dt} = B - D$$

Exponential Growth
$$\frac{dN}{dt} = r_{max}N$$

Logistic Growth
$$\frac{dN}{dt} = r_{max}N\left(\frac{K-N}{K}\right)$$

Temperature Coefficient Q10
$$Q_{10} = \left(\frac{k_2}{k_1}\right)^{\frac{10}{T_2 - T_1}}$$

Primary Productivity Calculation
$$\frac{\text{mg O}_2}{\text{L}} \times \frac{0.698 \text{ mL}}{\text{mg}} = \frac{\text{mL O}_2}{\text{L}}$$

$$\frac{\text{mL O}_2}{\text{L}} \times \frac{0.536 \text{ mg C fixed}}{\text{mL O}_2} = \frac{\text{mg C fixed}}{\text{L}}$$

(at standard temperature and pressure)

---

dY = amount of change

dt = change in time

B = birth rate

D = death rate

N = population size

K = carrying capacity

r_{max} = maximum per capita growth rate of population

T_2 = higher temperature

T_1 = lower temperature

k_2 = reaction rate at T_2

k_1 = reaction rate at T_1

Q_{10} = the factor by which the reaction rate increases when the temperature is raised by ten degrees

---

Water Potential (Ψ)

$$\Psi = \Psi_P + \Psi_S$$

Ψ_P = pressure potential

Ψ_S = solute potential

The water potential will be equal to the solute potential of a solution in an open container because the pressure potential of the solution in an open container is zero.

The Solute Potential of a Solution
$$\Psi_S = -iCRT$$

i = ionization constant (this is 1.0 for sucrose because sucrose does not ionize in water)

C = molar concentration

R = pressure constant (R = 0.0831 liter bars/mole K)

T = temperature in Kelvin (ºC + 273)

Surface Area and Volume

Volume of a Sphere
$$V = \frac{4}{3}\pi r^3$$

Volume of a Rectangular Solid
$$V = \ell wh$$

Volume of a Right Cylinder
$$V = \pi r^2 h$$

Surface Area of a Sphere
$$A = 4\pi r^2$$

Surface Area of a Cube
$$A = 6s^2$$

Surface Area of a Rectangular Solid
$$A = \sum \text{surface area of each side}$$

---

r = radius

ℓ = length

h = height

w = width

s = length of one side of a cube

A = surface area

V = volume

Σ = sum of all

Dilution (used to create a dilute solution from a concentrated stock solution)
$$C_iV_i = C_fV_f$$

i = initial (starting) C = concentration of solute
f = final (desired) V = volume of solution

Gibbs Free Energy

$$\Delta G = \Delta H - T\Delta S$$

ΔG = change in Gibbs free energy

ΔS = change in entropy

ΔH = change in enthalpy

T = absolute temperature (in Kelvin)

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

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.
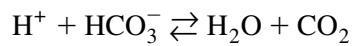
1. A dog is following the scent of a jackrabbit. Which of the following accurately describes how the dog's brain integrates information for smell?

   (A) Chemoreceptors in the brain send impulses for smell in the nasal cavity.
   (B) Chemoreceptor cells in the nasal cavity send impulses to the appropriate area of the brain.
   (C) Chemoreceptors on epithelial cells of the tongue send hormones to the appropriate area of the brain.
   (D) Receptors originating in the nose send action potentials to the motor regions of the brain.

2. Thrips are insects that feed on rose pollen. Scientists noted that the thrips population increased in the spring and decreased dramatically during the summer. The researchers hypothesized that food abundance was the limiting factor for the population. Which of the following types of data would be most useful for the scientists to collect at regular intervals on a designated test plot of rose plants?

   (A) Amount of sunlight (hours/day)
   (B) Mean temperature (°C)
   (C) Density of rose pollen produced (g/m^2)
   (D) Amount of pollen produced by each flower (g/flower)

3. If ATP breakdown (hydrolysis) is inhibited, which of the following types of movement across cell membranes is also inhibited?

   (A) Movement of oxygen into a cell
   (B) Movement of water through aquaporins
   (C) Passage of a solute against its concentration gradient
   (D) Facilitated diffusion of a permeable substance

4. Undersea landslides can disrupt marine habitats by burying organisms that live on the ocean floor. The graph above shows the size of a population of a certain organism that lives on the ocean floor. The population was affected by a recent landslide at the time indicated on the graph. Which of the following best predicts how the population will be affected by the landslide?

   (A) The surviving organisms will evolve into a new species.
   (B) The reduced population will likely have allelic frequencies that are different from the initial population.
   (C) The population will adapt to deeper waters to avoid future landslides.
   (D) The reduced population will have a greater number of different genes than the initial population.

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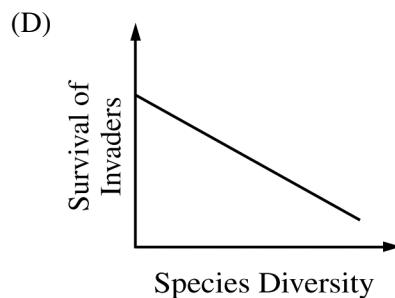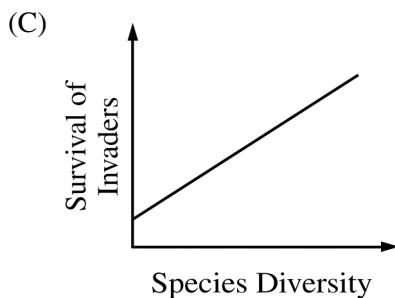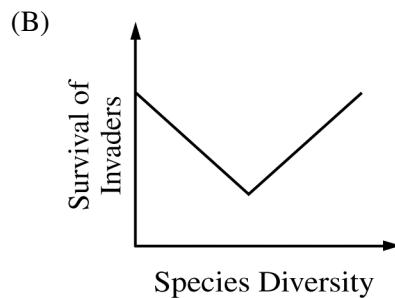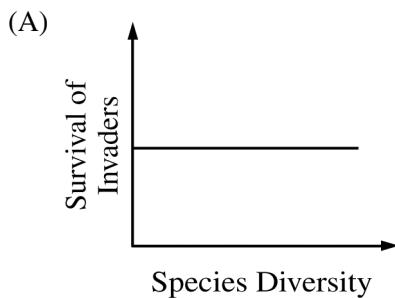
5. Which of the following questions is most relevant to understanding the Calvin cycle?

(A) How does chlorophyll capture light?
(B) How is ATP used in the formation of 3-carbon carbohydrates?
(C) How is $NADP^+$ reduced to $NADPH$?
(D) How is ATP produced in chemiosmosis?

6. Rosalind Franklin's x-ray diffraction images taken in the 1950s most directly support which of the following claims about DNA?

(A) The ratios of base pairs are constant.
(B) The nucleotide sequence determines genetic information.
(C) The two strands of DNA are antiparallel.
(D) The basic molecular structure is a helix.

$$H^+ + HCO_3^- \rightleftarrows H_2O + CO_2$$

7. The equation above shows one of the reversible reactions that occur in blood. After exercise, an athlete's blood pH has dropped below the normal level. How will normal blood pH be restored?

(A) An increase in O_2 concentration in the plasma will lead to an increase in H^+ concentration.
(B) An increase in temperature will lead to an increase in H^+ concentration.
(C) An increase in sweating will lead to a decrease in OH^- and H^+ concentration.
(D) An increase in breathing rate will lead to a decrease in blood CO_2 and H^+ concentration.

8. A researcher is investigating the relationship between the existing species diversity in a community and the ability of an introduced nonnative species to destabilize the community.

Which of the following graphs is most consistent with the claim that communities with high diversity are more resistant to change than are communities with low diversity?

(A)

Survival of Invaders vs. *Species Diversity* — horizontal line

(B)

Survival of Invaders vs. *Species Diversity* — V-shaped curve

(C)

Survival of Invaders vs. *Species Diversity* — increasing line

(D)

Survival of Invaders vs. *Species Diversity* — decreasing line

---

9. In 1944 Avery, MacLeod, and McCarty performed transformation experiments using live, harmless bacteria and extracts from virulent bacteria treated with various enzymes. Which of the following enzymes were used and why?

(A) Proteases and RNases to rule out protein and RNA as the transforming factors
(B) Lipase (an enzyme that facilitates the breakdown of lipids) to rule out lipoproteins as the transforming factor
(C) Kinase (an enzyme that facilitates transfer of a phosphate group from ATP to a substrate molecule) to show that transformation is phosphorylation dependent
(D) ATPase to show that transformation is not dependent on ATP

GO ON TO THE NEXT PAGE.

Questions 10-13

The figures below show the changes in populations of two species of flour beetles, *Tribolium confusum* (Figure I) and *Tribolium castaneum* (Figure II), in cultures without parasites (○) and in cultures infected with a parasite (●). Each data point represents the mean population size from ten culture dishes of equal size and food content.

FIGURE I: NUMBER OF *TRIBOLIUM CONFUSUM* OVER TIME
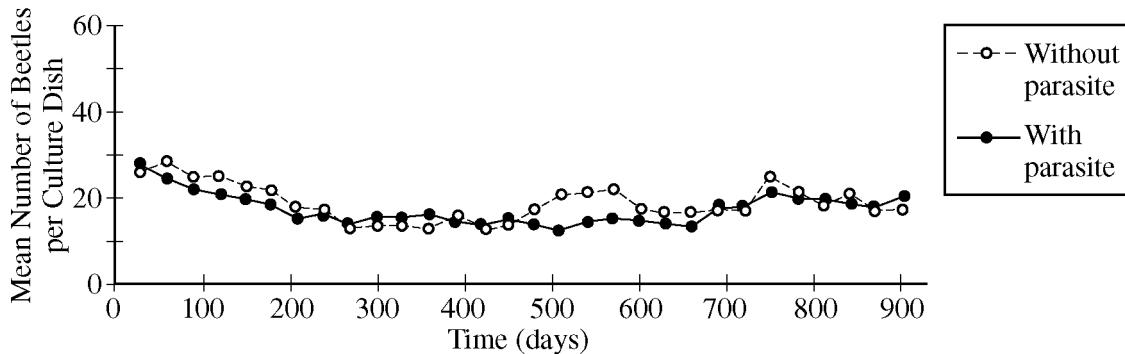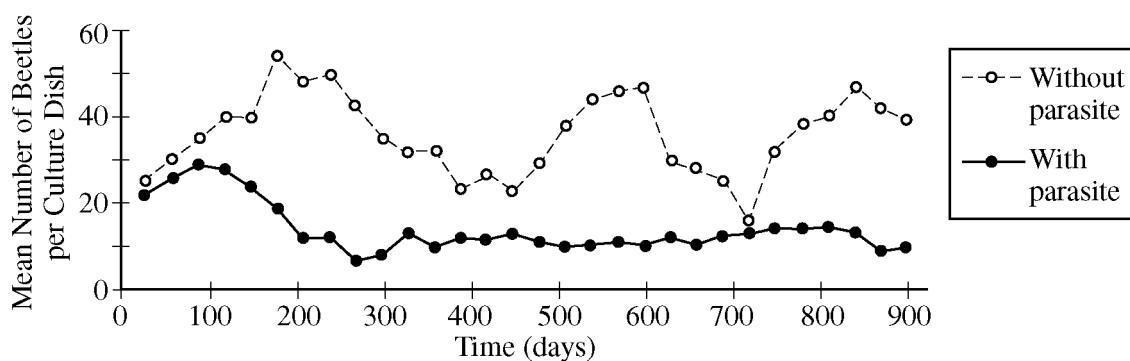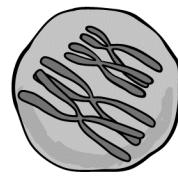
FIGURE II: NUMBER OF *TRIBOLIUM CASTANEUM* OVER TIME

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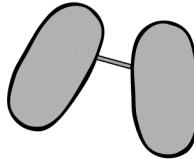
10. Under which of the following conditions is the observed number of beetles per culture dish the greatest?

(A) *T. confusum* with parasite at 500 days
(B) *T. confusum* without parasite at 300 days
(C) *T. castaneum* with parasite at 100 days
(D) *T. castaneum* with parasite at 600 days

11. The data over the duration of the experiment provide the strongest support for which of the following conclusions regarding the effect of the parasite on *Tribolium* populations?

(A) *T. confusum* is adversely affected by the parasite, while *T. castaneum* is not.
(B) *T. castaneum* is adversely affected by the parasite, while *T. confusum* is not.
(C) Both *T. confusum* and *T. castaneum* are adversely affected by the parasite.
(D) Both *T. confusum* and *T. castaneum* show increased fitness in the presence of the parasite.

12. In Figure I, the difference between the two curves can best be attributed to which of the following?

(A) The difference between controlled laboratory conditions and the natural environment
(B) The effect of the host on its parasite
(C) The influence of competition for limited resources
(D) The natural variation among populations

13. If the experiment was continued for an additional 500 days, the population density of *T. castaneum* with the parasite would most likely stabilize at a value closest to which of the following?

(A)   5 beetles/culture dish
(B) 10 beetles/culture dish
(C) 20 beetles/culture dish
(D) 25 beetles/culture dish

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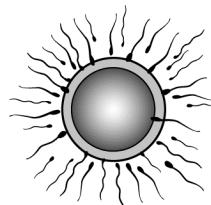
14. Beaked whales feed at various depths, but they defecate at the ocean's surface. Nitrogen-rich whale feces deposited in surface waters supply nutrients for algae that are eaten by surface-dwelling fish. Which of the following best predicts what would happen if the whale population decreased?

(A) There would be a reduction in surface nitrogen concentration, which would cause an algal bloom.
(B) The surface fish populations would decline due to reduced populations of algae.
(C) The remaining whales would accumulate mutations at a faster rate.
(D) The remaining whales would be forced to forage in the deepest parts of the ocean.
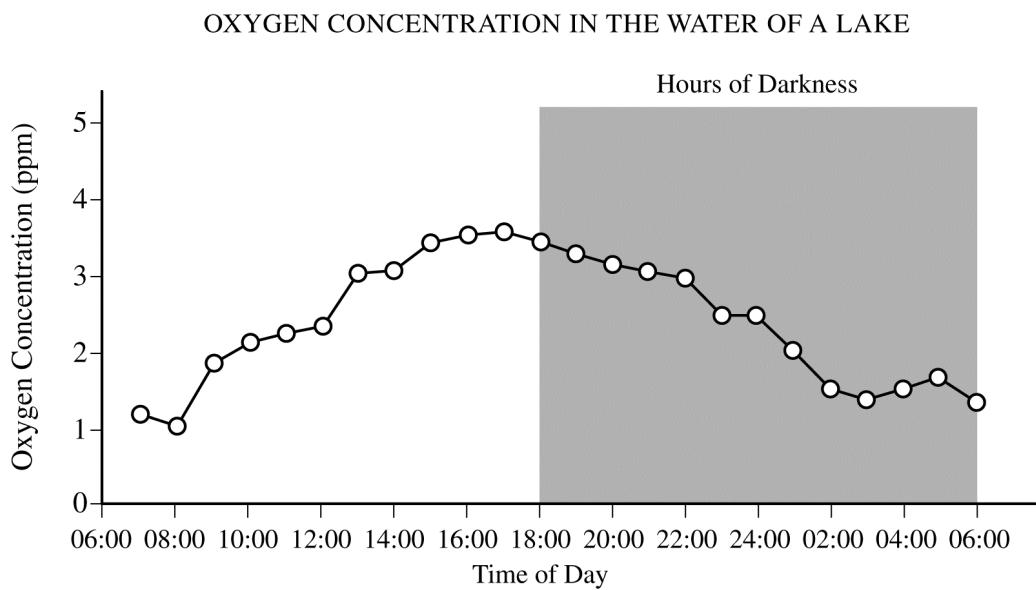
Crossing Over   Conjugation   Fertilization

15. The processes illustrated in the models depicted above all result in which of the following?

(A) Transcription
(B) An increase in genetic variation
(C) An increase in the chromosome number
(D) Horizontal gene transfer

GO ON TO THE NEXT PAGE.

16. The vertebrate forelimb initially develops in the embryo as a solid mass of tissue. As development progresses, the solid mass near the end of the forelimb is remodeled into individual digits. Which of the following best explains the role of apoptosis in remodeling of the forelimb?

    (A) Apoptosis replaces old cells with new ones that are less likely to contain mutations.
    (B) Apoptosis involves the regulated activation of proteins in specific cells of the developing forelimb that leads to the death of those cells.
    (C) Apoptosis involves the destruction of extra cells in the developing forelimb, which provides nutrients for phagocytic cells.
    (D) Apoptosis in the developing forelimb triggers the differentiation of cells whose fate was not already determined.

OXYGEN CONCENTRATION IN THE WATER OF A LAKE

17. What most likely causes the trends in oxygen concentration shown in the graph above?

    (A) The water becomes colder at night and thus holds more oxygen.
    (B) Respiration in most organisms increases at night.
    (C) More organisms are respiring at night than during the day.
    (D) Photosynthesis produces more oxygen than is consumed by respiration during the day.

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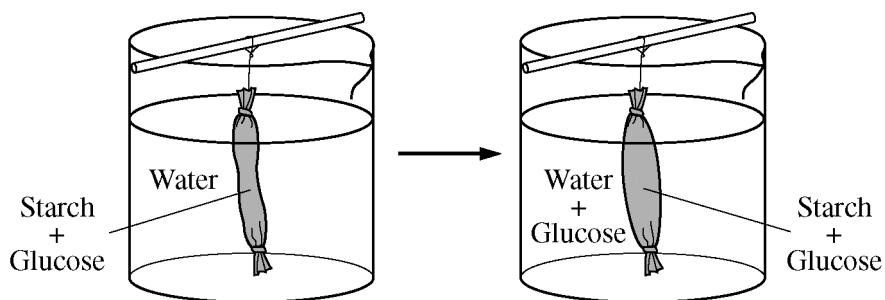
18. Data regarding the presence (+) or absence (−) of five derived traits in several different species are shown in the table below.

Species	Trait				
	1	2	3	4	5
V	+	+	+	−	−
W	+	+	−	−	−
X	+	−	−	+	+
Y	−	−	−	−	−
Z	+	−	−	−	+

Which of the following cladograms provides the simplest and most accurate representation of the data in the table?
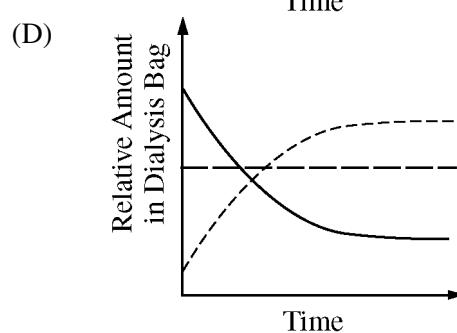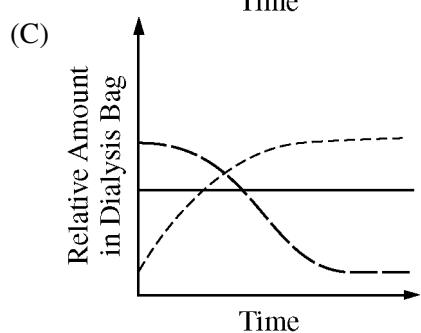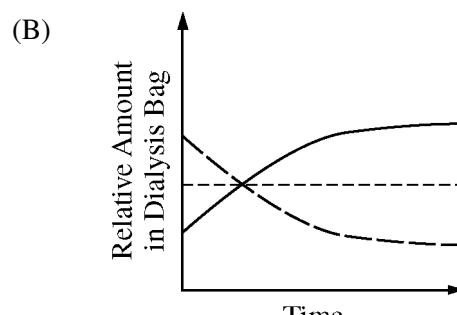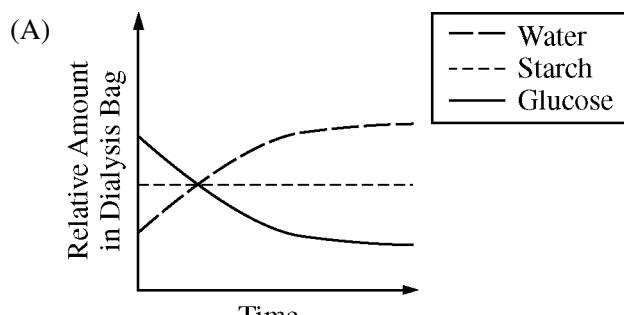
(A) Y   W   V Z   X

(B) X   Y Z   W   V

(C) Y   V   X W   Z

(D) Z   W X   V   Y

GO ON TO THE NEXT PAGE.

19. A common laboratory investigation involves putting a solution of starch and glucose into a dialysis bag and suspending the bag in a beaker of water, as shown in the figure below.

The investigation is aimed at understanding how molecular size affects movement through a membrane.

Which of the following best represents the amount of starch, water, and glucose in the dialysis bag over the course of the investigation?

(A)

(B)

(C)

(D)

GO ON TO THE NEXT PAGE.

Questions 20-22

Rhagoletis pomonella is a parasitic fly native to North America that infests fruit trees. The female fly lays her eggs in the fruit. The larvae hatch and burrow through the developing fruit. The next year, the adult flies emerge.
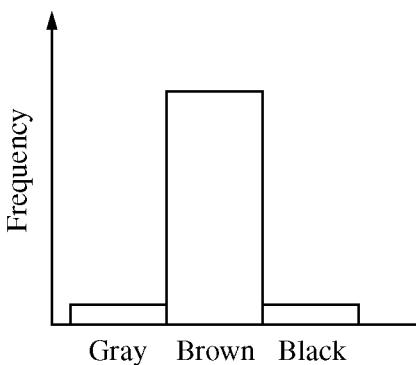
Prior to the European colonization of North America, the major host of *Rhagoletis* was a native species of hawthorn, *Crataegus marshallii*. The domestic apple tree, *Malus domestica,* is not native to North America, but was imported by European settlers in the late 1700s and early 1800s.

When apple trees were first imported into North America, there was no evidence that *Rhagoletis* could use them as hosts. Apples set fruit earlier in the season and develop faster, where hawthorns set later and develop more slowly.
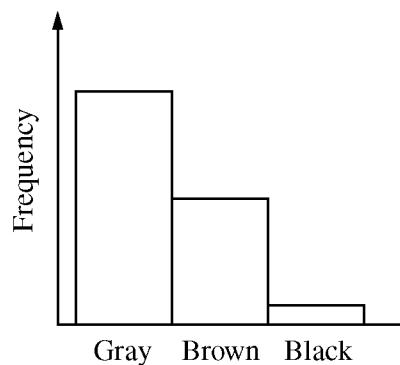
Recent analysis of *Rhagoletis* populations has shown that two distinct populations of flies have evolved from the original ancestral population of flies that were parasitic on hawthorns. One population infests only apple trees, and the other infests only hawthorns. The life cycles of both fly populations are coordinated with those of their host trees. The flies of each population apparently can distinguish and select mates with similar host preferences and reject mates from the population specific to the other host tree. There is very little hybridization (only about 5 percent) between the two groups.

20. The divergence between the two populations of *Rhagoletis* must have occurred very rapidly because

    (A) the apple tree was imported into North America with European settlement approximately 200 years ago
    (B) flies were imported into North America with European settlement approximately 200 years ago
    (C) long-distance rail transport of fruit increased only after the American Civil War (1861–1865)
    (D) heavy use of gunpowder during the American Civil War (1861–1865) led to increased mutation rates in many natural populations of plants and animals

21. Initially, which of the following isolating mechanisms is likely to have been the most important in preventing gene flow between the two populations of *Rhagoletis*?

    (A) Gamete incompatibility
    (B) Temporal isolation
    (C) Mechanical isolation
    (D) Reduced hybrid viability

22. Matings between individuals from the two populations of *Rhagoletis* produce hybrid flies that appear to be healthy and have normal life spans. The eggs laid by these hybrid flies, however, hatch less often than those of flies from either of the two populations. What isolating mechanism seems to be important in this hybrid population?

    (A) Prezygotic isolation
    (B) Mechanical isolation
    (C) Reduced hybrid fertility
    (D) Habitat isolation

GO ON TO THE NEXT PAGE.

FUR COLOR DISTRIBUTION
IMMEDIATELY AFTER RELEASE

Frequency

Gray   Brown   Black
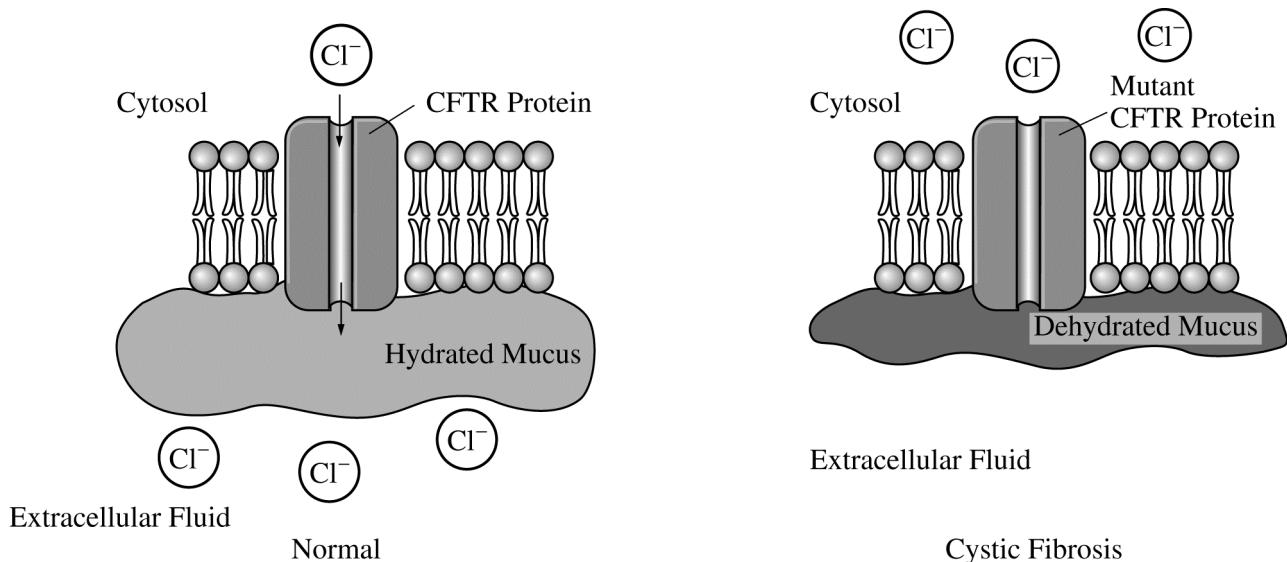
FUR COLOR DISTRIBUTION
AFTER TWENTY YEARS

Frequency

Gray   Brown   Black

23. A group of mice was released into a large field to which no other mice had access. Immediately after the release, a representative sample of the mice was captured, and the fur color of each individual in the sample was observed and recorded. The mice were then returned to the field. After twenty years, another representative sample of the mice was captured, and the fur color of each individual in the sample was again recorded. Which of the following best explains the change in the frequency distribution of fur color phenotypes in the mouse population, as shown in the figures above?

(A) The allele for gray fur color is unstable, and over twenty years most of those alleles mutated to become alleles for black fur.
(B) The field was composed primarily of light-colored soil and little vegetation, affording gray mice protection from predators.
(C) Sexual selection led to increased mating frequency of black and brown versus gray and brown.
(D) The gray mice were hardest to capture and so were underrepresented in the twenty-year sample.

GO ON TO THE NEXT PAGE.

24. Scientists have found that the existing populations of a certain species of amphibian are small in number, lacking in genetic diversity, and separated from each other by wide areas of dry land. Which of the following human actions is most likely to improve the long-term survival of the amphibians?

(A) Cloning the largest individuals to counteract the effects of aggressive predation
(B) Reducing the population size by one-fifth to decrease competition for limited resources
(C) Constructing a dam and irrigation system to control flooding
(D) Building ponds in the areas of dry land to promote interbreeding between the separated populations

25. A new mutation that arose in one copy of gene X in a somatic cell resulted in the formation of a tumor. Which of the following pieces of evidence best describes how the new mutation directly caused the tumor?

(A) Protein X normally stimulates cell division, and the mutation created an overactive version of protein X.
(B) Protein X normally activates a growth hormone receptor, and the mutation decreased the stability of protein X.
(C) Protein X normally prevents passage through the cell cycle, and the mutation created an overactive version of protein X.
(D) Protein X normally regulates gene expression, and the mutation created an underactive version of protein X that blocked the cell cycle.

Normal

Cystic Fibrosis

26. Cystic fibrosis is a recessively inherited disorder that results from a mutation in the gene encoding CFTR chloride ion channels located on the surface of many epithelial cells. As shown in the figure, the mutation prevents the normal movement of chloride ions from the cytosol of the cell to the extracellular fluid. As a consequence of the mutation, the mucus layer that is normally present on the surface of the cells becomes exceptionally dehydrated and viscous.
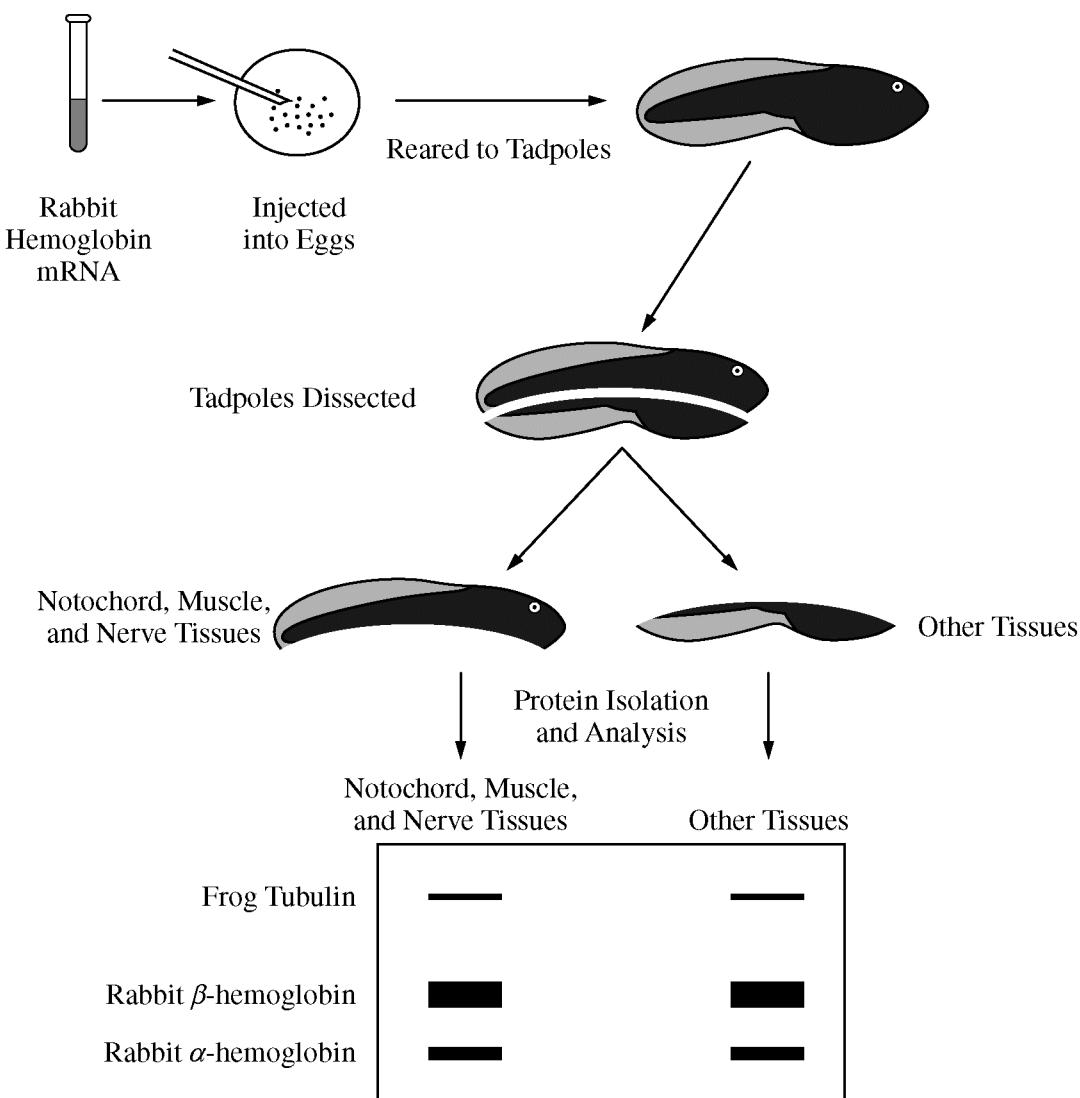
An answer to which of the following questions would provide the most information about the association between the CFTR mutation and the viscous mucus?

(A) Is the mucus also secreted from the cells through the CFTR proteins?
(B) How does the disrupted chloride movement affect the movement of sodium ions and water by the cell?
(C) How does the mutation alter the structure of the CFTR proteins?
(D) What is the change in nucleotide sequence that results in the CFTR mutation?
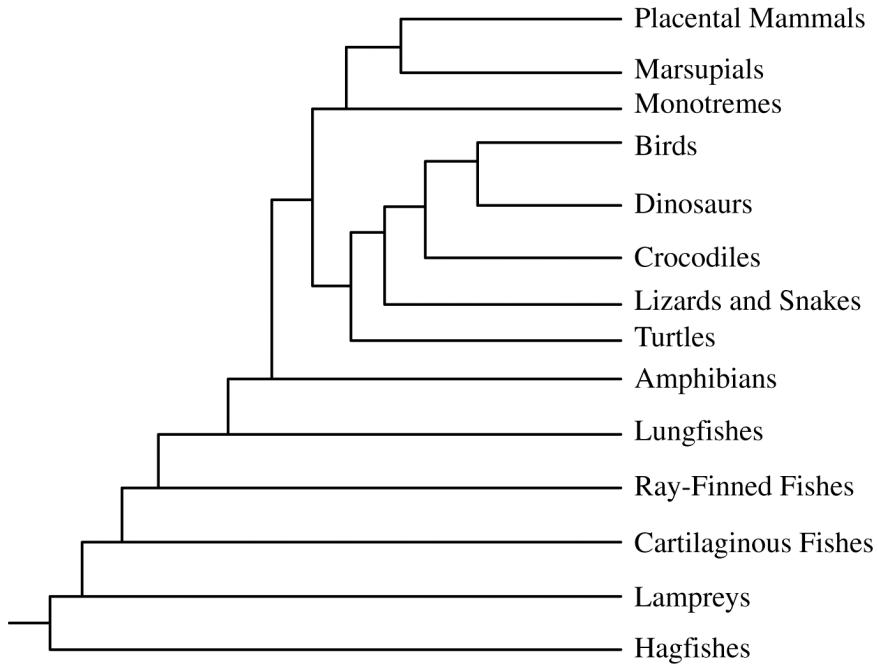
In a classic experiment from the 1970s investigating gene expression, a solution containing equal amounts of rabbit α-hemoglobin mRNA and β-hemoglobin mRNA, which encode subunits of a protein found in red blood cells, was injected into newly fertilized frog eggs. The injected mRNA was not degraded during the course of the experiment. Tadpoles that developed from the injected eggs were dissected into two fragments, one containing predominantly the notochord, muscle tissue, and nerve tissue and the other containing predominantly the other tissue types.

Equal amounts of total protein were analyzed after separation by electrophoresis to identify the relative amounts of the different proteins present in each sample. The thickness of the bands indicates the relative amounts of rabbit α-hemoglobin, rabbit β-hemoglobin, and frog tubulin (a cytoskeletal protein that is expressed at relatively constant levels in all tissues) present in each tadpole sample. The experimental protocol and results are summarized in the figure below.

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GO ON TO THE NEXT PAGE.

-18-

27. The observation that the rabbit mRNA was successfully translated in the frog tissues supports which of the following conclusions?

(A) Frog cells are able to replace their own hemoglobin with rabbit hemoglobin.
(B) Undeveloped frog eggs can be induced to form genetically identical copies of a rabbit.
(C) Rabbit hemoglobin can induce an immune response in frogs.
(D) Rabbits and frogs share a common genetic code for expressing heritable information.

28. The electrophoresis results best support which of the following conclusions?

(A) Cell specialization during development results in some cells losing the ability to synthesize proteins.
(B) Cells from different tissues share a common ability to use genetic material from a foreign source to produce protein.
(C) In comparison with other cells, nerve cells have a superior ability to produce cytoskeletal proteins.
(D) Muscle cells produce more β-hemoglobin than do cells from the other tissues in a tadpole.

29. Which of the following is the best justification for why the rabbit hemoglobin proteins were found throughout the tadpole?

(A) Rabbit mRNA is composed of nucleotides that are more stable than those in frog mRNA.
(B) Rabbit hemoglobin is synthesized more efficiently than frog hemoglobin in frog cells.
(C) After differentiation, the rabbit hemoglobin proteins move through the circulatory system of the tadpole to every cell.
(D) The mRNA injected into the newly fertilized frog eggs is distributed in the cytoplasm of every daughter cell during cell division.

30. Which of the following conclusions is most consistent with the results of the experiment?

(A) Rabbit mRNA is composed of nucleotides that are absent from frog mRNA.
(B) A larger volume of blood circulates through a rabbit than through a frog.
(C) The subunits of hemoglobin differ in size, shape, or charge.
(D) Synthesis of β-hemoglobin occurs at a faster rate in muscle cells than in other body cells.

31. Given that equal amounts of the different mRNAs were injected into fertilized frog eggs, which of the following conclusions is most consistent with the electrophoresis results?

(A) β-hemoglobin mRNA is translated more efficiently than is α-hemoglobin mRNA.
(B) α-hemoglobin is present only in cells where β-hemoglobin is absent.
(C) α-hemoglobin mRNA is more stable than β-hemoglobin mRNA.
(D) Tubulin inhibits translation of hemoglobin mRNA.

GO ON TO THE NEXT PAGE.

Placental Mammals

Marsupials

Monotremes

Birds

Dinosaurs

Crocodiles

Lizards and Snakes

Turtles

Amphibians

Lungfishes

Ray-Finned Fishes

Cartilaginous Fishes

Lampreys

Hagfishes

32. To determine the evolutionary history and relationships among organisms, scientists gather evidence from a wide variety of sources including paleontology, embryology, morphology, behavior, and molecular biology. A phylogenetic tree of vertebrates is shown.

Which of the following statements is most consistent with the phylogenetic tree shown?
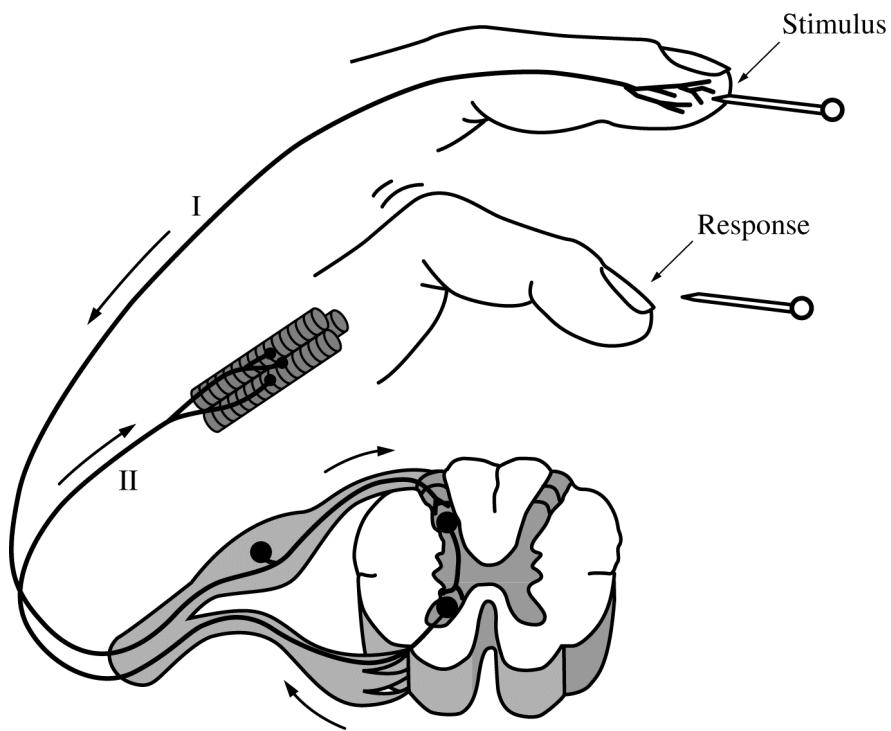
(A) Birds and turtles evolved their own means of gas exchange independently of the other vertebrates.
(B) Mammals are most closely related to birds because they share a direct common ancestor.
(C) The common ancestor of reptiles, birds, and mammals produced amniotic eggs.
(D) Crocodiles are direct descendents of ray-finned fishes since they live in the same environment.

GO ON TO THE NEXT PAGE.

33. A student in a biology class crossed a male *Drosophila melanogaster* having a gray body and long wings with a female *D. melanogaster* having a black body and apterous wings. The following distribution of traits was observed in the offspring.

Phenotype	Number of Offspring
Gray body, long wings	42
Black body, apterous wings	41
Gray body, apterous wings	9
Black body, long wings	8

Which of the following is supported by the data?

(A) The alleles for gray body and long wings are dominant.
(B) The alleles for gray body and long wings are recessive.
(C) Genes for the two traits are located on two different chromosomes, and independent assortment occurred.
(D) Genes for the two traits are located close together on the same chromosome, and crossing over occurred between the two gene loci.

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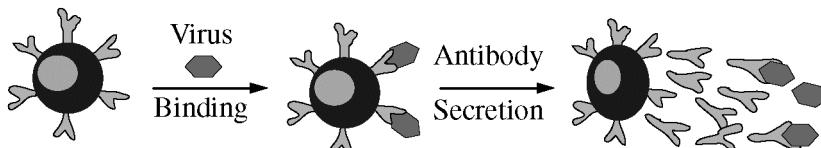
34. The diagram above depicts the response to a pinprick (stimulus) on the tip of a human finger. The arrows show the direction of impulse transmission along the labeled axons. If axon II was damaged before the pinprick, which of the following is most likely?

(A) The person will not feel the pinprick.
(B) The person can no longer feel pain.
(C) The person's finger will not withdraw reflexively.
(D) The person cannot transmit nerve impulses to the brain.

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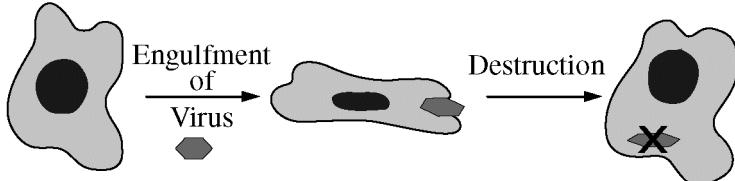
35. If chemical signals in the cytoplasm control the progression of a cell to the M phase of the cell cycle, then fusion of a cell in G_1 with a cell in early M phase would most likely result in the

(A) replication of chromosomes only in the G_1 cell

(B) exiting of both cells from the cell cycle and into the G_0 phase

(C) condensation of chromatin in preparation of nuclear division in both cells

(D) transfer of organelles from the G_1 cell to the cell in the M phase

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36. The healthy human immune system responds to pathogens with both specific and nonspecific processes. Which of the following models depicts a nonspecific response?
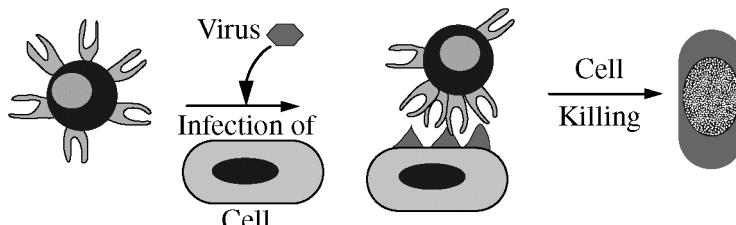
(A) B cell
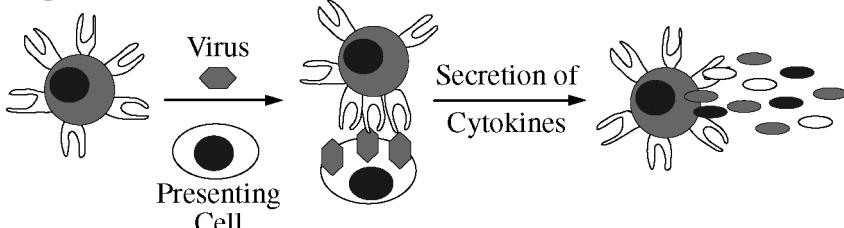
(B) Macrophage
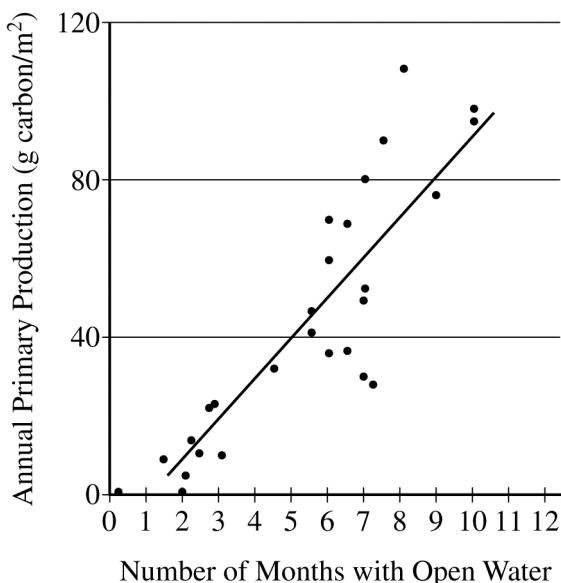
(C) Cytotoxic T cell

(D) Helper T cell

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Number of Months with Open Water
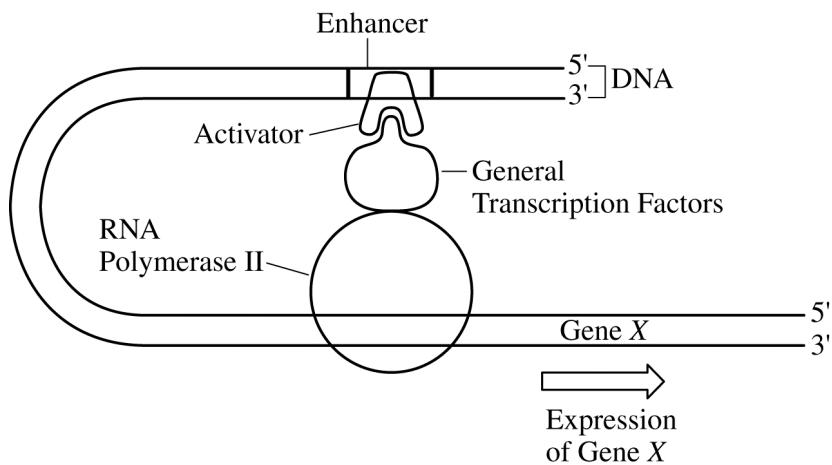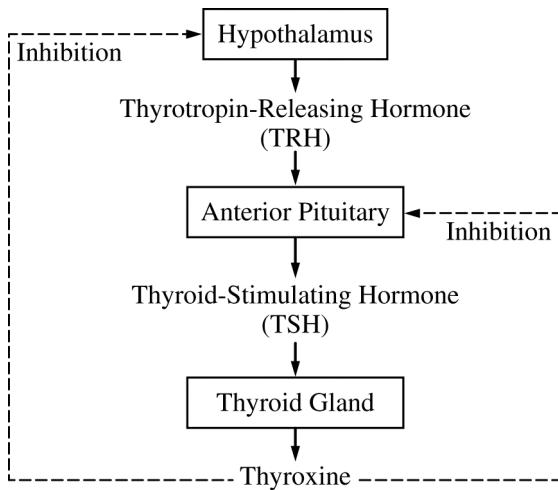
37. In the Arctic Ocean, the predominant primary producers are phytoplankton. Phytoplankton are consumed by zooplankton, which in turn are eaten by codfish. In years when there is more open water (less ice coverage), there are more zooplankton and fish than in years with less open water (more ice coverage). Based on the graph above, the difference is most likely because

(A) when there is less open water, light is blocked from the zooplankton, so they cannot produce as much food for the fish
(B) when there is more open water, the temperature is warmer, so the zooplankton and fish populations increase in size
(C) the ice blocks the light, so in years with more ice coverage, there is less photosynthesis by the phytoplankton
(D) the ice increases the light available for photosynthesis, so primary production increases and zooplankton populations increase in size

Expression
of Gene *X*

38. The figure above depicts the DNA-protein complex that is assembled at the transcriptional start site of gene *X* when the expression of gene *X* is activated in liver cells. Previous studies have shown that gene *X* is never expressed in nerve cells. Based on the diagram, which of the following most likely contributes to the specific expression pattern of gene *X* ?

   (A) Expression of gene *X* produces large amounts of tRNA but undetectable amounts of mRNA.
   (B) The general transcription factors inhibit the activation of gene *X* in liver cells by blocking the activator from binding to RNA polymerase II.
   (C) The activator is a sequence-specific DNA-binding protein that is present in some tissues but not in other tissues.
   (D) The enhancer is a unique DNA segment that is added to the nuclear DNA of some cells of an organism during the process of mitotic cell division but not other cells.

GO ON TO THE NEXT PAGE.

```
            ┌──────────────┐
   ┌ ─ ─ ─ ─→│ Hypothalamus │
Inhibition   └──────────────┘
   │                │
   │                ▼
   │   Thyrotropin-Releasing Hormone
   │             (TRH)
   │                │
   │                ▼
   │   ┌──────────────────┐
   │   │ Anterior Pituitary │◄─ ─ ─ ─ ┐
   │   └──────────────────┘  Inhibition
   │                │                │
   │                ▼                │
   │   Thyroid-Stimulating Hormone   │
   │             (TSH)               │
   │                │                │
   │                ▼                │
   │       ┌──────────────┐          │
   │       │ Thyroid Gland │          │
   │       └──────────────┘          │
   │                │                │
   │                ▼                │
   └ ─ ─ ─ ─ ─ Thyroxine ─ ─ ─ ─ ─ ─┘
```

39. The diagram above illustrates feedback control as exerted by the hormone thyroxine. Following surgical removal of the thyroid gland, the level of TSH in the blood will increase. Which of the following best explains this increase?

(A) Residual blood thyroxine, from prior to thyroid gland removal, will bind to cells in the anterior pituitary, signaling more TSH secretion.
(B) Thyroxine will remain bound to thyroxine receptors on various body cells, and these body cells will secrete additional hormones that stimulate the anterior pituitary to secrete TSH.
(C) Thyroxine that was stored in the anterior pituitary prior to thyroid gland removal will signal more TSH secretion.
(D) A decrease in thyroxine levels means a loss of inhibition to the hypothalamus and anterior pituitary, leading to increased TSH secretion.

GO ON TO THE NEXT PAGE.

40. The data below demonstrate the frequency of tasters and nontasters of a certain compound in four isolated populations that are in Hardy-Weinberg equilibrium. The allele for nontasters is recessive. In which population is the frequency of the recessive allele highest?

|	Population	Tasters	Nontasters	Size of Population
(A)	1	110	32	142
(B)	2	8,235	4,328	12,563
(C)	3	215	500	715
(D)	4	11,489	2,596	14,085

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Questions 41-45
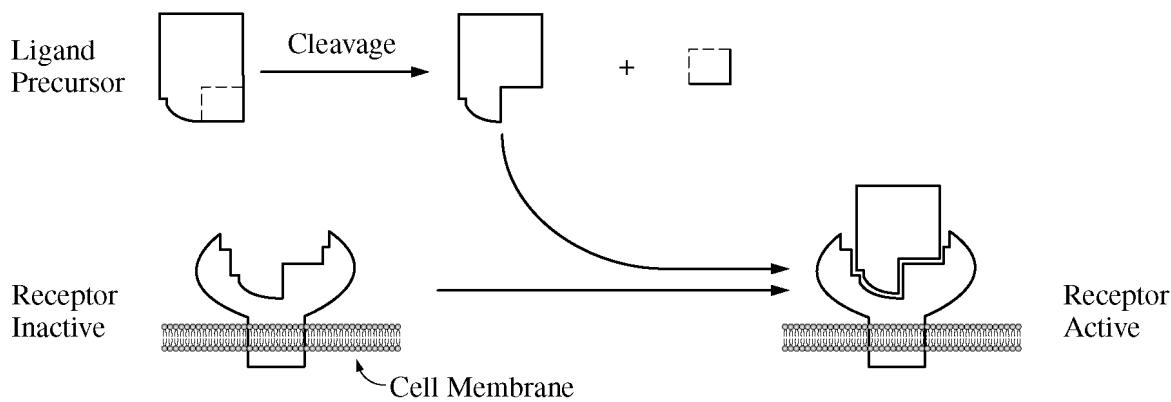
Photosynthetic activity can be measured using chloroplasts suspended in a buffered solution containing DCPIP, a dye that can accept electrons from the electron transport chain of photosynthesis. Transfer of electrons to DCPIP decreases the relative absorbance of a specific wavelength of light (605 nm) by a solution that contains the dye.

A buffered solution containing chloroplasts and DCPIP was divided equally among six identical samples. The samples were placed at various distances from a lamp, and then all samples were exposed to white light from the lamp for 60 minutes at room temperature. Sample 3 was wrapped in foil to prevent any light from reaching the solution. At 20-minute intervals, the photosynthetic activity in each sample was determined by measuring the relative absorbance of 605 nm light. The results of the experiment are provided below.

Sample	Distance from Lamp (cm)	Relative Absorbance of 605 nm Light (arbitrary units)			
		0 min	20 min	40 min	60 min
1	15	0.89	0.61	0.34	0.04
2	30	0.90	0.67	0.41	0.14
3*	30	0.88	0.87	0.86	0.87
4	45	0.86	0.69	0.47	0.26
5	60	0.92	0.75	0.59	0.41
6	75	0.88	0.79	0.71	0.58
* wrapped in foil					

GO ON TO THE NEXT PAGE.

41. Which of the following provides the best indication that light is required for the activation of electron transfer reactions in chloroplasts?

(A) Calculating the rate of change of the absorbance for sample 1
(B) Comparing the observed results for sample 2 and sample 3
(C) Repeating the entire experimental procedure at night
(D) Including multiple trials for all the samples

42. Which of the following can be reasonably concluded from the experimental results?

(A) Chloroplasts must be suspended in a buffer solution to function properly.
(B) The optimal temperature for activation of electron transfer is 25°C.
(C) DCPIP inhibits biochemical reactions in suspended chloroplasts.
(D) Light from a lamp can substitute for sunlight in stimulating chloroplast processes.

43. If an additional sample containing the chloroplast/DCPIP solution was placed at a distance of 90 cm from the lamp, which of the following predictions would be most consistent with the experimental results?

(A) The concentration of DCPIP in the solution will increase exponentially.
(B) The absorbance at 60 minutes will be roughly equal to 1.4.
(C) The change in absorbance over time in the solution will be less than that of the other samples.
(D) The temperature of the solution will exceed 75°C.

44. Which of the following descriptions of photosynthesis best explains the results of the experiment?

(A) Availability of electrons for transfer to DCPIP depends on light energy.
(B) Movement of DCPIP across chloroplast membranes occurs in less than 60 minutes.
(C) Chlorophyll molecules degrade rapidly in the presence of DCPIP.
(D) DCPIP can only be used to measure photosynthetic activity at low light levels.

45. Which of the following scientific questions could be investigated using a similar experimental setup?

(A) How much carbon dioxide is required by a plant cell to produce one molecule of glucose?
(B) What wavelength of light best activates electron transfer reactions in chloroplasts?
(C) Which molecule in chloroplasts accepts activated electrons from DCPIP during photosynthesis?
(D) Are the same genes that are expressed in chloroplasts also expressed in mitochondria?

GO ON TO THE NEXT PAGE.

Ligand Precursor   Cleavage   +

Receptor Inactive   Cell Membrane   Receptor Active

46. The figure above shows a model of a ligand precursor being cleaved to produce an active ligand that binds to a specific receptor. Which of the following is most likely to reduce the binding of the active ligand to its receptor?

(A) A change in the cytoskeletal attachment of transmembrane proteins
(B) The presence of a large amount of the precursor form of the ligand
(C) An increase in the ratio of the number of unsaturated to the number of saturated fatty acid tails of the membrane lipids
(D) A mutation in the receptor gene that causes a substitution of a charged amino acid for a nonpolar amino acid in the ligand binding site of the receptor

GO ON TO THE NEXT PAGE.

47. Students in a class measured the mass of various living organisms. They then kept the organisms in the dark for 24 hours before remeasuring them. None of the organisms were provided with nutrients during the 24-hour period. The data are as follows.

Organism	Starting Mass (g)	Final Mass (g)
Elodea (submerged aquatic plant)	15.10	14.01
Goldfish	10.10	9.84
Sea anemone	25.60	24.98

Which of the following is the best explanation for the pattern of change in mass of the organisms over time?

(A) Water loss due to evaporation
(B) Cellular respiration
(C) The law of conservation of matter
(D) Growth and reproduction

GO ON TO THE NEXT PAGE.

The following figures display data collected while studying a family, some members of which have sickle-cell disease—a rare genetic disorder caused by a mutation in the hemoglobin beta gene (*HBB*). There are at least two alleles of the *HBB* gene: the *HbA* allele encodes wild-type hemoglobin and the *HbS* allele encodes the sickle-cell form of hemoglobin. Genetic testing provided insight into the inheritance pattern for sickle-cell disease.
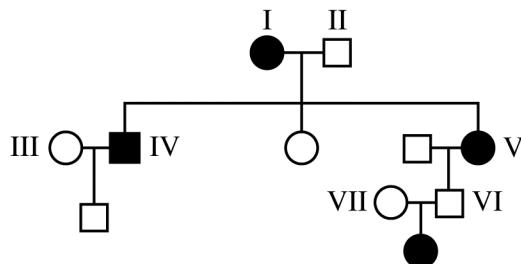

Figure 1. Pedigree of a family with affected individuals. Squares represent males, circles represent females, shaded symbols represent individuals with sickle-cell disease.

5′ CTG ACT CCT GAG GAG AAG TCT 3′   Non-template Strand
3′ GAC TGA GGA CTC CTC TTC AGA 5′   Template Strand

Figure 2. A portion of the DNA sequence from the wild-type hemoglobin allele (*HbA*) that codes for normal hemoglobin.

Second Base in Codon

		U	C	A	G	
First Base in Codon	U	UUU ⎤ Phe UUC ⎦ UUA ⎤ Leu UUG ⎦	UCU ⎤ UCC ⎥ Ser UCA ⎥ UCG ⎦	UAU ⎤ Tyr UAC ⎦ UAA Stop UAG Stop	UGU ⎤ Cys UGC ⎦ UGA Stop UGG Trp	U C A G
	C	CUU ⎤ CUC ⎥ Leu CUA ⎥ CUG ⎦	CCU ⎤ CCC ⎥ Pro CCA ⎥ CCG ⎦	CAU ⎤ His CAC ⎦ CAA ⎤ Gln CAG ⎦	CGU ⎤ CGC ⎥ Arg CGA ⎥ CGG ⎦	U C A G
	A	AUU ⎤ AUC ⎥ Ile AUA ⎦ AUG Met or Start	ACU ⎤ ACC ⎥ Thr ACA ⎥ ACG ⎦	AAU ⎤ Asn AAC ⎦ AAA ⎤ Lys AAG ⎦	AGU ⎤ Ser AGC ⎦ AGA ⎤ Arg AGG ⎦	U C A G
	G	GUU ⎤ GUC ⎥ Val GUA ⎥ GUG ⎦	GCU ⎤ GCC ⎥ Ala GCA ⎥ GCG ⎦	GAU ⎤ Asp GAC ⎦ GAA ⎤ Glu GAG ⎦	GGU ⎤ GGC ⎥ Gly GGA ⎥ GGG ⎦	U C A G

Third Base in Codon

Figure 3. Codon table showing nucleotide sequences for each amino acid.

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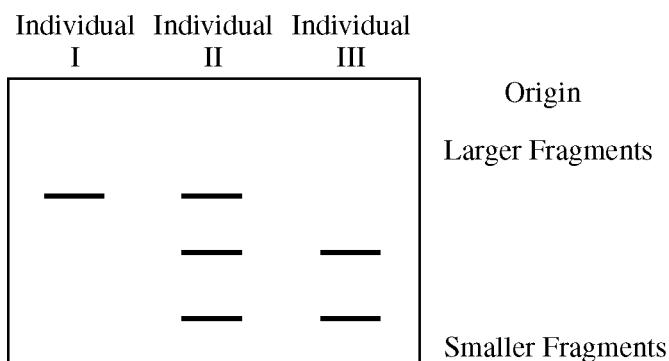
Figure 4. Image of a gel following electrophoretic separation of DNA fragments of the *HBB* gene from three individuals in the pedigree in Figure 1.

48. Based on the data shown in Figure 1, which of the following best describes the genotypes of individual family members in the pedigree?

(A) All affected individuals possess at least one dominant allele of the hemoglobin beta gene.
(B) Healthy individuals may possess one mutant allele (*HbS*) of the hemoglobin beta gene.
(C) Individuals IV and V must be heterozygous for the *HbS* (mutant) allele.
(D) Individuals II and VI possess two copies of the *HbA* (wild-type) allele.

49. The *HbS* allele, which causes sickle-cell disease, results from a mutation in the DNA sequence shown in Figure 2 that produces a valine (val) in the place of a glutamic acid (glu) residue in the hemoglobin protein. Which of the following mRNA sequences is derived from the *HbS* allele?

(A) 5′ GAC TGA GGA CTC CTC TTC AGA 3′
(B) 5′ UCU GAA GAG GAA UCC UCA GUC 3′
(C) 5′ AGA CTT CTC CTC AGG AGT CAG 3′
(D) 5′ CUG ACU CCU GUG GAG AAG UCU 3′

50. The restriction endonuclease *Mst* II recognizes the sequence 5′ CCT(N)AG (where N = any nucleotide) and cuts DNA at that site, producing separate fragments. Which of the following best explains the banding patterns exhibited in Figure 4 ?

(A) The *HbA* DNA contains a recognition site for the *Mst* II restriction enzyme.
(B) The *HbA/HbS* DNA contains three recognition sites for the *Mst* II restriction endonuclease.
(C) Individual I has only one copy of the hemoglobin gene; therefore there is only one band on the gel.
(D) The *HbS/HbA* DNA contains three different alleles for sickle-cell disease.

51. Possessing a single copy of the *HbS* allele has been shown to provide some resistance to infection by *Plasmodium falciparum*, the parasite that causes malaria. Which of the following individuals represented in the pedigree would have the greatest selective advantage in an area where malaria is common?

(A) I
(B) II
(C) III
(D) V

GO ON TO THE NEXT PAGE.

52. Antidiuretic hormone (ADH) is important in maintaining homeostasis in mammals. ADH is released from the hypothalamus in response to high tissue osmolarity. In response to ADH, the collecting duct and distal tubule in the kidney become more permeable to water, which increases water reabsorption into the capillaries. The amount of hormone released is controlled by a negative feedback loop.

Based on the model presented, which of the following statements expresses the proper relationship between osmolarity, ADH release, and urine production?

(A) As tissue osmolarity rises, more ADH is released, causing less water to be excreted as urine.
(B) As tissue osmolarity rises, less ADH is released, causing less water to be excreted as urine.
(C) As tissue osmolarity rises, more ADH is released, causing more water to be excreted as urine.
(D) As tissue osmolarity rises, less ADH is released, causing more water to be excreted as urine.

GO ON TO THE NEXT PAGE.

53. Ellis-van Creveld syndrome is a recessive genetic disorder that includes the characteristics of short stature and extra fingers or toes. In the general population, this syndrome occurs in approximately 1 in 150,000 live births. In a particular isolated population, however, the incidence of this syndrome among live births is 1 in 500.

Assume that both the isolated population and the general population are in Hardy-Weinberg equilibrium with respect to this syndrome. Which of the following best describes the difference between the frequency of the allele that causes the syndrome in the general population and the frequency of the allele in the isolated population?

(A) The frequency of the Ellis-van Creveld allele is 0.002 in the isolated population and 0.0000066 in the general population, which suggests that selection for this trait is occurring in both populations.

(B) The frequency of the Ellis-van Creveld allele is 0.0447 in the isolated population and 0.0026 in the general population, showing that the rate of genetic mutation is highest among individuals in the isolated population.

(C) The frequency of the Ellis-van Creveld allele is 0.002 in the isolated population and 0.0000066 in the general population, which demonstrates gametic incompatibility between the populations.

(D) The frequency of the Ellis-van Creveld allele is 0.0447 in the isolated population and 0.0026 in the general population, which suggests that genetic drift has occurred in the isolated population.

GO ON TO THE NEXT PAGE.

Directions: The next five questions, numbered 121–125, require numeric answers.
Determine the correct answer for each question and enter it in the grid on page 3 of the answer sheet.
Use the following guidelines for entering your answers.

- Start your answer in any column, space permitting. Unused columns should be left blank.

- Write your answer in the boxes at the top of the grid and fill in the corresponding circles. Mark only one circle in any column. You will receive credit only if the circles are filled in completely.

- Provide your answer in the format specified by the question. The requested answer may be an integer, a decimal, or a fraction, and it may have a negative value.

- To enter a fraction, use one of the division slashes to separate the numerator from the denominator, as shown in the example below. Fractions only need to be reduced enough to fit in the grid.

- Do not enter a mixed number, as this will be scored as a fraction. For example, 2 1/2 (two and one-half) will be scored as 21/2 (twenty-one halves).

Integer answer: 5024
(either position is correct)
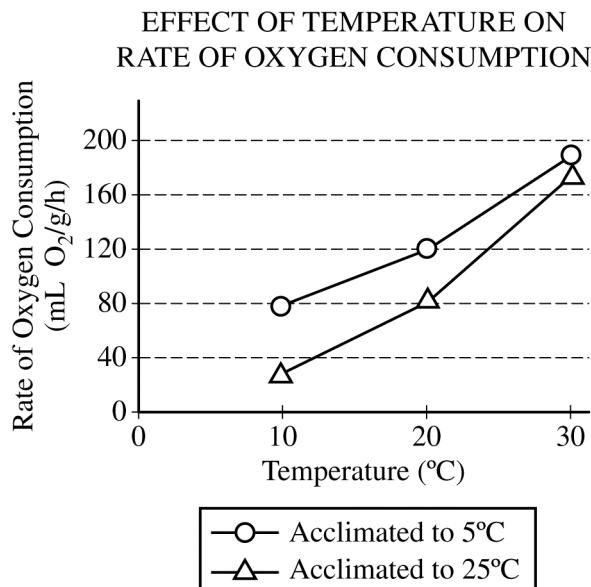
Decimal answer
−4.13

Fraction answer: −2/10
(does not have
to be reduced)

121. Some people have the ability to taste a bitter chemical called phenylthiocarbamide (PTC). The ability to taste PTC is due to the presence of at least one dominant allele for the PTC taste gene. The incidence of nontasters in North America is approximately 45%. Assuming the population is in Hardy-Weinberg equilibrium, what percent of the North American population is homozygous dominant for the ability to taste PTC? Provide your answer as a number between 0 and 1 to the nearest hundredth.

EFFECT OF TEMPERATURE ON
RATE OF OXYGEN CONSUMPTION

Rate of Oxygen Consumption (mL O_2/g/h)

200, 160, 120, 80, 40, 0

Temperature (ºC): 0, 10, 20, 30

—O— Acclimated to 5ºC
—△— Acclimated to 25ºC

122. Based on the data shown, calculate the average rate of increase in oxygen consumption for animals acclimated to 5°C as the temperature increases from 10°C to 30°C. Give the answer in mL O_2/g/h/°C to the nearest tenth.

GO ON TO THE NEXT PAGE.

123. To estimate the size of an animal population, researchers often use a method known as mark-recapture, which involves marking individuals from a large population for easy identification upon recapture. The mark-recapture method assumes that the proportion of marked individuals in the recapture group is equal to the proportion of marked individuals in the entire population.

Researchers used the mark-recapture method to estimate the number of individuals in a population. Using the results presented in the table below, estimate the total number of individuals in the population. Give your answer to the nearest whole number.
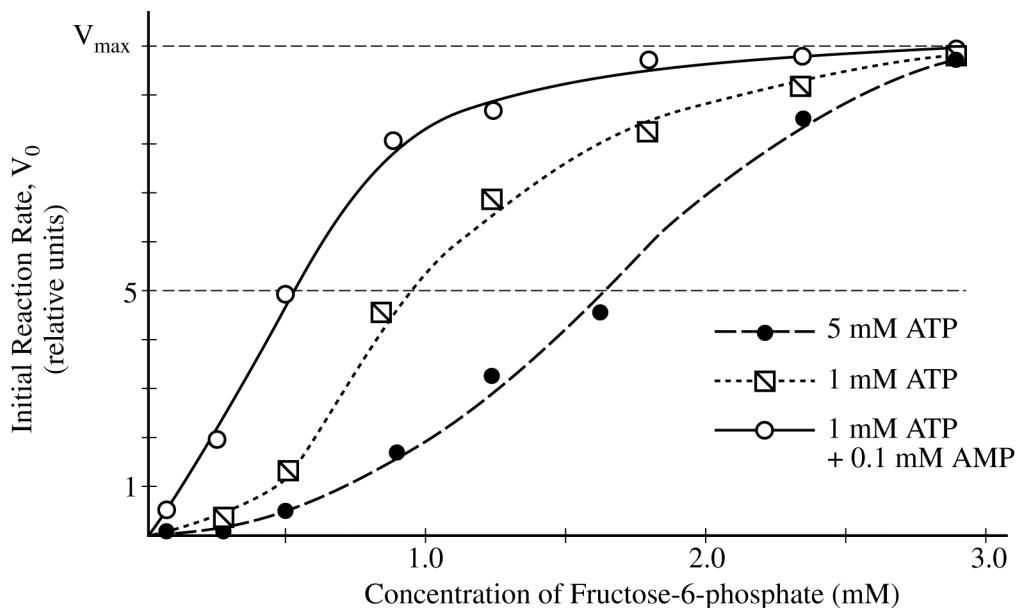
	Number of Marked Individuals	Total Number of Individuals
Recapture group	14	88
Entire population	180	?

124. A certain species of plant has four unlinked genetic loci, W, X, Y, and Z. Each genetic locus has one dominant allele and one recessive allele. For a plant with the genotype $WwXxYyZz$, what is the probability that the plant will produce a gamete with a haploid genotype of $Wxyz$? Give your answer as a fraction or as a value between 0 and 1, to four decimal places.

GO ON TO THE NEXT PAGE.

125. The enzyme phosphofructokinase (PFK) is an allosterically regulated enzyme that catalyzes the following reaction.

Fructose-6-phosphate + ATP → Fructose-1,6-bisphosphate + ADP

The graph below shows that at certain concentrations ATP inhibits the enzyme, whereas AMP activates it. According to the information presented in the graph, when the concentration of fructose-6-phosphate is 0.5 mM, how many times more active is PFK in cells with 1 mM ATP + 0.1 mM AMP than in cells with 5 mM ATP? Express your answer to the nearest whole number.

S T O P

END OF SECTION I

IF YOU FINISH BEFORE TIME IS CALLED,
YOU MAY CHECK YOUR WORK ON THIS SECTION.

DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.

_____

MAKE SURE YOU HAVE DONE THE FOLLOWING.

- **PLACED YOUR AP NUMBER LABEL ON YOUR ANSWER SHEET**

- **WRITTEN AND GRIDDED YOUR AP NUMBER CORRECTLY ON YOUR ANSWER SHEET**

- **TAKEN THE AP EXAM LABEL FROM THE FRONT OF THIS BOOKLET AND PLACED IT ON YOUR ANSWER SHEET.**

Section II: Free-Response Questions

This is the free-response section of the 2013 AP exam. It includes cover material and other administrative instructions to help familiarize students with the mechanics of the exam. (Note that future exams may differ in look from the following content.)

AP® Biology Exam

SECTION II: Free Response

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
1 hour, 30 minutes
Number of Questions
8
Percent of Total Score
50%
Writing Instrument
Pen with black or dark blue ink
Electronic Device
Four-function calculator (with square root)

Reading Period

Time
10 minutes. Use this time to read the questions and plan your answers.

Writing Period

Time
1 hour, 20 minutes
Suggested Time
Approximately 22 minutes per long question, and 6 minutes per short question.
Weight
Approximate weights
Questions 1 and 2: 25% each
Questions 3–5: 10% each
Questions 6–8: 7% each

IMPORTANT Identification Information

PLEASE PRINT WITH PEN:

1. First two letters of your last name

   First letter of your first name

2. Date of birth

   Month   Day   Year

3. Six-digit school code

4. Unless I check the box below, I grant the College Board the unlimited right to use, reproduce, and publish my free-response materials, both written and oral, for educational research and instructional purposes. My name and the name of my school will not be used in any way in connection with my free-response materials. I understand that I am free to mark "No" with no effect on my score or its reporting.

   No, I do not grant the College Board these rights.

Instructions

The questions for Section II are printed in this booklet. You may use the unlined pages to organize your answers and for scratch work, but you must write your answers on the labeled pages provided for each question.

The proctor will announce the beginning and end of the reading period. You are advised to spend the 10-minute period reading all the questions, and to use the unlined pages to sketch graphs, make notes, and plan your answers. The focus of the reading period should be the organization of questions 1 and 2. Do NOT begin writing on the lined pages until the proctor tells you to do so.

Each answer should be written in paragraph form; an outline or bulleted list alone is not acceptable. Do not spend time restating the questions or providing more than the number of examples called for. For instance, if a question calls for two examples, you can earn credit only for the first two examples that you provide. Labeled diagrams may be used to supplement discussion, but unless specifically called for by the question, a diagram alone will not receive credit. Write clearly and legibly. Begin each answer on a new page. Do not skip lines. Cross out any errors you make; crossed-out work will not be scored.

Manage your time carefully. You may proceed freely from one question to the next. You may review your responses if you finish before the end of the exam is announced.

AP® BIOLOGY EQUATIONS AND FORMULAS

Statistical Analysis and Probability

Mean uuu

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Standard Deviation

$$S = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

Standard Error of the Mean

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

Chi-Square

$$\chi^2 = \sum \frac{(o-e)^2}{e}$$

$\bar{x}$ = sample mean

n = size of the sample

s = sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population)

o = observed results

e = expected results

Degrees of freedom are equal to the number of distinct possible outcomes minus one.

Chi-Square Table

p value	Degrees of Freedom							
	1	2	3	4	5	6	7	8
0.05	3.84	5.99	7.82	9.49	11.07	12.59	14.07	15.51
0.01	6.64	9.21	11.34	13.28	15.09	16.81	18.48	20.09

Laws of Probability

If A and B are mutually exclusive, then:

$$P(\text{A or B}) = P(\text{A}) + P(\text{B})$$

If A and B are independent, then:

$$P(\text{A and B}) = P(\text{A}) \times P(\text{B})$$

Hardy-Weinberg Equations

$$p^2 + 2pq + q^2 = 1$$

$$p + q = 1$$

p = frequency of the dominant allele in a population

q = frequency of the recessive allele in a population

Metric Prefixes

Factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Mode = value that occurs most frequently in a data set

Median = middle value that separates the greater and lesser halves of a data set

Mean = sum of all data points divided by number of data points

Range = value obtained by subtracting the smallest observation (sample minimum) from the greatest (sample maximum)

Rate and Growth

Rate

$$\frac{dY}{dt}$$

Population Growth

$$\frac{dN}{dt} = B - D$$

Exponential Growth

$$\frac{dN}{dt} = r_{max}N$$

Logistic Growth

$$\frac{dN}{dt} = r_{max}N\left(\frac{K - N}{K}\right)$$

Temperature Coefficient Q₁₀

$$Q_{10} = \left(\frac{k_2}{k_1}\right)^{\frac{10}{T_2 - T_1}}$$

Primary Productivity Calculation

$$\frac{\text{mg O}_2}{\text{L}} \times \frac{0.698 \text{ mL}}{\text{mg}} = \frac{\text{mL O}_2}{\text{L}}$$

$$\frac{\text{mL O}_2}{\text{L}} \times \frac{0.536 \text{ mg C fixed}}{\text{mL O}_2} = \frac{\text{mg C fixed}}{\text{L}}$$

(at standard temperature and pressure)

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dY = amount of change

dt = change in time

B = birth rate

D = death rate

N = population size

K = carrying capacity

r_{max} = maximum per capita growth rate of population

T_2 = higher temperature

T_1 = lower temperature

k_2 = reaction rate at T_2

k_1 = reaction rate at T_1

Q_{10} = the factor by which the reaction rate increases when the temperature is raised by ten degrees

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Water Potential (Ψ)

$$\Psi = \Psi_P + \Psi_S$$

Ψ_P = pressure potential

Ψ_S = solute potential

The water potential will be equal to the solute potential of a solution in an open container because the pressure potential of the solution in an open container is zero.

The Solute Potential of a Solution

$$\Psi_S = -iCRT$$

i = ionization constant (this is 1.0 for sucrose because sucrose does not ionize in water)

C = molar concentration

R = pressure constant (R = 0.0831 liter bars/mole K)

T = temperature in Kelvin (ºC + 273)

Surface Area and Volume

Volume of a Sphere

$$V = \frac{4}{3}\pi r^3$$

Volume of a Rectangular Solid

$$V = \ell wh$$

Volume of a Right Cylinder

$$V = \pi r^2 h$$

Surface Area of a Sphere

$$A = 4\pi r^2$$

Surface Area of a Cube

$$A = 6s^2$$

Surface Area of a Rectangular Solid

$$A = \sum \text{surface area of each side}$$

---

r = radius

ℓ = length

h = height

w = width

s = length of one side of a cube

A = surface area

V = volume

Σ = sum of all

Dilution (used to create a dilute solution from a concentrated stock solution)

$$C_iV_i = C_fV_f$$

i = initial (starting) C = concentration of solute
f = final (desired) V = volume of solution

Gibbs Free Energy

$$\Delta G = \Delta H - T\Delta S$$

ΔG = change in Gibbs free energy

ΔS = change in entropy

ΔH = change in enthalpy

T = absolute temperature (in Kelvin)

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

Directions: Questions 1 and 2 are long free-response questions that require about 22 minutes each to answer and are worth 10 points each. Questions 3–8 are short free-response questions that require about 6 minutes each to answer. Questions 3–5 are worth 4 points each and questions 6–8 are worth 3 points each.

Read each question carefully and completely. Write your response in the space provided for each question. Only material written in the space provided will be scored. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable.

Choice Chamber

1. In an investigation of fruit-fly behavior, a covered choice chamber is used to test whether the spatial distribution of flies is affected by the presence of a substance placed at one end of the chamber. To test the flies' preference for glucose, 60 flies are introduced into the middle of the choice chamber at the insertion point indicated by the arrow in the figure above. A cotton ball soaked with a 10% glucose solution is placed at one end of the chamber, and a dry cotton ball with no solution is placed at the other end. The positions of flies are observed and recorded every minute for 10 minutes.

   (a) **Predict** the distribution of flies in the chamber after 10 minutes and **justify** your prediction.

   (b) **Propose** ONE specific improvement to each of the following parts of the experimental design and **explain** how the modification will affect the experiment.

   - Experimental control

   - Environmental factors

   (c) The experiment described above is repeated with ripe bananas at one end and unripe bananas at the other end. Once again the positions of the flies are observed and recorded every minute for 10 minutes. The positions of flies after 1 minute and after 10 minutes are shown in the table below.

GO ON TO THE NEXT PAGE.

DISTRIBUTION OF FLIES IN CHOICE CHAMBER

Time (minutes)	Position in Chamber		
	End with Ripe Banana	Middle	End with Unripe Banana
1	21	18	21
10	45	3	12

Perform a chi-square test on the data for the 10-minute time point in the banana experiment. **Specify** the null hypothesis that you are testing and **enter** the values from your calculations in the table below.

(d) **Explain** whether your hypothesis is supported by the chi-square test and **justify** your explanation.

(e) Briefly **propose** a model that describes how environmental cues affect the behavior of the flies in the choice chamber.

**THIS PAGE MAY BE USED FOR TAKING NOTES AND PLANNING YOUR ANSWERS.
NOTES WRITTEN ON THIS PAGE WILL NOT BE SCORED.
WRITE ALL YOUR RESPONSES ON THE LINED PAGES.**

PAGE FOR ANSWERING QUESTION 1

PART (C): CHI-SQUARE CALCULATION

Null Hypothesis:			
	Observed (o)	Expected (e)	$(o - e)^2/e$
End with ripe banana			
Middle			
End with unripe banana			
Total			

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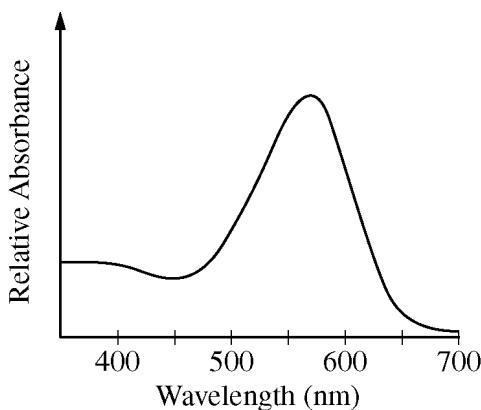
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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

Graph I

Graph II

Color	Wavelength (nm)
Violet	380–450
Blue	450–475
Cyan	475–495
Green	495–570
Yellow	570–590
Orange	590–620
Red	620–750

2. An absorption spectrum indicates the relative amount of light absorbed across a range of wavelengths. The graphs above represent the absorption spectra of individual pigments isolated from two different organisms. One of the pigments is chlorophyll *a*, commonly found in green plants. The other pigment is bacteriorhodopsin, commonly found in purple photosynthetic bacteria. The table above shows the approximate ranges of wavelengths of different colors in the visible light spectrum.

(a) **Identify** the pigment (chlorophyll *a* or bacteriorhodopsin) used to generate the absorption spectrum in each of the graphs above. **Explain** and **justify** your answer.

(b) In an experiment, identical organisms containing the pigment from Graph II as the predominant light-capturing pigment are separated into three groups. The organisms in each group are illuminated with light of a single wavelength (650 nm for the first group, 550 nm for the second group, and 430 nm for the third group). The three light sources are of equal intensity, and all organisms are illuminated for equal lengths of time. **Predict** the relative rate of photosynthesis in each of the three groups. **Justify** your predictions.

(c) Bacteriorhodopsin has been found in aquatic organisms whose ancestors existed before the ancestors of plants evolved in the same environment. **Propose** a possible evolutionary history of plants that could have resulted in a predominant photosynthetic system that uses only some of the colors of the visible light spectrum.

GO ON TO THE NEXT PAGE.

**THIS PAGE MAY BE USED FOR TAKING NOTES AND PLANNING YOUR ANSWERS.
NOTES WRITTEN ON THIS PAGE WILL NOT BE SCORED.
WRITE ALL YOUR RESPONSES ON THE LINED PAGES.**

PAGE FOR ANSWERING QUESTION 2

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

3. Fossils of lobe-finned fishes, which are ancestors of amphibians, are found in rocks that are at least 380 million years old. Fossils of the oldest amphibian-like vertebrate animals with true legs and lungs are found in rocks that are approximately 363 million years old.

Three samples of rocks are available that might contain fossils of a transitional species between lobe-finned fishes and amphibians: one rock sample that is 350 million years old, one that is 370 million years old, and one that is 390 million years old.

(a) **Select** the most appropriate sample of rocks in which to search for a transitional species between lobe-finned fishes and amphibians. **Justify** your selection.

(b) **Describe** TWO pieces of evidence provided by fossils of a transitional species that would support a hypothesis that amphibians evolved from lobe-finned fishes.

PAGE FOR ANSWERING QUESTION 3

GO ON TO THE NEXT PAGE.

4. Matter continuously cycles through an ecosystem. A simplified carbon cycle is depicted below.

I

CO_2 → Organic Molecules

II

(a) **Identify** the key metabolic process for step I and the key metabolic process for step II, and briefly **explain** how each process promotes movement of carbon through the cycle. For each process, your explanation should focus on the role of energy in the movement of carbon.

(b) **Identify** an organism that carries out both processes.

PAGE FOR ANSWERING QUESTION 4

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5. The table below shows the amino acid sequence of the carboxyl-terminal segment of a conserved polypeptide from four different, but related, species. Each amino acid is represented by a three-letter abbreviation, and the amino acid residues in the polypeptide chains are numbered from the amino end to the carboxyl end. Empty cells indicate no amino acid is present.

Species	Relative Amino Acid Position									
	1	2	3	4	5	6	7	8	9	10
I	Val	His	Leu	Val	Glu	Glu	His	Val	Glu	His
II	Val	His	Leu	Lys	Glu	Glu	His	Val	Glu	His
III	Val	His	Leu	Val	Glu	Glu	His	Val		
IV	Val	His	Leu	Val	Arg	Trp	Ala	Cys	Met	Asp

(a) Assuming that species I is the ancestral species of the group, **explain** the most likely genetic change that produced the polypeptide in species II and the most likely genetic change that produced the polypeptide in species III.

(b) **Predict** the effects of the mutation on the structure and function of the resulting protein in species IV. **Justify** your prediction.

PAGE FOR ANSWERING QUESTION 5

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GO ON TO THE NEXT PAGE.

6. The following data were collected by observing subcellular structures of three different types of eukaryotic cells.

RELATIVE AMOUNTS OF ORGANELLES IN THREE CELL TYPES

Cell Type	Smooth ER	Rough ER	Mitochondria	Cilia	Golgi Bodies
X	Small amount	Small amount	Large number	Present	Small amount
Y	Large amount	Large amount	Moderate number	Absent	Large amount
Z	Absent	Absent	Absent	Absent	Absent

Based on an analysis of the data, **identify** a likely primary function of each cell type and **explain** how the data support the identification.

PAGE FOR ANSWERING QUESTION 6
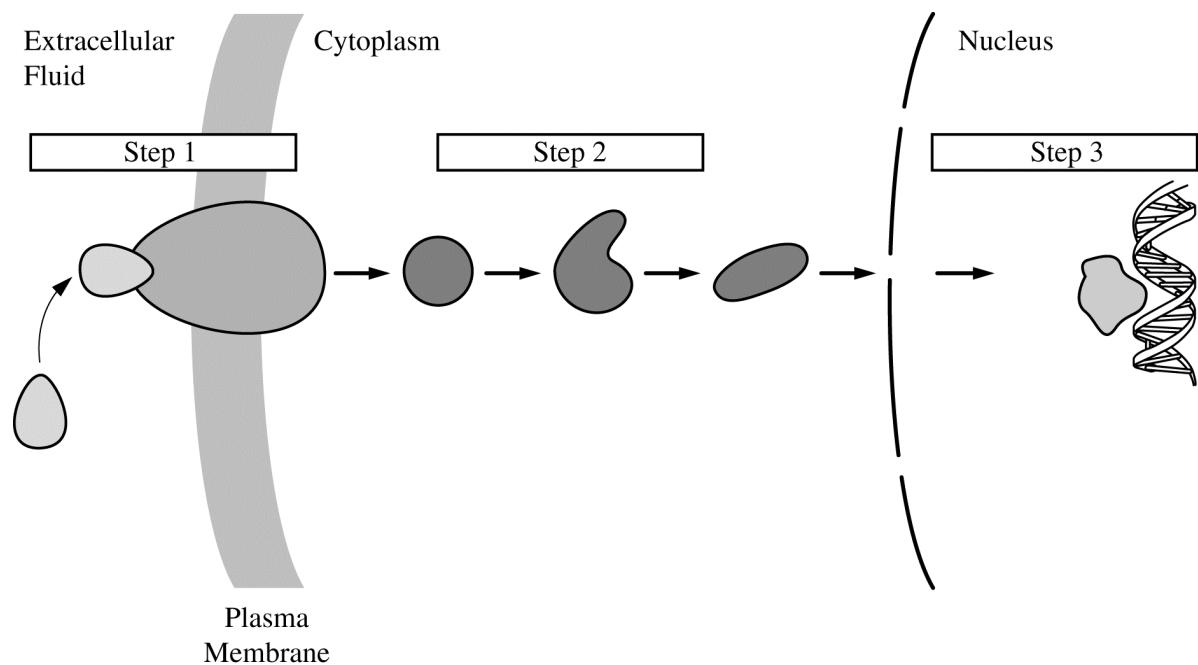
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7. In an experiment, rats averaging 300 g of body mass were tested several times over a three-month period. For each individual rat, urine was collected over a three-hour period after ingestion of 10 mL of liquid (water, 1% ethyl alcohol solution, or 5% ethyl alcohol solution). The volume of urine was then measured, and the results were averaged for all individuals within each experimental group. The data are shown in the table below.

THREE-HOUR URINE OUTPUT FOLLOWING FLUID INGESTION

Fluid ingested (10 mL)	Water	1% Ethyl Alcohol	5% Ethyl Alcohol
Average urine output (mL)	3.5	3.8	4.7

(a) **Pose** ONE scientific question that the researchers were most likely investigating with the experiment.

(b) **State** a hypothesis that could be tested to address the question you posed in part (a).

(c) Using the data in the table, **describe** the effect of ethyl alcohol on urine production.

PAGE FOR ANSWERING QUESTION 7

GO ON TO THE NEXT PAGE.

Extracellular Fluid   Cytoplasm   Nucleus

Step 1   Step 2   Step 3

Plasma
Membrane

8. The figure above represents a generalized hormone-signaling pathway. Briefly **explain** the role of each numbered step in regulating target gene expression.

PAGE FOR ANSWERING QUESTION 8

GO ON TO THE NEXT PAGE.

S T O P

END OF EXAM

IF YOU FINISH BEFORE TIME IS CALLED,
YOU MAY CHECK YOUR WORK ON THIS SECTION.

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THE FOLLOWING INSTRUCTIONS APPLY TO THE COVERS OF THE SECTION II BOOKLET.

- **MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE FRONT <u>AND</u> BACK COVERS OF THE SECTION II BOOKLET.**

- **CHECK TO SEE THAT YOUR AP NUMBER LABEL APPEARS IN THE BOX ON THE FRONT COVER.**

- **MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON <u>ALL</u> AP EXAMS YOU HAVE TAKEN THIS YEAR.**

Multiple-Choice Answer Key

The following contains the answers to the
multiple-choice questions in this exam.

Answer Key for AP Biology
Practice Exam, Section I

Question 1: B	Question 19: A	Question 37: C
Question 2: C	Question20: A	Question 38: C
Question 3: C	Question 21: B	Question 39: D
Question 4: B	Question 22: C	Question 40: C
Question 5: B	Question 23: B	Question 41: B
Question 6: D	Question 24: D	Question 42: D
Question 7: D	Question 25: A	Question 43: C
Question 8: D	Question 26: B	Question 44: A
Question 9: A	Question 27: D	Question 45: B
Question 10: C	Question 28: B	Question 46: D
Question 11: B	Question 29: D	Question 47: B
Question 12: D	Question 30: C	Question 48: B
Question 13: B	Question 31: A	Question 49: D
Question 14: B	Question 32: C	Question 50: A
Question 15: B	Question 33: D	Question 51: B
Question 16: B	Question 34: C	Question 52: A
Question 17: D	Question 35: C	Question 53: D
Question 18: A	Question 36: B	

Question 121: Any value from 0.09 to 0.11, inclusive, or
Any value from 9/100 to 11/100, inclusive

Question 122: Any value from 5.0 to 5.5, inclusive, or
Any value from 5/1 to 55/10, inclusive

Question 123: 1131

Question 124: .0625 or 1/16
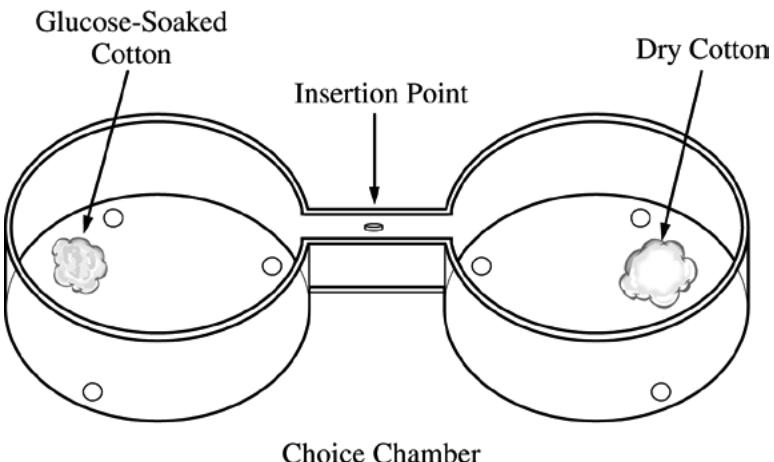
Question 125: Any value from 10 to 15, inclusive, or
Any value from 10/1 to 15/1, inclusive

Free-Response Scoring Guidelines

The following contains the scoring guidelines
for the free-response questions in this exam.

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Question 1

Glucose-Soaked Cotton — Insertion Point — Dry Cotton

Choice Chamber

In an investigation of fruit-fly behavior, a covered choice chamber is used to test whether the spatial distribution of flies is affected by the presence of a substance placed at one end of the chamber. To test the flies' preference for glucose, 60 flies are introduced into the middle of the choice chamber at the insertion point indicated by the arrow in the figure above. A cotton ball soaked with a 10 percent glucose solution is placed at one end of the chamber, and a dry cotton ball with no solution is placed at the other end. The positions of flies are observed and recorded every minute for 10 minutes.

(a) **Predict** the distribution of flies in the chamber after 10 minutes and **justify** your prediction. (**2 points maximum**)
- 1 point for predicting the location of the flies in the choice chamber
- 1 point for justifying the prediction

(b) **Propose** ONE specific improvement to each of the following parts of the experimental design and **explain** how the modification will affect the experiment. (**4 points maximum**)
- Experimental control
- Environmental factors

	Proposed Improvement (includes but not limited to) (**1 point maximum**)	Explanation (**1 point maximum**)
Experimental control	Replace the dry cotton ball with a water-soaked cotton ball.	Ensures that glucose is the attractant
	Constant light or temperature or duration of experiment or time of day, etc.	Other variables must be held constant

	Proposed Improvement (includes but not limited to) (**1 point maximum**)	Explanation (**1 point maximum**)
Environmental factors	• Use different concentrations of glucose • Use different temperature(s) • Use different light levels • Use a different choice chamber (size/shape) • Vary duration of the experiment • Vary time of day when experiment is performed	Attributes movement of flies only to glucose preference

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Question 1 (continued)

(c) The experiment described above is repeated with ripe bananas at one end and unripe bananas at the other end. Once again the positions of the flies are observed and recorded every minute for 10 minutes. The positions of flies after 1 minute and after 10 minutes are shown in the table below.

DISTRIBUTION OF FLIES IN CHOICE CHAMBER

Time (minutes)	Position in Chamber		
	End with Ripe Banana	Middle	End with Unripe Banana
1	21	18	21
10	45	3	12

Perform a chi-square test on the data for the 10-minute time point in the banana experiment. **Specify** the null hypothesis that you are testing and **enter** the values from your calculations in the table below. (**2 points maximum**)

PART (c): CHI-SQUARE CALCULATION

Null Hypothesis: (**1 point**)

The flies will be evenly distributed across the three different parts of the choice chamber.

	Observed (o)	Expected (e)* (**1 point**)	$(o - e)^2/e$
End with ripe banana	45	20	31.25
Middle	3	20	14.45
End with unripe banana	12	20	3.2
Total	60	60	48.9

*Expected values must be those predicted by the null hypothesis provided in the student response, add up to 60, and include no cells equal to 0.

(d) **Explain** whether your hypothesis is supported by the chi-square test and **justify** your explanation. (**1 point maximum**)
  - Correct explanation with justification of why the stated null hypothesis is rejected or not rejected. Response must clarify each of the following:
    - degrees of freedom (df) = 2 and p = 0.05 (critical value = 5.99)
      OR
      degrees of freedom (df) = 2 and p = 0.01 (critical value = 9.21)
    - how the calculated test statistic compares to the selected critical value
   - whether the null hypothesis should be rejected
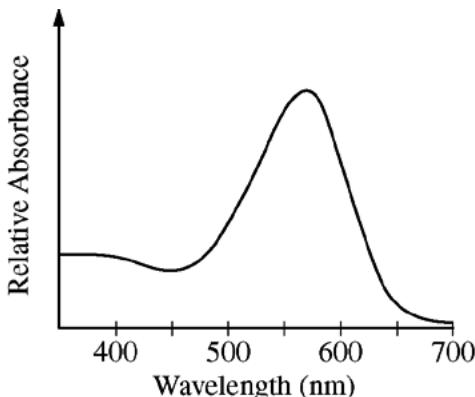
(e) Briefly **propose** a model that describes how environmental cues affect the behavior of the flies in the choice chamber. (**1 point maximum**)
  - Stimulus → Response
  - Input →(possible integration) →Output
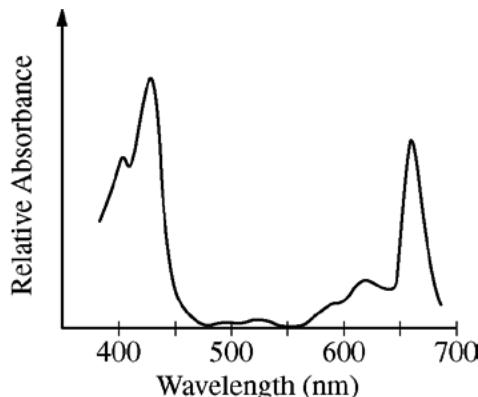
Question 2

Graph I

Graph II

Color	Wavelength (nm)
Violet	380–450
Blue	450–475
Cyan	475–495
Green	495–570
Yellow	570–590
Orange	590–620
Red	620–750

An absorption spectrum indicates the relative amount of light absorbed across a range of wavelengths. The graphs above represent the absorption spectra of individual pigments isolated from two different organisms. One of the pigments is chlorophyll *a*, commonly found in green plants. The other pigment is bacteriorhodopsin, commonly found in purple photosynthetic bacteria. The table above shows the approximate ranges of wavelengths of different colors in the visible light spectrum.

(a) **Identify** the pigment (chlorophyll *a* or bacteriorhodopsin) used to generate the absorption spectrum in each of the graphs above. **Explain** and **justify** your answer. (**3 points maximum**)

1 point per box
Identify BOTH pigments: Graph 1 = bacteriorhodopsin AND graph 2 = chlorophyll *a*
Explain that an organism containing bacteriorhodopsin appears purple because the pigment absorbs light in the green range of the light spectrum and/or reflects violet or red and blue light. The reflected red and blue light appears purple.
Explain that an organism containing chlorophyll *a* appears green because the pigment absorbs light in the red and blue ranges of the light spectrum and/or reflects green light.

(b) In an experiment, identical organisms containing the pigment from Graph II as the predominant light-capturing pigment are separated into three groups. The organisms in each group are illuminated with light of a single wavelength (650 nm for the first group, 550 nm for the second group, and 430 nm for the third group). The three light sources are of equal intensity, and all organisms are illuminated for equal lengths of time. **Predict** the relative rate of photosynthesis in each of the three groups. **Justify** your predictions. (**5 points maximum**)

Wavelength (Group)	Prediction (**1 point each box**)	Justification (**1 point each box**)
650 nm (1st Group)	Intermediate rate	An intermediate level of absorption occurs at 650 nm (compared to 430 nm and 550 nm); *therefore*, an intermediate amount of energy is available to drive photosynthesis.
550 nm (2nd Group)	Lowest rate	The lowest level of absorption occurs at 550 nm; *therefore*, the least amount of energy is available to drive photosynthesis.
430 nm (3rd Group)	Highest rate	The highest level of absorption occurs at 430 nm; *therefore*, the greatest amount of energy is available to drive photosynthesis.

NOTE: A student who combines two groups (e.g., "the 650 nm and 430 nm groups have higher rates of photosynthesis compared to the 550 nm group") can earn a maximum of 4 points: up to 2 points for the prediction and up to 2 points for the justification.

(c) Bacteriorhodopsin has been found in aquatic organisms whose ancestors existed before the ancestors of plants evolved in the same environment. **Propose** a possible evolutionary history of plants that could have resulted in a predominant photosynthetic system that uses only some of the colors of the visible light spectrum. (**1 point per box; 2 points maximum**)

Proposal that includes an environmental selective pressure: - Green light was being absorbed by aquatic organisms using bacteriorhodopsin.   - Unabsorbed wavelengths of light were available resources that organisms could exploit.   - Absorbing visible light at all wavelengths may provide too much energy to the organism.   - Absorbing light from ultraviolet wavelengths (shorter wavelengths = higher energy) could cause damage to the organism.   - Absorbing light with longer wavelengths may not provide sufficient energy for the organism.
Appropriate reasoning to support the proposal: - Natural selection favored organisms that rely on pigments that absorb available wavelengths of light.   - Endosymbiosis: chloroplasts evolved from cyanobacteria with pigments that used only certain wavelengths.   - Genetic drift eliminated pigments that absorbed certain wavelengths of light.   - Mutation(s) altered the pigment(s) used by organism.

Question 3

Fossils of lobe-finned fishes, which are ancestors of amphibians, are found in rocks that are at least 380 million years old. Fossils of the oldest amphibian-like vertebrate animals with true legs and lungs are found in rocks that are approximately 363 million years old.

Three samples of rocks are available that might contain fossils of a transitional species between lobe-finned fishes and amphibians: one rock sample that is 350 million years old, one that is 370 million years old, and one that is 390 million years old.

(a) **Select** the most appropriate sample of rocks in which to search for a transitional species between lobe-finned fishes and amphibians. **Justify** your selection. (**2 points maximum**)

- Selection: Rocks from 370 MYA sample.

- Justification: Transitional fossils are found between 380 MYA (when lobe-finned fishes lived) and 363 MYA (when amphibians appeared) OR between different strata/layers in the correct order.

(b) **Describe** TWO pieces of evidence provided by fossils of a transitional species that would support a hypothesis that amphibians evolved from lobe-finned fishes. **(2 points maximum)**
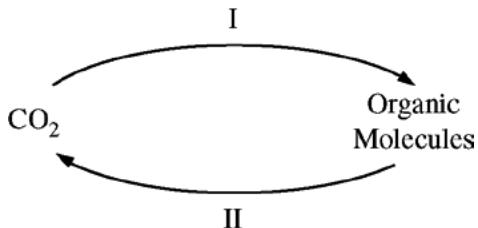
Descriptions include but are not limited to the following:

- Bones OR specific skeletal structures

    legs /limbs/digits
    vertebrae
    flat skulls
    (interlocking) ribs
    flexible neck

- Scales

- Teeth

- Other homologous structures

- Has traits of both the lobe-finned fish and the amphibian

- Finding the transitional fossils in the same area/same environment as either the lobe-finned fish or the amphibian

- Molecular (DNA) evidence

Question 4

Matter continuously cycles through an ecosystem. A simplified carbon cycle is depicted below.

(a) **Identify** the key metabolic process for step I and the key metabolic process for step II and briefly **explain** how each process promotes movement of carbon through the cycle. For each process, your explanation should focus on the role of energy in the movement of carbon.

Identification: **1 point maximum**

I = photosynthesis / Calvin cycle AND II = (cellular) respiration / citric acid cycle / Krebs cycle

Explanation: **1 point each row; 2 points maximum**

Process	Carbon Input	Role of Energy in the Movement of Carbon	Carbon Output
Photosynthesis	CO_2 is fixed	Uses (light) energy OR ATP from light reactions	Organic molecules
(Cellular) Respiration	Organic molecules are hydrolyzed / broken down	Uses energy for cellular processes such as growth and /or ATP production	CO_2

(b) **Identify** an organism that carries out both processes. **(1 point maximum)**

- Plant
- Algae
- Photosynthetic protist (e.g., Euglena)
- Cyanobacterium
- CO_2 fixing bacterium
- Lichen (not fungus)

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Question 5

The table below shows the amino acid sequence of the carboxyl-terminal segment of a conserved polypeptide from four different, but related, species. Each amino acid is represented by a three-letter abbreviation, and the amino acid residues in the polypeptide chains are numbered from the amino end to the carboxyl end. Empty cells indicate no amino acid is present.

Species	Relative Amino Acid Position									
	1	2	3	4	5	6	7	8	9	10
I	Val	His	Leu	Val	Glu	Glu	His	Val	Glu	His
II	Val	His	Leu	Lys	Glu	Glu	His	Val	Glu	His
III	Val	His	Leu	Val	Glu	Glu	His	Val		
IV	Val	His	Leu	Val	Arg	Trp	Ala	Cys	Met	Asp

(a) Assuming that species I is the ancestral species of the group, **explain** the most likely genetic change that produced the polypeptide in species II and the most likely genetic change that produced the polypeptide in species III. **(2 points maximum)**

Explanation: **1 point per row**
NOTE: Specific names of mutation types are not required.

Species	Genetic Change in DNA / Bases	Result of Change to Polypeptide / Protein
II	mutation / substitution / point mutation / missense mutation	an amino acid change only at position 4 (Val to Lys)
III	mutation (e.g., substitution / insertion / deletion / point mutation / frameshift mutation / nonsense mutation) that introduces a stop codon after the codon for Val	termination of the polypeptide after the Val at position 8

(b) **Predict** the effects of the mutation on the structure and function of the resulting protein in species IV. **Justify** your prediction. (**2 points maximum**)

Predicted Change (**1 point maximum**)	Justification of Prediction (**1 point maximum**)
Protein may have a different structure and a change in function.	Change in amino acid sequence of the protein starting at position 5 could alter the overall structure or local structural regions, interfering with function of the protein.
Protein may have a different structure and no change in function.	Change in amino acid sequence alters the shape / conformation / folding / binding region / regulatory region of the protein, but does not affect the critical functional region(s) of the protein.
Protein structure and function may not be affected.	Change in amino acid sequence does not alter the protein shape / conformation / folding and does not alter function.

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Question 6

The following data were collected by observing subcellular structures of three different types of eukaryotic cells.

RELATIVE AMOUNTS OF ORGANELLES IN THREE CELL TYPES

Cell Type	Smooth ER	Rough ER	Mitochondria	Cilia	Golgi Bodies
X	Small amount	Small amount	Large number	Present	Small amount
Y	Large amount	Large amount	Moderate number	Absent	Large amount
Z	Absent	Absent	Absent	Absent	Absent

Based on an analysis of the data, **identify** a likely primary function of each cell type and **explain** how the data support the identification. (**3 points maximum**)

Cell Type	Identify function		Explain how data support identification (1 point each correct pair). NOTE: No points for identification without explanation.		
X	• Locomotion • Movement / surface transport	**AND**	Has cilia for movement <u>and</u> large amounts of mitochondria to provide energy for locomotion of cell itself (ciliated protist) or movement of particles (mucus /oocyte) along cell surface		
Y	• Secretion / exocytosis • Protein synthesis	**AND**	Has large amounts of rough ER <u>and</u> Golgi to produce and package proteins		
	• Lipid/hormone synthesis • Detoxification	**AND**	Has large amounts of smooth ER to produce lipids / hormones		
Z	• Transport	**OR**	• Oxygen transport in animal cells • Water transport in plant cells	**AND**	Does not require these organelles
	• Protection	**OR**	• Epidermal cells (stratum corneum, cork, nails)	**AND**	
	• Support	**OR**	• Ground tissue (schlerenchyma) • Vascular tissue (xylem)	**AND**	
	• Storage	**OR**	• Maximizes volume / space available (hemoglobin, oxygen)	**AND**	
	• No function	**OR**	• Is a dead cell/is undergoing apoptosis	**AND**	

Question 7

In an experiment, rats averaging 300 g of body mass were tested several times over a three-month period. For each individual rat, urine was collected over a three-hour period after ingestion of 10 mL of liquid (water, 1 percent ethyl alcohol solution, or 5 percent ethyl alcohol solution). The volume of urine was then measured, and the results were averaged for all individuals within each experimental group. The data are shown in the table below.

THREE-HOUR URINE OUTPUT FOLLOWING FLUID INGESTION

Fluid ingested (10 mL)	Water	1% Ethyl Alcohol	5% Ethyl Alcohol
Average urine output (mL)	3.5	3.8	4.7

(a) **Pose** ONE scientific question that the researchers were most likely investigating with the experiment. (**1 point**)

Appropriate questions include but are not limited to the following:
- How does alcohol consumption affect urine output in rats (or any mammal)?
- How does alcohol consumption affect regulation of the kidney?

(b) **State** a hypothesis that could be tested to address the question you posed in part (a). (**1 point**)

Appropriate hypotheses include but are not limited to the following:
- Alcohol consumption increases urine output in rats.
- Alcohol consumption increases water retention/reabsorption in rat kidneys.
- Alcohol consumption reduces urine output in rats.
- Alcohol consumption has no effect on urine output in rats.
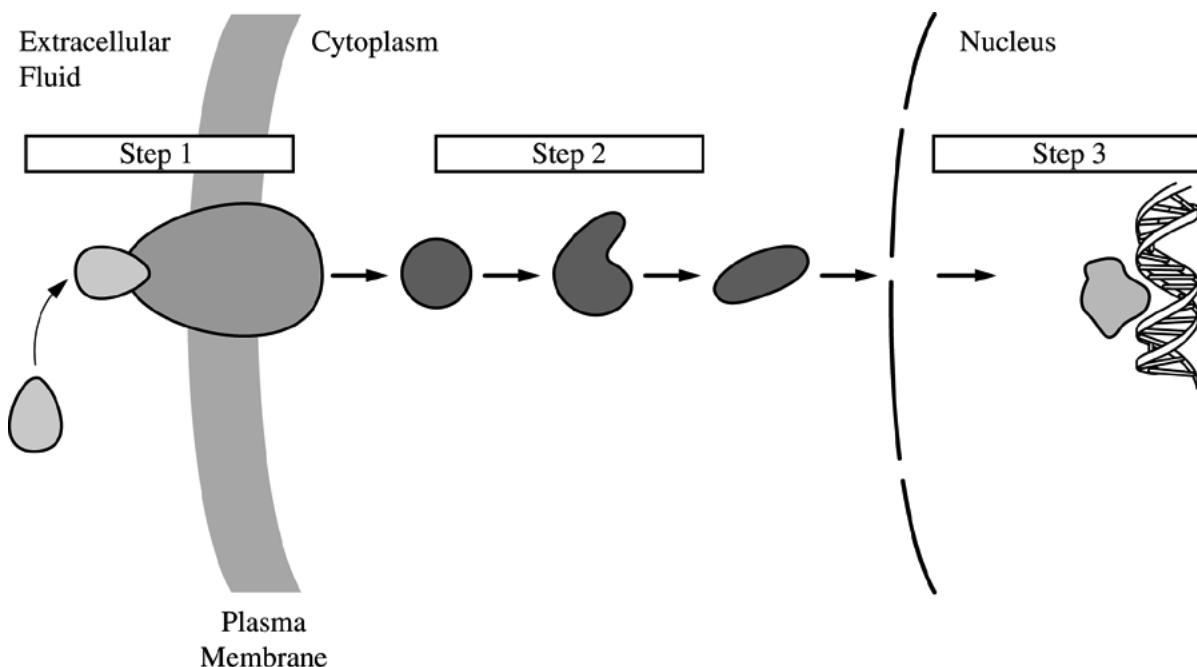
 NOTE: This point may be earned without earning the point in part (a)

(c) Using the data in the table, **describe** the effect of ethyl alcohol on urine production. (**1 point**)

- Alcohol consumption increases urine output.

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Question 8

The figure above represents a generalized hormone-signaling pathway. Briefly **explain** the role of each numbered step in regulating target gene expression. (**3 points maximum**)

- Step 1 = hormone/ligand binding to receptor to initiate/trigger/induce signaling OR signal reception
- Step 2 = an intracellular cascade that transduces/amplifies/transfers the signal from plasma membrane to nucleus (or other cellular effectors)
- Step 3 = transcription/expression of target genes is stimulated/repressed

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Scoring Worksheet

The following provides a worksheet and conversion table
used for calculating a composite score of the exam.

2013 AP Biology Scoring Worksheet

Section I: Multiple Choice

$$\underset{\substack{\text{Number Correct}\\\text{(out of 58)}}}{\underline{\hspace{4cm}}} \times\ 1.0344\ =\ \underset{\substack{\text{Weighted Section I Score}\\\text{(Do not round)}}}{\underline{\hspace{5cm}}}$$

Section II: Free Response

Question 1 $\quad\underset{\text{(out of 10)}}{\underline{\hspace{3cm}}} \times\ 1.5000\ =\ \underset{\text{(Do not round)}}{\underline{\hspace{3cm}}}$

Question 2 $\quad\underset{\text{(out of 10)}}{\underline{\hspace{3cm}}} \times\ 1.5000\ =\ \underset{\text{(Do not round)}}{\underline{\hspace{3cm}}}$

Question 3 $\quad\underset{\text{(out of 4)}}{\underline{\hspace{3cm}}} \times\ 1.4285\ =\ \underset{\text{(Do not round)}}{\underline{\hspace{3cm}}}$

Question 4 $\quad\underset{\text{(out of 4)}}{\underline{\hspace{3cm}}} \times\ 1.4285\ =\ \underset{\text{(Do not round)}}{\underline{\hspace{3cm}}}$

Question 5 $\quad\underset{\text{(out of 4)}}{\underline{\hspace{3cm}}} \times\ 1.4285\ =\ \underset{\text{(Do not round)}}{\underline{\hspace{3cm}}}$

Question 6 $\quad\underset{\text{(out of 3)}}{\underline{\hspace{3cm}}} \times\ 1.4285\ =\ \underset{\text{(Do not round)}}{\underline{\hspace{3cm}}}$

Question 7 $\quad\underset{\text{(out of 3)}}{\underline{\hspace{3cm}}} \times\ 1.4285\ =\ \underset{\text{(Do not round)}}{\underline{\hspace{3cm}}}$

Question 8 $\quad\underset{\text{(out of 3)}}{\underline{\hspace{3cm}}} \times\ 1.4285\ =\ \underset{\text{(Do not round)}}{\underline{\hspace{3cm}}}$

$$\text{Sum}\ =\ \underset{\substack{\text{Weighted}\\\text{Section II}\\\text{Score}\\\text{(Do not round)}}}{\underline{\hspace{3cm}}}$$

Composite Score

$$\underset{\substack{\text{Weighted}\\\text{Section I Score}}}{\underline{\hspace{3cm}}} +\ \underset{\substack{\text{Weighted}\\\text{Section II Score}}}{\underline{\hspace{3cm}}}\ =\ \underset{\substack{\text{Composite Score}\\\text{(Round to nearest}\\\text{whole number)}}}{\underline{\hspace{3cm}}}$$

AP Score Conversion Chart
Biology

Composite Score Range	AP Score
93-120	5
75-92	4
54-74	3
30-53	2
0-29	1

AP Biology

The College Board

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