CollegeBoard

AP® Biology Practice Exam

From the 2015 Administration

NOTE: This is a modified version of the 2015 AP Biology Exam.

Contents

Note: This publication shows the page numbers that appeared in the *2014–15 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 *2014–15 AP Exam Instructions* book.

AP® Biology Exam

Regularly Scheduled Exam Date: Monday morning, May 11, 2015

Late-Testing Exam Date: Friday afternoon, May 22, 2015

Section I Total Time: 1 hr. 30 min. Section II Total Time: 1 hr. 30 min.

Section I

Total Time: 1 hour 30 minutes

Number of Questions: 69*

(63 multiple-choice questions plus 6 grid-in questions; 90 minutes)

Percent of Total Score: 50%

Writing Instrument: Pencil required

**The number of questions may vary slightly depending on the form of the exam.*

Section II

Total Time: 1 hour 30 minutes

Number of Questions: 8 questions

(2 ten-point questions, 3 four-point questions, and 3 three-point questions, 10-minute reading period, 80-minute writing period)

Percent of Total Score: 50%

Writing Instrument: Pen with black or dark blue ink

Note: Four-function calculators (with square root) may be used on all sections of the AP Biology Exam.

What Proctors Need to Bring to This Exam

- Exam packets
- Answer sheets
- AP Student Packs
- *2014-15 AP Coordinator's Manual*
- This book — *AP Exam Instructions*
- AP Exam Seating Chart template(s)
- School Code and Home-School/Self-Study Codes
- Extra calculators
- Pencil sharpener
- Container for students' electronic devices (if needed)
- 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 and Grid-In

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 43–46 of the *2014-15 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 44 of the *2014-15 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. Remember: You must complete a seating chart for this exam. See pages 279–280 for a seating chart template and instructions. See the *2014-15 AP Coordinator's Manual* for exam seating requirements (pages 48–50, 88).

If you are giving the regularly scheduled exam, say:

It is Monday morning, May 11, 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 22, 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 *2014-15 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 light blue box near the top right-hand corner that reads "AP Exam Label."

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 and grid-in 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.

For the grid-in questions, you will solve each problem, write your final numeric answer in the boxes at the top of the grid, and fill in the corresponding circles. Enter your responses for the grid-in questions on page 3 of the answer sheet beginning with number 121. You will receive credit only 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 20 minutes, say:

There are 10 minutes remaining.

After 10 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. Sit quietly while I collect your answer sheets.

Collect an answer sheet from each student. Check that each answer sheet has an AP number label and an AP Exam label. After all answer sheets have been collected, say:

Now you must seal your exam booklet using the white seals you set aside earlier. 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. All items you placed under your chair at the beginning of this exam must stay there, and you are not permitted to open or access them in any way. Leave your shrinkwrapped Section II packet on your desk during the break. You are not allowed to consult teachers, other students, or textbooks 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 may never discuss the multiple-choice questions at any time in any form with anyone, including your teacher and other students. If you disclose these questions through any means, your AP Exam score will 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 last name and the first letter of your first 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. . . .

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 recommended 10-minute reading period. You are advised to take advantage of the reading period to plan what you will write. It is designed to provide you with time to develop your responses. You may begin writing your exam responses before the 10 minutes is over. You may take notes on the pages that contain the exam questions, but your responses must be written on the designated lined pages. Are there any questions? . . .

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. Be sure that you answer all of the questions. If you need more paper during the exam, raise your hand. At the top of each extra sheet of paper you use, be sure to write only your AP number and the number of the question you are working on — for example, Question 1. Do not write your name. 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 _____. After 10 minutes, say:

The reading period is over. You should begin or continue writing your responses.

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. Complete an Incident Report and include any exam booklets with extra sheets of paper in an Incident Report return envelope (see page 57 of the *AP Coordinator's Manual* for details). 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 or share these specific free-response questions with anyone unless they are released on the College Board website in about two days. Your AP Exam score results will be available 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 Exam score results will be available 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 must be placed 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 *2014-15 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.

Be sure to give the completed seating chart to the AP Coordinator. Schools must retain seating charts for at least six months (unless the state or district requires that they be retained for a longer period of time). Schools should not return any seating charts in their exam shipments unless they are required as part of an Incident Report.

Student Answer Sheet for the Multiple-Choice and Grid-In Section

Use this section to capture student responses. (Note that the following answer sheet is a sample, and may differ from one used in an actual exam.)

AP Answer Sheet 2015

AP Number Label
(from Student Pack)

B123456789T

AP Exam Label
(from Section I Booklet)

CollegeBoard

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 seal the multiple-choice booklet when asked to do so, and I will not discuss these questions with anyone at any time after completing the section. I am aware of and agree to the AP Program's policies and procedures as outlined in the *2014-15 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

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: Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec | Day | Year

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

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

779934

SCHOOL USE ONLY

Section Number: 1 2 3 4 5 6 7 8 9

Fee Reduction Granted: 1 Option 1 2 Option 2

104246-00657 • UNLWEB315

Q3914/1-4

COMPLETE THIS AREA AT EACH EXAM (IF APPLICABLE).

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

1 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ	4 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ	7 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ
2 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ	5 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ	8 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ
3 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ	6 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ	9 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ

P. 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 and Culture, 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). Mark only one response per question for Questions 1 through 120. If a question has only four answer options, do not mark option E. Answers written in the multiple-choice booklet will not be scored.

COMPLETE MARK ● EXAMPLES OF INCOMPLETE MARKS 

You must use a No. 2 pencil and marks must be complete. Do not use a mechanical pencil. It is very important that you fill in the entire circle darkly and completely. If you change your response, erase as completely as possible. Incomplete marks or erasures may affect your score.

1 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	26 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	51 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
2 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	27 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	52 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
3 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	28 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	53 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
4 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	29 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	54 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
5 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	30 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	55 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
6 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	31 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	56 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
7 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	32 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	57 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
8 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	33 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	58 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
9 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	34 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	59 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
10 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	35 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	60 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
11 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	36 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	61 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
12 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	37 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	62 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
13 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	38 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	63 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
14 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	39 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	64 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
15 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	40 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	65 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
16 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	41 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	66 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
17 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	42 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	67 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
18 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	43 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	68 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
19 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	44 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	69 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
20 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	45 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	70 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
21 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	46 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	71 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
22 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	47 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	72 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
23 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	48 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	73 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
24 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	49 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	74 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
25 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	50 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	75 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

ETS USE ONLY

Exam		0 1 2 3 4 5 6 7 8 9
		0 1 2 3 4 5 6 7 8 9
Exam		0 1 2 3 4 5 6 7 8 9
		0 1 2 3 4 5 6 7 8 9

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

DO NOT WRITE IN THIS AREA

QUESTIONS 76–120

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

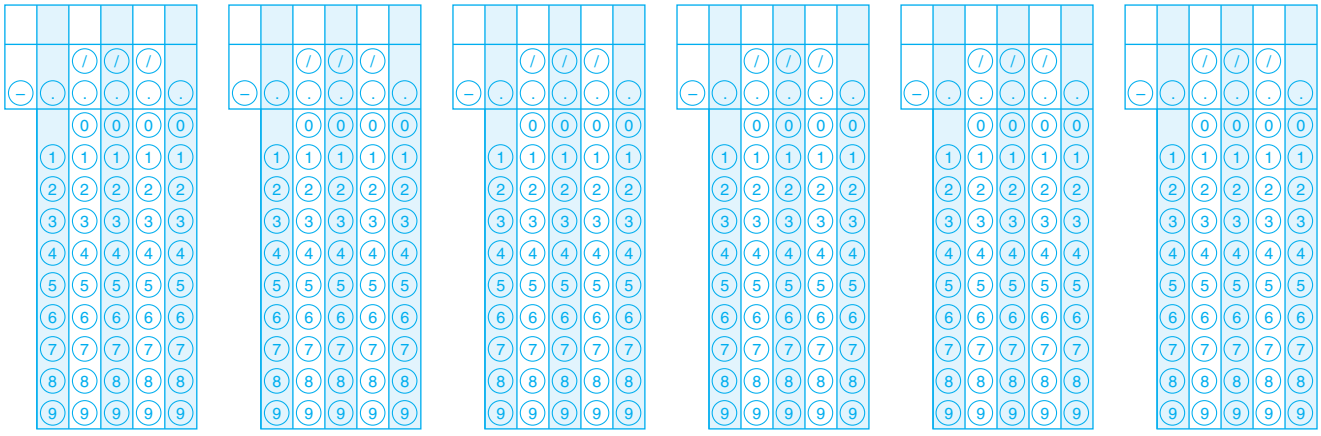
76	A B C D E	91	A B C D E	106	A B C D E
77	A B C D E	92	A B C D E	107	A B C D E
78	A B C D E	93	A B C D E	108	A B C D E
79	A B C D E	94	A B C D E	109	A B C D E
80	A B C D E	95	A B C D E	110	A B C D E
81	A B C D E	96	A B C D E	111	A B C D E
82	A B C D E	97	A B C D E	112	A B C D E
83	A B C D E	98	A B C D E	113	A B C D E
84	A B C D E	99	A B C D E	114	A B C D E
85	A B C D E	100	A B C D E	115	A B C D E
86	A B C D E	101	A B C D E	116	A B C D E
87	A B C D E	102	A B C D E	117	A B C D E
88	A B C D E	103	A B C D E	118	A B C D E
89	A B C D E	104	A B C D E	119	A B C D E
90	A B C D E	105	A B C D E	120	A B C D E

QUESTIONS 121–126

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



QUESTIONS 131–142

For Students Taking AP Physics 1 or AP Physics 2

Mark two responses per question. You will receive credit only if both correct responses are selected.

131	A B C D	135	A B C D	139	A B C D
132	A B C D	136	A B C D	140	A B C D
133	A B C D	137	A B C D	141	A B C D
134	A B C D	138	A B C D	142	A B C D

DO NOT WRITE IN THIS AREA

COMPLETE THIS AREA ONLY ONCE.

Q. 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

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		
○ DC	○ LA	○ NE	○ SD	○ AA	
○ DE	○ MA	○ NH	○ TN	○ AE	
○ FL	○ MD	○ NJ	○ TX	○ AP	
○ GA	○ ME	○ NM	○ UT	○ Other	
		○ NV	○ VA		

R. FOR STUDENTS OUTSIDE THE UNITED STATES ONLY

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

Address	City	State or Province	Country	ZIP or Postal Code

T. 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 *2014-15 Bulletin for AP Students and Parents*.

S. STUDENT IDENTIFIER (Student ID Number)

U. STUDENT SEARCH SERVICE®

Colleges and scholarship programs may request your information to inform you of educational opportunities and financial aid.

Would you like us to supply your information?

○ Yes ○ No

If you don't answer and previously chose to participate in this service, we will continue providing your information.

V. SEX

○ Female ○ Male

W. WHICH LANGUAGE DO YOU KNOW BEST?

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

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

In the first column, indicate the highest level of education of your parent/guardian. If you have two parents/guardians, indicate the level of education for your other parent/guardian in the second column. In the appropriate column for each parent/guardian, indicate whether this is your mother or female guardian or your father or male guardian.

○ Grade school	○ Grade school
○ Some high school	○ Some high school
○ High school diploma or equivalent	○ High school diploma or equivalent
○ Vocational or trade school	○ Vocational or trade school
○ Some college	○ Some college
○ Associate or two-year degree	○ Associate or two-year degree
○ Bachelor's or four-year degree	○ Bachelor's or four-year degree
○ Some graduate or professional school	○ Some graduate or professional school
○ Graduate or professional degree	○ Graduate or professional degree
○ Mother or female guardian	○ Mother or female guardian
○ Father or male guardian	○ Father or male guardian

Section I:
Multiple-Choice and Grid-In Questions

This is the multiple-choice and grid-in section of the 2015 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.)

For purposes of test security and/or statistical analysis, some questions
have been removed from the version of the exam that was administered
in 2015. Therefore, the timing indicated here may not be appropriate
for a practice exam.

PLACE SEAL HERE

AP® Biology Exam

SECTION I: Multiple Choice and Grid-In

2015

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 through 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 through 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 through 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 through 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 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.

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Form I
Form Code 4LBP4-S

20

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DO NOT seal answer sheet inside

AP® BIOLOGY EQUATIONS AND FORMULAS

Statistical Analysis and Probability

Mean

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

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

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

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

$\bar{x}$ = 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.

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 Q_{10}

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

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

$$V = \ell w h$$

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

$A = \sum$ 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)

$$C_i V_i = C_f V_f$$

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)

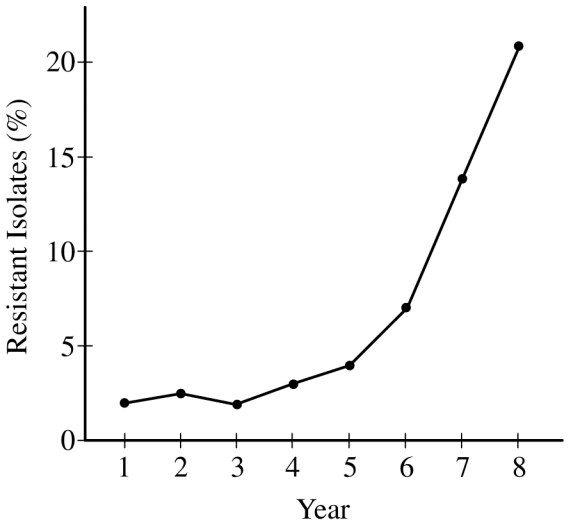
$$\text{pH} = -\log_{10} [\text{H}^+]$$

BIOLOGY
Section I
53 Multiple-Choice Questions
5 Grid-In Questions
Time—90 Minutes

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 genetic counselor is consulted by a young man who is worried about developing Huntington's disease, an inherited disorder caused by a dominant allele of a single gene. The young man explains that his cousin was recently diagnosed with Huntington's disease, and the news has caused him to consider his own risk of developing the disorder. Which of the following questions will best help the genetic counselor to evaluate the risk of the young man developing Huntington's disease and transmitting it to his children?

   (A) Were you and your cousin born in the same geographical area?
   (B) Were your parents or grandparents ever diagnosed with Huntington's disease?
   (C) Were you in physical contact with a person diagnosed with Huntington's disease?
   (D) Were you ever exposed to substances that are suspected of being mutagens?



2. Over several years, bacteria were isolated from members of a human population and tested for antibiotic resistance. The percent of bacterial isolates that were found to be antibiotic resistant is presented in the graph above for each year of the study. Which of the following conclusions is best supported by the information presented in the graph?

   (A) The greatest increase in antibiotic resistance occurred from the first year to the third year of the study.
   (B) Gene flow in the population occurred at the same rate for the entire duration of the eight-year study.
   (C) Because evolution in bacterial populations occurs over millions of years, the results are due to random variation.
   (D) Natural selection over multiple generations is favoring antibiotic resistance in the population of bacteria.

GO ON TO THE NEXT PAGE.

3. Lobe-finned fishes were present in the oceans of the world approximately 400 million years ago. The first tetrapods (vertebrates that had limbs and could move on land) date to about 365 million years ago. One hypothesis states that early tetrapods evolved from lobe-finned fishes. Which of the following is the best plan for testing the hypothesis?

   (A) Determining the number of fins found on lobe-finned fishes from different geographical locations
   (B) Measuring the proportion of radioisotopes found in fossils of early tetrapods
   (C) Comparing the arrangements of bones in the fins of lobe-finned fishes and limbs of the earliest tetrapods
   (D) Sequencing DNA isolated from fossils of lobe-finned fishes to determine the size of the genome

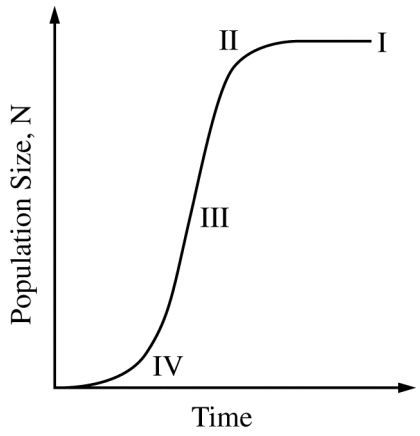
4. Which of the following describes a metabolic consequence of a shortage of oxygen in muscle cells?

   (A) An increase in blood pH due to the accumulation of lactic acid
   (B) No ATP production due to the absence of substrate-level phosphorylation
   (C) A buildup of lactic acid in the muscle tissue due to fermentation
   (D) A decrease in the oxidation of fatty acids due to a shortage of ATP

5. Prairie dogs are small mammals that live in large colonies in burrows in the ground. Prairie dogs that are near their own relatives when a predator approaches are much more likely to issue a warning bark than those that are near unrelated prairie dogs. The prairie dogs that hear a warning bark are more likely to hide in their burrows than to remain above ground. However, the prairie dog that gives the warning bark is putting itself at increased risk of being identified and killed by the predator.

   Which of the following presents the most likely evolutionary explanation for the behaviors described?

   (A) The warning bark changes the behavior of the related prairie dogs nearby, allowing the prairie dog's family to have increased survival and reproductive success.
   (B) The barking prairie dog chooses to warn other prairie dogs, leading to more prairie dogs living above ground.
   (C) The barking prairie dog is alerting unrelated prairie dogs to the predator, so it is not giving any advantage to its own relatives.
   (D) The failure of the individual to bark when surrounded by unrelated prairie dogs ensures survival of the individual.



6. One model of a sustainable fisheries practice is for individual fish to be removed from a natural population at a rate equal to the highest possible growth rate of an ideal population. The graph above represents a population of bluefin tuna living along the Atlantic coast. At which labeled point in the graph is the population growth rate the highest?

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

GO ON TO THE NEXT PAGE.

Questions 7-11

EFFECT OF WATER-SOLUBLE POLLUTANTS ON MEMBRANE PERMEABILITY

Treatment Group	Treatment Solution*	Mean Absorbance of 460 nm Light (n = 5)	2×Standard Error of the Mean (2×SEM)
I	70% isopropanol; 30% water	0.164	0.032
II	90% isopropanol; 10% water	0.125	0.100
III	50% acetone; 50% water	0.215	0.034
IV	70% acetone; 30% water	0.274	0.018
V	100% water	0.095	0.004
*Concentrations are reported as percent by volume.			

A student formulated a hypothesis that water-soluble pollutants damage living organisms by increasing the permeability of cellular membranes. To test the hypothesis, the student investigated the effect of isopropanol and acetone on beet root cells. The vacuoles of beet root cells contain large amounts of betacyanin, a water-soluble pigment that is released into the extracellular environment as a result of increased membrane permeability.

The student prepared identical samples of beet root tissue and incubated each sample for 15 minutes in the specific solution for that group. At the end of the incubation period, the student measured the absorbance of 460 nm light for each sample. A greater concentration of betacyanin in the solution surrounding the beet root cells results in a greater absorbance of 460 nm light. The results of the experiment are shown in the table above.

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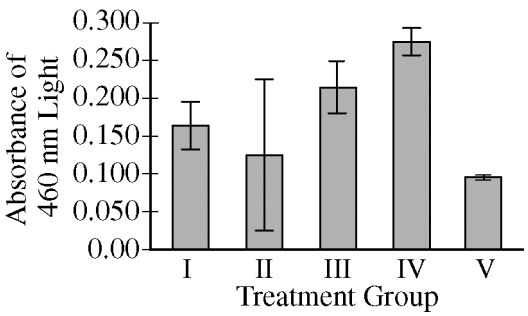
7. Which of the following is the dependent variable in the experiment?

   (A) The percent by volume of isopropanol in the treatment solutions
   (B) The percent by volume of water in the treatment solutions
   (C) The length of time each sample was incubated in the treatment solutions
   (D) The absorbance of 460 nm light by the treatment solutions

8. Which of the following graphs is the most appropriate representation of the experimental data?

(A)



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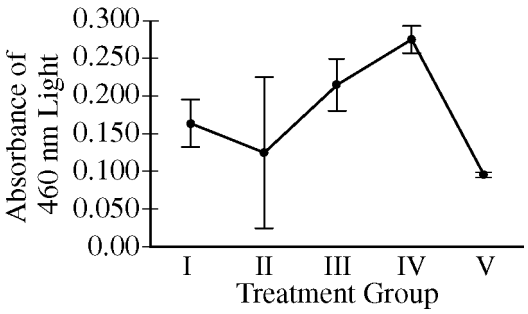

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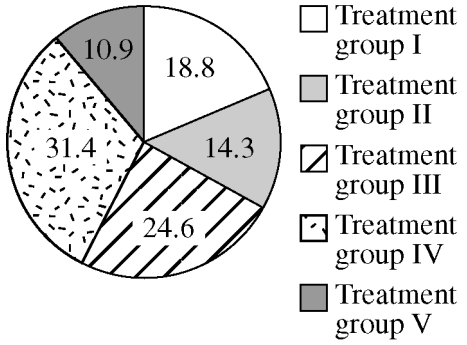
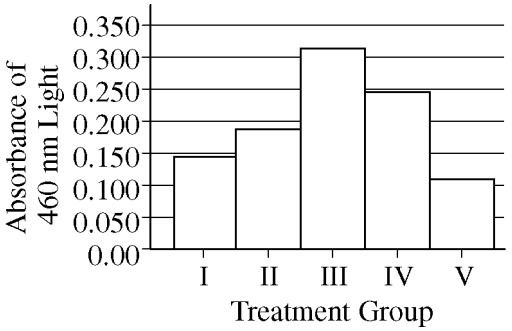


(D)



Questions 9-11 are on page 10.

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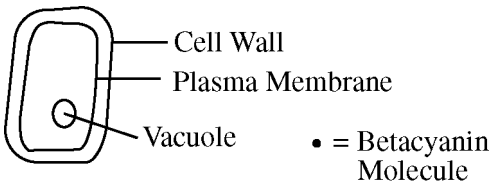
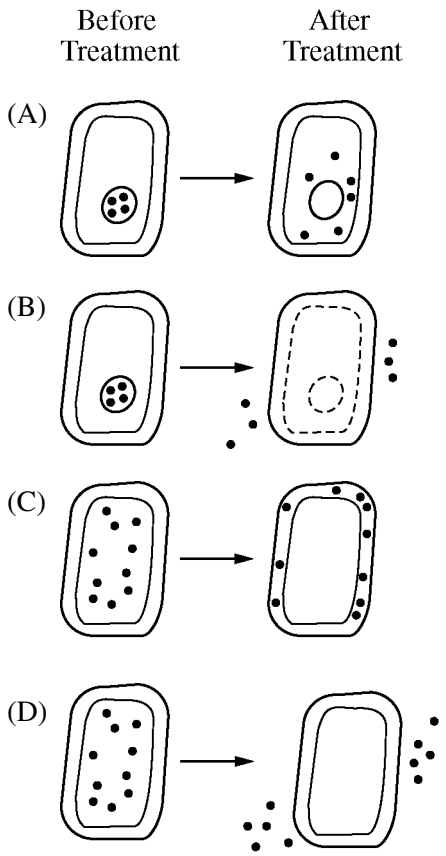


9. The illustration above is a model of a typical beet root cell. Based on the experimental results, which of the following best represents the effect of acetone on the permeability of cellular membranes?



10. The student analyzed the data from the investigation and concluded that the estimate of the mean of one treatment group was unreliable. Which of the following identifies the treatment group most likely to have provided an unreliable estimate of the mean, and correctly explains why the estimate appears unreliable?

(A) Treatment group II; it has a lower than expected mean absorbance and the largest standard error of the mean.
(B) Treatment group III; it has a higher than expected mean absorbance and the largest standard error of the mean.
(C) Treatment group IV; it has a higher than expected mean absorbance and the smallest standard error of the mean.
(D) Treatment group V; it has a lower than expected mean absorbance and the smallest standard error of the mean.

11. Based on the data from the investigation, which of the following is the best scientific question about organisms living in water that is polluted with organic solvents?

(A) Do organisms without pigments have a selective advantage in polluted environments?
(B) Will organisms living in polluted environments exhibit detrimental effects from an increased permeability of their cellular membranes?
(C) Will organic solvents from the environment become incorporated into the cell membranes of organisms living in polluted environments?
(D) Should governments place more stringent restrictions on the release of organic solvents into aquatic ecosystems?

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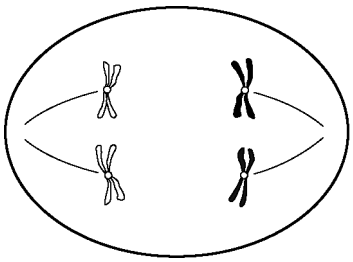
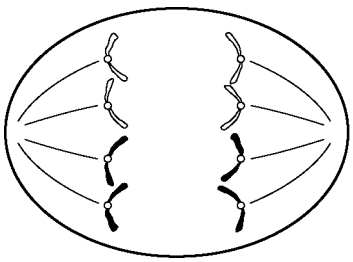
12. Within a forest ecosystem, there is a large amount of diversity among members of a warbler species. Of the following stages of meiosis illustrated for a typical cell, which contributes most to diversity among the warblers?

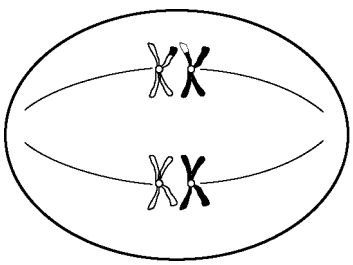
(A)



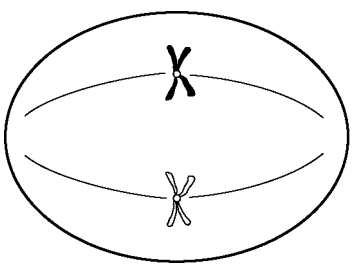
(B)



(C)



(D)



13. In an experiment, 100 mice were released into a field to which no other mice had access. Immediately after their release, a representative sample of mice was captured, their fur color was recorded, and they were returned to the field. After twenty years, a representative sample of mice was captured and the distribution of fur color was again recorded.

Fur Color	Initial Distribution (%)	Distribution after Twenty Years (%)
Brown	80	20
Gray	10	75
Black	10	5

Which of the following could best explain the change in fur color distribution, as shown in the table above?

(A) The allele for black fur color is unstable, and over twenty years most of the black fur alleles mutated to become alleles for gray fur.
(B) The field was primarily composed 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 harder to catch, and so were underrepresented in the twenty-year sample.

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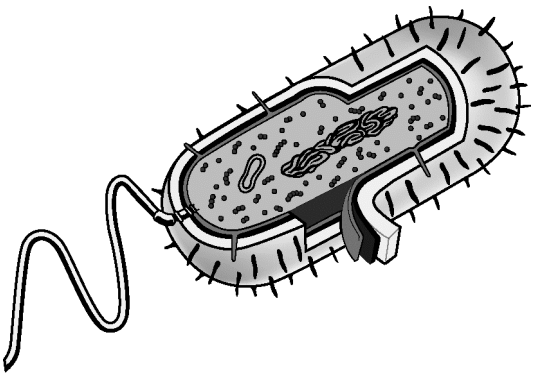
14. Liver cells manufacture glycoproteins, while adipose cells store fat. Which of the following subcellular structures is likely to be more prominent in liver cells than in adipose cells?

(A) Nucleus
(B) Golgi apparatus
(C) Cytoskeleton
(D) Plasma membrane

15. Intravenous (IV) solutions administered to patients are normally isotonic. Which of the following is most likely if an IV of distilled water is administered to a patient?

(A) The cells that are exposed to hypotonic solutions will shrink as a result of salt moving into the blood.
(B) The liver will secrete additional bile salts into the blood to raise the tonicity of the administered fluid.
(C) The cells that are exposed to hypotonic solutions will expand as water moves osmotically into the cells from the blood.
(D) The patient's respiration rate will slow to compensate for the higher levels of circulating blood.



16. The diagram above represents a typical rod-shaped bacterium. Which of the following best describes a feature shown in the diagram that is unique to archaea and bacteria?

(A) The organism is surrounded by a cell wall.
(B) The organism contains ribosomes.
(C) The organism does not have a nuclear membrane surrounding its genetic material.
(D) The organism is not capable of making or providing itself with ATP.

17. Which of the following best supports the claim that organisms of different domains share a common ancestor?

(A) Photosynthesis occurs in chloroplasts, and the citric acid cycle occurs in mitochondria.
(B) Glycolysis occurs in both prokaryotic cells and eukaryotic cells.
(C) Introns are present in eukaryotic DNA but not in prokaryotic DNA.
(D) Errors in DNA synthesis provide some of the genetic variation in a population.

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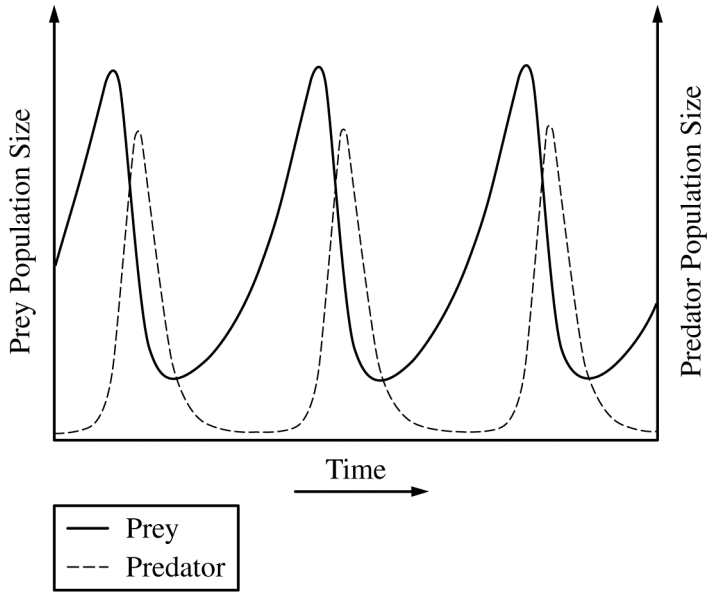
18. The graph below shows a model of population changes over time in a predator and its prey.



Which of the following data would be most helpful in predicting possible disruptions to the relationship between the predator and its prey?

(A) Time of day, because as days become shorter, nighttime hunting increases
(B) Average birth weight of predators, because heavier offspring will begin hunting at younger ages
(C) Numbers of additional predator species, because additional predators will increase competition for prey
(D) Prey metabolic rates, because predators are less successful against prey with higher metabolic rates

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Questions 19-22

The three-spined stickleback (*Gasterosteus aculeatus*) is a small fish found in both marine and freshwater environments. Marine stickleback populations consist mostly of individuals with pronounced pelvic spines, as shown in Figure 1. Individuals in freshwater stickleback populations, on the other hand, typically have reduced pelvic spines, as shown in Figure 2.

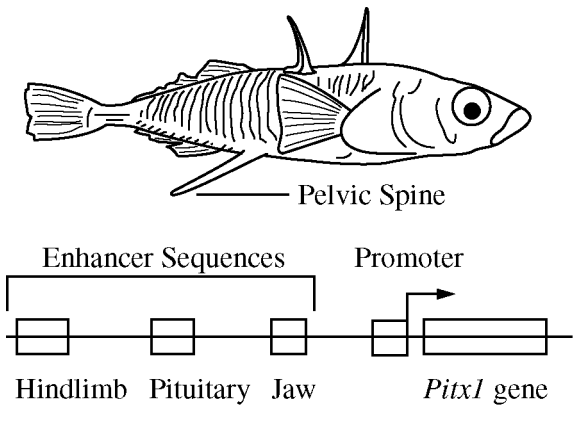

Figure 1. Marine stickleback

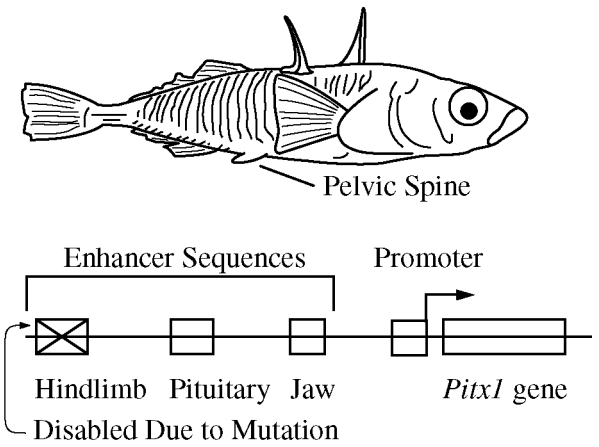

Figure 2. Freshwater stickleback

As represented in Figure 1 and Figure 2, the phenotypic difference between marine and freshwater sticklebacks involves *Pitx1*, a gene that influences the formation of the jaw, pituitary gland, and pelvic spine. Enhancer sequences upstream of the *Pitx1* genetic locus regulate expression of the *Pitx1* gene at the appropriate times and in the appropriate tissues during development. Previous studies have found that a mutation in the hindlimb enhancer interferes with the formation of a pronounced pelvic spine.

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19. Which of the following best describes how sticklebacks in the same population with identical copies of the *Pitx1* gene can still show phenotypic variation in the pelvic spine character?

(A) The *Pitx1* gene is carried on different chromosomes in different individuals.
(B) Expression of the *Pitx1* gene is affected by mutations at other genetic loci.
(C) The genetic code of the *Pitx1* gene is translated differently in males and females.
(D) The subcellular location of the *Pitx1* gene changes when individuals move to a new environment.

20. A mutation that affects *Pitx1* gene function in all tissue types is most likely to be at which of the following genetic loci?

(A) Hindlimb enhancer
(B) Pituitary enhancer
(C) Jaw enhancer
(D) Promoter

21. In sticklebacks, which of the following is most likely to occur if the jaw enhancer is disabled instead of the hindlimb enhancer?

(A) The jaw and a pronounced pelvic spine develop normally because the *Pitx1* gene is expressed in both developing tissues.
(B) Neither the jaw nor a pronounced pelvic spine develop normally because there is no *Pitx1* gene expression in either developing tissue.
(C) The jaw develops normally, but a pronounced pelvic spine does not develop because the *Pitx1* gene is expressed in the developing jaw but not in the developing pelvis.
(D) The jaw does not develop normally, but a pronounced pelvic spine does develop because the *Pitx1* gene is expressed in the developing pelvis but not in the developing jaw.

22. Which of the following describes a possible selective mechanism to explain why freshwater sticklebacks typically have reduced pelvic spines?

(A) Reduced pelvic spines increase the likelihood of escaping predators in freshwater environments.
(B) Reduced pelvic spines expand the range of foods that can be used as sources of energy in freshwater environments.
(C) Reduced pelvic spines result in males becoming effectively invisible to potential mating partners in freshwater environments.
(D) Reduced pelvic spines allow individual fish to pass through narrow waterways on their way to marine environments.

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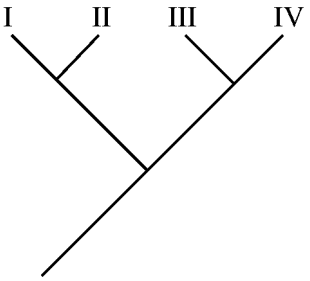
23. *Hydrangea macrophylla* is a species of plant with blue or pink flowers. Flower color in *Hydrangea macrophylla* plants is thought to be determined primarily by soil conditions rather than by inherited differences. Which of the following will provide the most direct evidence that flower color in *Hydrangea macrophylla* is due primarily to soil conditions?

(A) Comparing DNA sequence information for *Hydrangea macrophylla* to DNA sequence information for a different species of flowering plant
(B) Performing a genetic cross between a pink-flowered plant and a blue-flowered plant and then determining the ratio of phenotypes in the offspring
(C) Growing cuttings from the same *Hydrangea macrophylla* plant under controlled conditions that vary only with regard to soil pH
(D) Analyzing fossilized remains of an ancestral species that grew in geographic areas similar to the habitats of modern *Hydrangea macrophylla*



24. Based on morphological characteristics, the phylogenetic tree above has been developed for species I, II, III, and IV. DNA sequencing has recently been completed for a particular gene found in all four species. The sequencing will provide additional information for answering which of the following questions?

(A) Is species I the common ancestor of species II and III?
(B) Does species I contain the greatest number of vestigial structures?
(C) Are species III and IV the most closely related?
(D) Should the positions of species III and IV be reversed?

25. The transmission of information from sensory neurons to interneurons typically involves the

(A) exchange of electrons between specialized proteins embedded in the plasma membrane of the sensory neuron to the plasma membrane of the interneuron
(B) release of chemical messengers into the space between the axon of the sensory neuron and the plasma membrane of the interneuron
(C) transfer of a phosphate group from ATP in the sensory neuron to a protein substrate in the interneuron
(D) flow of protons down an electrochemical gradient through a gated channel between the sensory neuron and the interneuron

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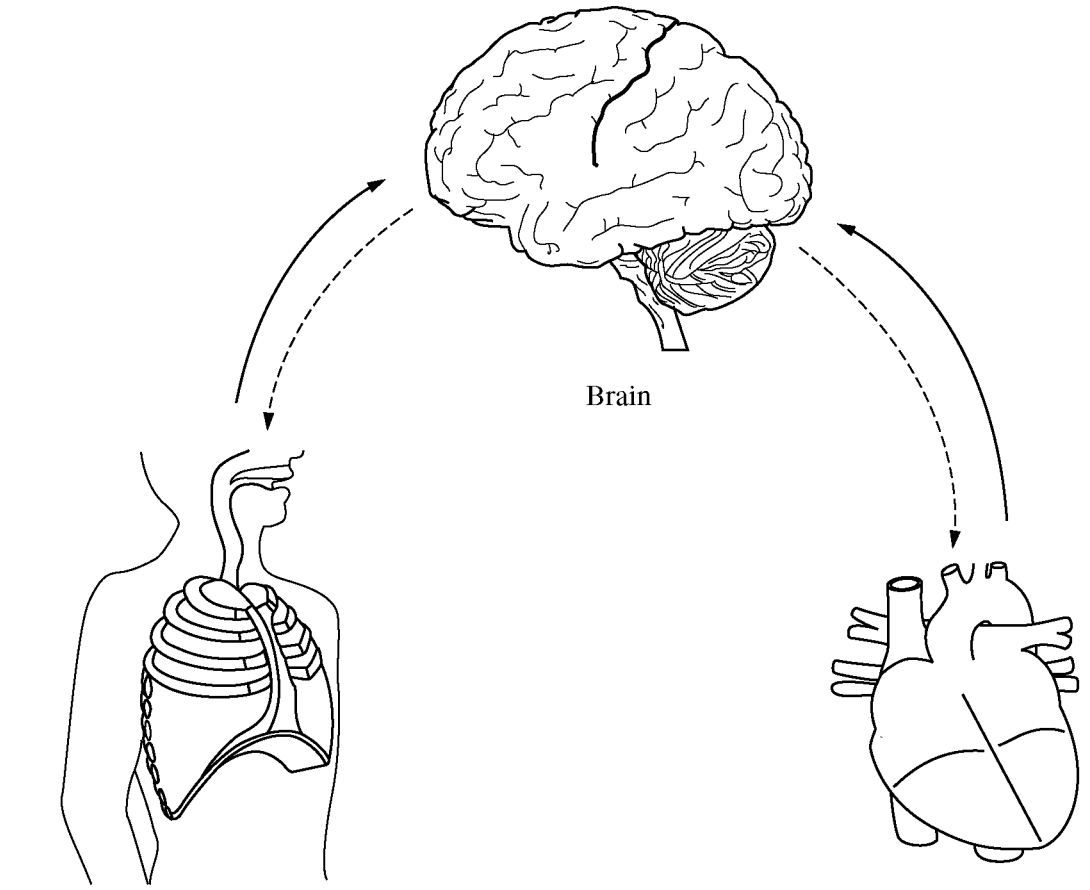

26. The brain coordinates the circulatory and respiratory systems of the human body. The control of breathing, for example, involves neural pathways among the structures represented in the figure above. One important stimulus in the control of breathing is an increase in blood CO_2 concentration, which is detected as a decrease in blood pH. Which of the following best describes the physiological response to an overall increase in cellular respiration in the body?

(A) In response to depleted blood CO_2 levels, the pH sensors send signals directly to the rib muscles, resulting in an increase in the rate of CO_2 uptake by the lungs and a decrease in CO_2 utilization by the brain.

(B) In response to low blood pH, the pH sensors send a signal to the brain, which then sends a signal to the diaphragm, resulting in an increased rate of breathing to help eliminate excess blood CO_2.

(C) In response to high blood pH, the pH sensors send a signal directly to the lungs, resulting in a slower rate of breathing, and the lungs send a signal back to the heart once CO_2 availability has been restored.

(D) In response to an increased rate of breathing, the rib muscles send a signal to the brain, which then sends a signal to the heart, resulting in a decrease in heart activity and slower flow of blood through the body.

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27. Thyroxin is a hormone that increases metabolic activities within various tissue targets. Low levels of circulating thyroxin trigger the secretion of thyroid-stimulating hormone (TSH) from the anterior pituitary. TSH secretion then stimulates thyroxin production and release by the thyroid gland. The increased level of circulating thyroxin inhibits further secretion of TSH from the anterior pituitary.

Based on the information provided, which of the following can most likely be concluded about the TSH–thyroxin loop?

(A) A person taking thyroxin to supplement low thyroxin secretion will produce more TSH.
(B) Increased thyroxin production would cause elevated ribosomal activity in the anterior pituitary.
(C) The structure of the loop would lead to elevated thyroid and tissue activity due to positive feedback.
(D) The feedback mechanism would maintain relatively constant levels of thyroxin throughout tissue targets.

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28. The Stanley Miller apparatus demonstrated that organic molecules could assemble spontaneously in an environment lacking free oxygen and containing water, methane, and ammonia in the presence of an abundant energy source, such as an electric discharge. The research was considered supportive of the organic soup hypothesis, which states that the primitive atmosphere provided inorganic precursors from which organic molecules could have been synthesized in the presence of an energy source. Based on subsequent research, the primordial atmosphere was determined to contain less methane and more carbon dioxide. The new data about the composition of the early atmosphere had which of the following effects on origin-of-life hypotheses?

(A) Miller's work was discarded as not relevant to an origin-of-life hypothesis.
(B) Miller's work was used to refute the new hypothesis about the composition of the atmosphere.
(C) The organic soup hypothesis was abandoned as no longer being supportable.
(D) A new organic soup hypothesis was proposed to account for the new data about the atmosphere.

Questions 29-33

Ascorbic acid (vitamin C) is an organic molecule necessary for the health of plants and animals. The majority of animals, including most mammals, synthesize ascorbic acid from organic precursors, but some primates are unable to synthesize ascorbic acid and must instead acquire it from dietary sources, such as certain fruits and vegetables.

The *L-gulonolactone oxidase (GULO)* gene encodes an enzyme that catalyzes a required step in the biosynthesis of ascorbic acid. Most mammals carry a functional copy of the *GULO* gene, but some primates carry only a *GULO* pseudogene, which is a nonfunctional variant.

A comparison of *GULO* genes and *GULO* pseudogenes from different animals can provide insight into the evolutionary relatedness of the animals. In Table I, selected members of some mammalian groups are listed, along with an indication of their ability to synthesize ascorbic acid. Table II shows an alignment of amino acid coding sequences from homologous regions of the *GULO* genes and *GULO* pseudogenes of the organisms listed in Table I. Figure 1 represents the universal genetic code.

TABLE I: SELECTED MAMMALIAN GROUPS

Group	**Selected Members**	**Biosynthesis of Ascorbic Acid**
Nonprimate mammals	Elephant, mouse	Yes
Primate mammals	Lemur	Yes
	Orangutan, chimpanzee	No
	Human	No

TABLE II: DNA SEQUENCE ALIGNMENT*

	Relative Positions of Nucleotides in Nontemplate (Coding) Sequence																										
	1 (5′)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27 (3′)
Elephant	G	A	C	A	C	C	C	A	T	C	T	G	A	A	G	A	A	G	T	C	G	G	A	A	T	A	C
Mouse	G	A	C	A	G	C	C	A	C	C	T	G	A	A	G	A	A	G	T	C	T	G	A	G	T	A	C
Lemur	G	A	C	A	G	C	C	A	C	C	T	G	A	A	G	A	G	G	T	C	C	G	A	G	T	A	C
Orangutan	G	A	C	A	G	C	-	A	T	T	G	G	A	A	G	A	A	A	T	C	T	G	A	G	G	A	C
Chimp	G	A	C	A	G	C	-	A	T	T	G	G	A	A	G	A	A	A	T	C	T	G	A	G	G	A	C
Human	G	A	C	A	G	C	-	A	T	T	G	G	A	A	G	A	A	A	T	C	T	G	A	G	G	A	C

*For each DNA segment, the alternating shaded and unshaded nucleotides indicate the triplet codons of the open reading frame, shown from left (5′) to right (3′) as the nontemplate (coding) strand. An "–" indicates the absence of a nucleotide.

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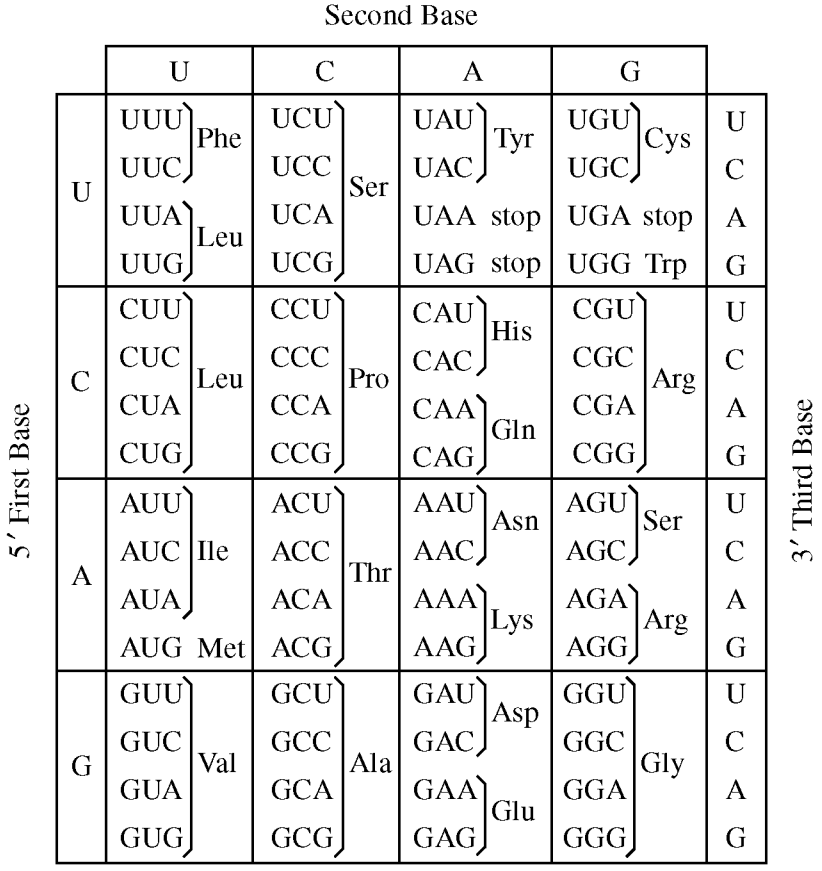

Figure 1. Universal genetic code.

Questions 29-33 are on pages 22 and 23.

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Item 29 was not scored.

30. Comparison of DNA sequences in Table II suggests that a functional *GULO* gene in lemurs can have a G, C, or T at position 21 but only a G at position 22. Which of the following pairs of predictions is most helpful in explaining the discrepancy?

	A substitution at position 21 would result in	**A substitution at position 22 would result in**
(A)	No change to the protein	A premature stop codon or an amino acid with different biochemical characteristics
(B)	A different amino acid	A premature stop codon or an amino acid with different biochemical characteristics
(C)	No change to the protein	A frame shift producing an inactive protein
(D)	An amino acid with different biochemical characteristics	No transcription of the gene

31. Which of the following is the most likely effect of the mutation at nucleotide position 7 in the *GULO* gene of humans?

(A) The mutation results in the deletion of the *GULO* gene, so no polypeptide can be translated.
(B) The deletion of the single nucleotide causes a frame shift, changing the primary structure downstream of the mutation and resulting in a nonfunctional protein.
(C) The point mutation causes a substitution of the amino acid isoleucine (Ile) for histidine (His) at position 7, resulting in a protein with higher than normal activity.
(D) The substitution of a single nucleotide in the *GULO* coding region results in a stop codon. This results in a smaller nonfunctional protein.

32. Lemurs are primates that live on the island of Madagascar off the coast of Africa. Lemurs have a functional *GULO* gene and are able to produce ascorbic acid. However, primates that live in other places (e.g., humans, chimpanzees, and orangutans) have a *GULO* pseudogene and are unable to produce ascorbic acid. Which of the following best explains the genetic variation among primate species?

(A) Food sources on the island of Madagascar were deficient in ascorbic acid, which caused the primates to migrate to the mainland where ascorbic acid–rich foods are more widely available.
(B) Human activity on Madagascar, including poaching, drove the other primates into extinction on the island.
(C) Food sources where non-Madagascar primates lived provided ample ascorbic acid in the diet, which removed the selective pressure for maintaining a functional *GULO* gene.
(D) Food sources on the island of Madagascar were deficient in ascorbic acid, which caused lemurs to adapt by developing the ability to produce an active GULO protein.

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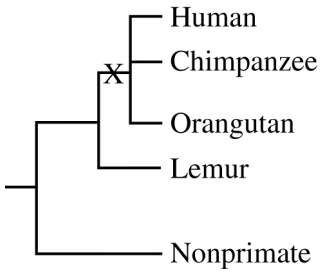
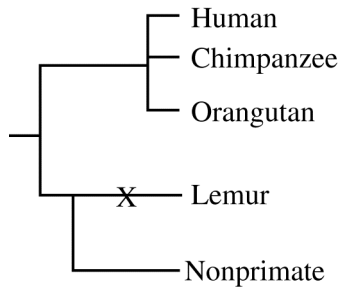
33. Which of the following phylogenetic trees best illustrates (with the X) the point at which the mutation in the *GULO* gene most likely occurred during the evolutionary history of these organisms?

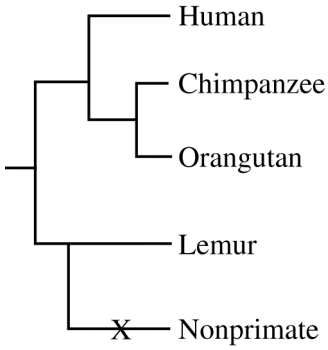
(A)



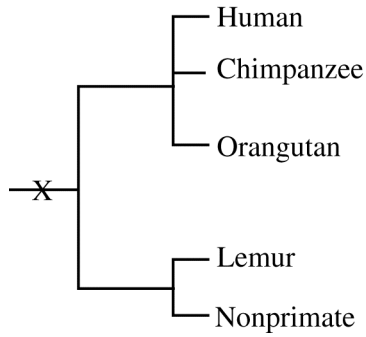
(B)

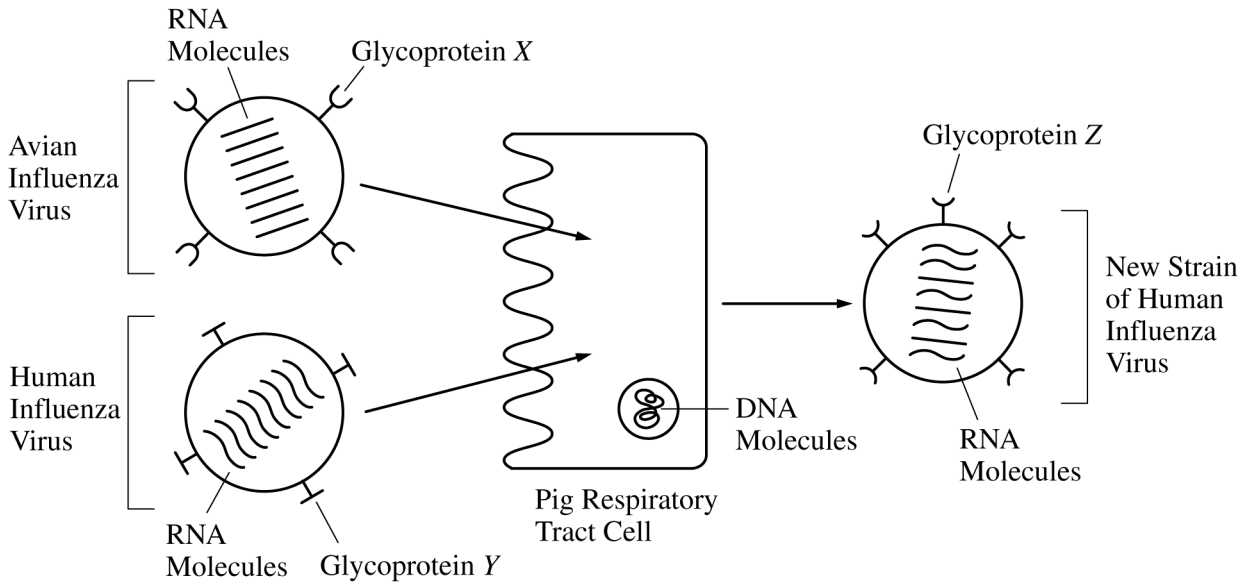


(C)



(D)





34. The cells lining the respiratory tract of pigs have receptors for both avian and human influenza viruses. Based on the model above, which of the following best describes the origin of the new strain of human influenza virus?

(A) The new viral strain inherited a mixture of genetic material from both avian influenza virus and human influenza virus.
(B) The new viral strain inherited RNA molecules from the avian influenza virus and packaged them inside the human influenza virus membrane.
(C) The new viral strain inherited a mutant DNA molecule from the pig respiratory tract cell.
(D) The new viral strain inherited an RNA molecule that had recombined with a DNA molecule from the pig respiratory tract cell.

35. In the "RNA world" model for the origin of life, the first protocells (probionts) relied on RNA, not DNA, for information storage and transmission. Which of the following could best be considered evidence in support of the RNA world model?

(A) DNA is more stable than is RNA.
(B) Some RNA molecules in contemporary cells have catalytic function.
(C) RNA is so complex in both structure and function that it must have preceded DNA.
(D) RNA has secondary structure whereas DNA does not.

36. Which of the following pieces of evidence best supports the hypothesis that birds and crocodilians (crocodiles and alligators) are more closely related to each other than they are to other organisms?

(A) Modern birds and crocodilians utilize different niches within the same geographical region.
(B) Like turtles and snakes, modern birds and crocodilians build nests in which they lay shelled eggs.
(C) The skulls of birds and crocodilians have an opening that is absent in the skulls of other reptiles.
(D) Fossil evidence indicates that both modern birds and crocodilians originated during the Jurassic Period.

Cellular Shape	Ratio of Surface Area to Volume
Cube	1.7
Regular Tetrahedron	0.5
Cylinder	0.9
Sphere	0.6

37. In an experiment, the efficiency of oxygen exchange across the plasma membrane is being assessed in four artificial red blood cells. The table above lists some properties of those artificial cells. Other conditions being equal, which artificial cell is predicted to be the most efficient in exchanging oxygen with the environment by diffusion?

(A) The cuboidal cell
(B) The tetrahedral cell
(C) The cylindrical cell
(D) The spherical cell

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38. To test the hypothesis that a particular plant synthesizes storage lipids by using glyceraldehyde 3-phosphate (G3P) from photosynthesis, a researcher plans to use radiolabeled precursors to track the molecules through the biosynthetic pathway. Which of the following radiolabeled precursors is most appropriate for the researcher to use?

(A) ^{15}N-labeled N_2, because atmospheric nitrogen is fixed to amino acids by photosynthesis

(B) ^{14}C-labeled CO_2, because atmospheric carbon is fixed to carbohydrates by photosynthesis

(C) ^{35}S-labeled methionine, because amino acids are incorporated into lipids during photosynthesis

(D) ^{32}P-labeled phosphate, because lipids are stored in plants as phospholipids

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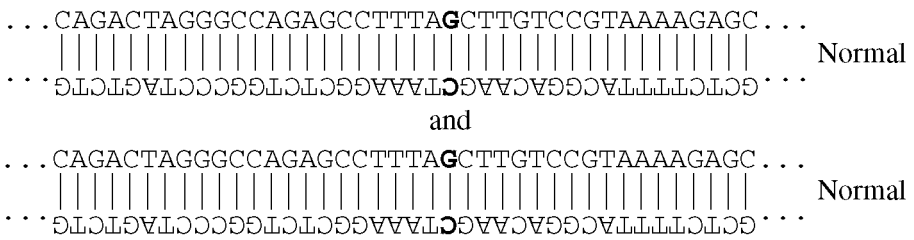
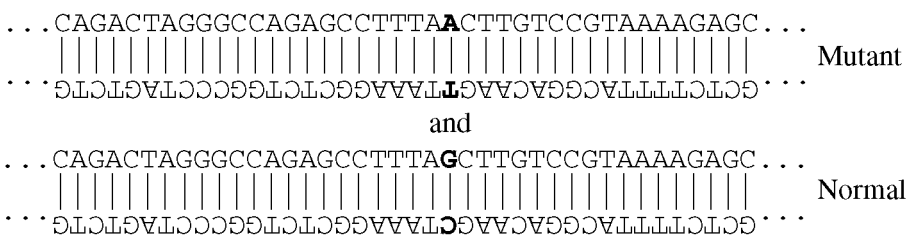
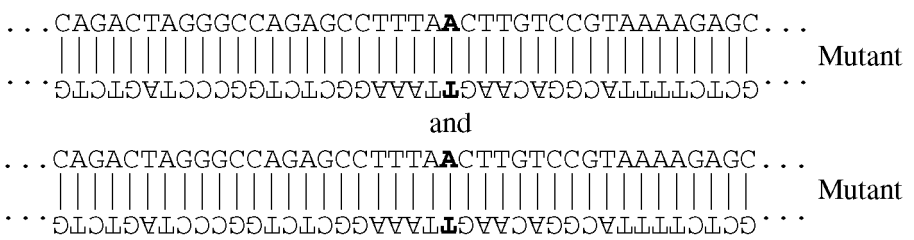
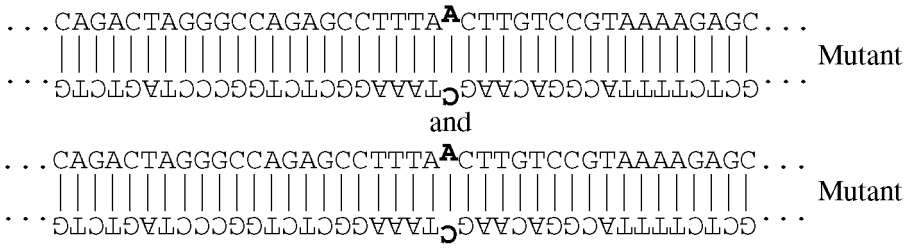
39. Mutations in DNA are usually caused by chemical or radiation damage to DNA molecules, followed by imperfect repair of the damage. Immediately after this kind of imperfect repair, there may be a mismatched base pair in the DNA. The illustration below shows an example of a mismatch, with the relevant pair bases in bold.

Which of the following best represents the DNA of the two daughter cells produced when a bacterial cell with this particular mismatch replicates its DNA and divides?

(A)


(B)


(C)


(D)


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Questions 40-44

Iron is an essential nutrient that is acquired by organisms from the environment. When intracellular levels of iron are relatively high, living cells synthesize an iron-storage protein called ferritin.

The induction of ferritin synthesis by iron was investigated in rats. Figure 1 shows the results of an experiment in which cellular levels of ferritin protein were measured in the presence or absence of iron and actinomycin D, a drug that inhibits transcription.

Figure 2 shows the results of an experiment in which cellular levels of ferritin protein were measured in the presence or absence of iron and cycloheximide, a drug that inhibits translation.

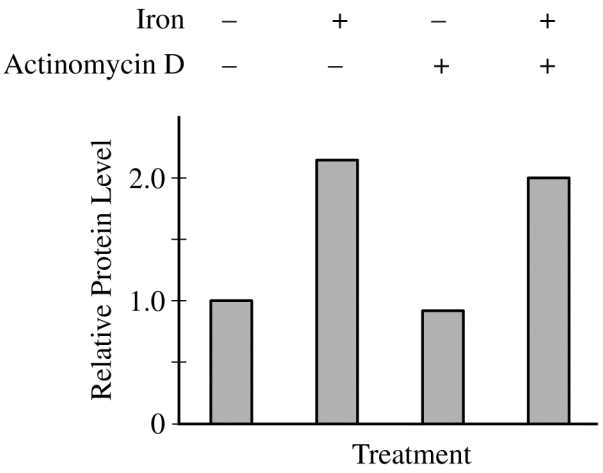

Figure 1. Ferritin Protein Levels

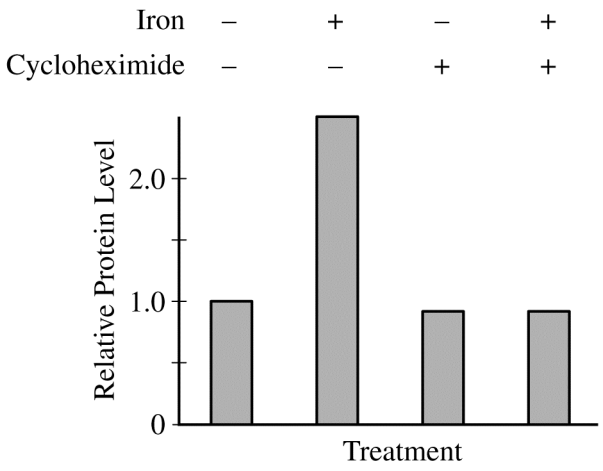

Figure 2. Ferritin Protein Levels

40. Which of the following biotechnology approaches could be used to identify ferritin mRNA in a sample of total cellular RNA?

(A) RNA samples could be directly cloned into a DNA plasmid, grown in bacteria, and tested for the ability to bind iron.
(B) RNA samples could be separated by size using agarose gel electrophoresis and incubated with labeled single-stranded DNA molecules that are complementary to the ferritin mRNA.
(C) RNA samples could be converted to protein and subsequently cut with a restriction endonuclease that recognizes DNA sequences.
(D) RNA samples could be examined under a high-power microscope to visually identify the ferritin mRNA.

41. In individuals with iron-rich diets, intracellular levels of iron are higher than in individuals with iron-poor diets. Which of the following best explains how organisms regulate ferritin protein levels in response to available iron?

(A) Translation of ferritin mRNA is inhibited in the presence of iron.
(B) Translation of ferritin mRNA is stimulated by iron.
(C) Ferritin protein is more stable in the presence of iron.
(D) Ferritin protein is less stable in the presence of iron.

42. The data can best be used to support which of the following claims about the mechanism for regulating ferritin gene expression?

(A) Iron increases ribosome binding to ferritin mRNA.
(B) Iron causes the ferritin mRNA to be degraded.
(C) Iron increases the effect of actinomycin D on RNA polymerase.
(D) Iron decreases the ability of ferritin mRNA to bind to ribosomes.

43. The gene sequences responsible for the iron - mediated changes in ferritin protein levels are highly conserved and are called iron response elements (IREs). IREs have been observed in a number of genes involved in iron transport and metabolism. The IRE sequences found in the ferritin gene are found in all multicellular organisms, whereas other nonferritin IRE sequences are found only in certain vertebrate organisms. Which of the following is the best explanation for the observations?

(A) Ferritin IREs arose in the common ancestor of multicellular organisms, whereas nonferritin IREs arose later in specific evolutionary lineages.
(B) Nonferritin IREs arose at different times in the common ancestor of multicellular organisms.
(C) Ferritin IREs arose in diverse organisms by convergent evolution, while the nonferritin IREs arose by recombination events between closely related species.
(D) Ferritin IREs have evolved independently in different evolutionary lineages, whereas nonferritin IREs arose in the common ancestor of multicellular organisms.

44. Hereditary hemochromatosis (HHC) is an iron storage disease that results in reduced uptake of iron into cells. Based on the data, which of the following is the most likely effect of HHC on ferritin protein levels?

(A) Elevated levels of ferritin protein because there is more iron in the blood of affected individuals
(B) Reduced levels of ferritin protein because there is less iron in the cytosol of affected individuals
(C) Elevated levels of ferritin protein because ferritin replaces the mutant protein in affected individuals
(D) Reduced levels of ferritin protein because iron stimulates ferritin breakdown

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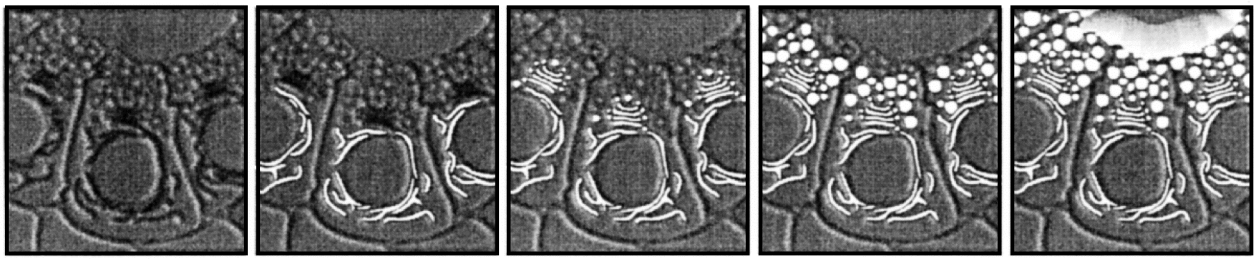

45. The figure above shows a series of microscope images taken over time of ovalbumin production in chick oviduct cells in response to stimulation with estrogen. The ovalbumin protein was detected using a fluorescent dye as shown by the white areas in the time-lapse sequence.

The microscope images indicate that ovalbumin

(A) is synthesized on soluble ribosomes and packaged into lysosomes, from which it is secreted into the oviduct
(B) is synthesized on ribosomes bound to the rough endoplasmic reticulum, and then secreted directly into the oviduct
(C) crosses the endoplasmic reticulum membrane as it is translated, then moves to the Golgi apparatus, then to vesicles from which it is secreted
(D) crosses the Golgi apparatus membrane post-translationally, is taken up by the Golgi apparatus and endoplasmic reticulum, then is packaged into secretory vesicles

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46. Freshwater bony fish secrete large volumes of very dilute urine. Many marine bony fish secrete small volumes of concentrated urine. Which of the following best explains the differences in nitrogenous-waste excretion between freshwater and marine bony fish?

(A) The differences arose during divergence, as fish from a common ancestor faced different selective pressures in environments of different osmolarity.
(B) The differences resulted from the evolution of kidneys in independent evolutionary lineages that were adapted to different environmental conditions.
(C) The differences are accidents of evolutionary divergence and are unrelated to the osmotic differences in freshwater and marine environments.
(D) The differences arise in each generation because of the physiological adjustment of individual fish to fluctuating salt concentrations in the environments in which they live.

47. Malaria is caused by several different species of *Plasmodium*, a protozoan parasite. *Plasmodium* resistance to the common drugs used to treat malaria has increased in recent years.

In a scientific study, *Plasmodium* samples were analyzed in blood drawn from a large number of infected patients before drug treatment and subsequently from the subset of infected patients with drug-resistant *Plasmodium*. DNA sequences of four different *Plasmodium* genes thought to be involved in resistance were compared between samples from patients with drug-sensitive *Plasmodium* and patients with drug-resistant *Plasmodium*.

Which of the following best supports the hypothesis that preexisting mutations confer drug resistance?

(A) Drug resistance can sometimes be reversed by simultaneous treatment with a drug that inhibits the drug-pumping mechanism of *Plasmodium*.
(B) Some of the mutations that occur most frequently in samples from patients treated with antimalarial drugs are detectable in *Plasmodium* samples collected prior to use of antimalarial drugs.
(C) Continued use of the same antimalarial drugs leads to increased *Plasmodium* resistance.
(D) The same mechanism of drug resistance in *Plasmodia* isolated from separate populations of patients resulted from an accumulation of new genetic mutations.

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Questions 48-50

Insulin, a hormone secreted by pancreatic cells, stimulates glucose uptake in skeletal muscle cells by mobilizing glucose transporter proteins (GLUT4) to the plasma membrane. As depicted in Figure 1, binding of insulin to the insulin receptor triggers an intracellular signaling cascade in which certain molecules activate other molecules in a relay of the hormone signal to cell targets. One outcome of the signaling cascade is mobilization of GLUT4 from vesicle storage sites in the cytoplasm to sites at the cell surface, where GLUT4 allows glucose to enter the cell.

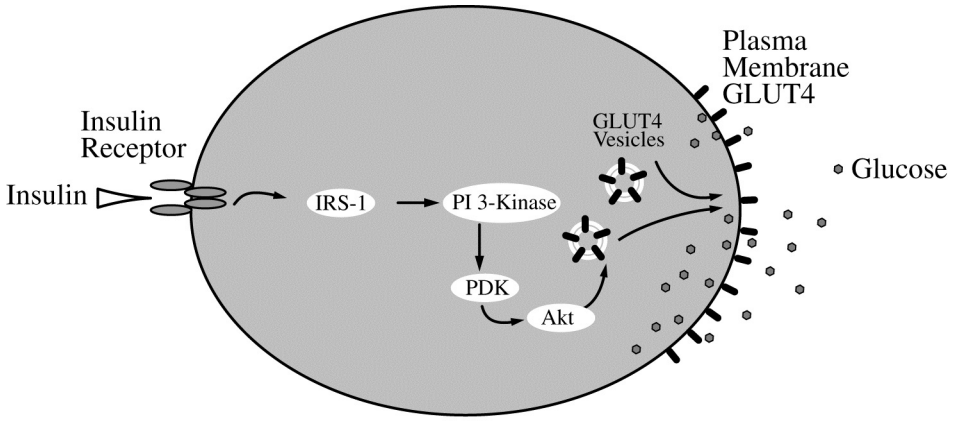

Figure 1. Insulin signaling in muscle cells

In type 2 diabetes, the cellular response to insulin is disrupted, and individuals with type 2 diabetes cannot properly regulate their blood glucose levels. In an investigation of the insulin signaling pathway, samples of skeletal muscle were isolated from individuals who have type 2 diabetes and from individuals who do not. The results of several experiments that were performed on the muscle samples are shown in Figure 2, Figure 3, and Figure 4.

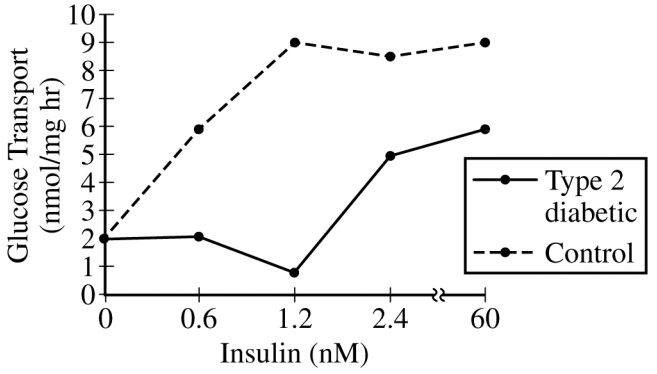

Figure 2. Insulin-stimulated glucose uptake

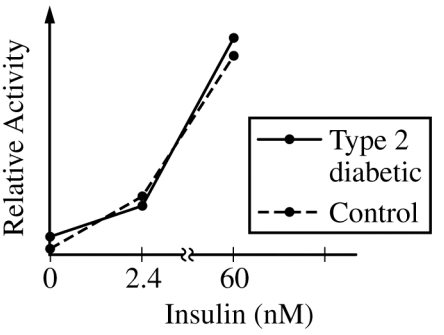

Figure 3. Insulin receptor activation

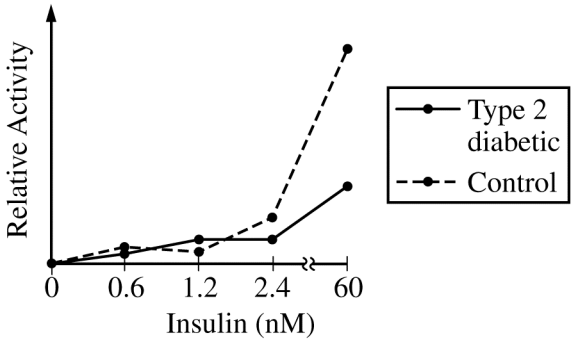

Figure 4. IRS-1 activation

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48. Which of the following is a valid interpretation of the experimental results that explains how individuals with type 2 diabetes differ from individuals without diabetes?

(A) The relatively low levels of glucose uptake in individuals with type 2 diabetes indicate that mobilization of GLUT4 to the cell surface is reduced in muscle cells of those individuals.
(B) The relatively low levels of glucose uptake in individuals with type 2 diabetes indicate that no functional GLUT4 protein is produced in the muscle cells of those individuals.
(C) The absence of activated insulin receptors in individuals with type 2 diabetes indicates that no insulin is secreted by the pancreatic cells of those individuals.
(D) The absence of activated IRS-1 in individuals with type 2 diabetes indicates that no functional insulin receptor protein is produced in the muscle cells of those individuals.

49. Based on the experimental results, which of the following describes the most likely defect in muscle cells of patients with type 2 diabetes?

(A) Insulin receptor proteins do not reach the cell surface.
(B) Insulin does not activate its receptor.
(C) IRS-1 activation is reduced at high insulin concentrations.
(D) GLUT4 blocks glucose from entering cells.

50. Based on the information presented, which of the following genetic changes in an individual without diabetes is most likely to result in a disrupted cellular response to insulin signaling similar to that of an individual with type 2 diabetes?

(A) A deletion in the gene encoding the insulin receptor that removes only the cytoplasmic domain of the protein
(B) Duplication of the gene encoding a PI-3 kinase that results in synthesis of a muscle-specific variant of the enzyme in skin cells as well as in muscle cells
(C) A mutation in the gene encoding IRS-1 that causes the protein to be active in muscle cells even in the absence of insulin signaling
(D) Insertion of a small segment of DNA into the promoter of the *Glut4* gene that results in increased synthesis of GLUT4 proteins in muscle cells

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51. Trypsinogen is split by the enzyme enterokinase to form an activated molecule of the protease trypsin. Which of the following would confirm that the activation of trypsin is an example of how a positive feedback mechanism can amplify a biological process?

(A) The activated trypsin enzyme can use enterokinase as a substrate.
(B) The trypsin produced by the reaction is capable of splitting and activating additional trypsinogen molecules.
(C) If levels of trypsin were to get too high, the trypsin molecules would inhibit the enzyme enterokinase.
(D) Each mRNA molecule that codes for trypsinogen can be translated repeatedly to form many peptide molecules.

52. Cancer can result from a variety of different mutational events. Which of the following is LEAST likely to result in the initiation of a cancerous tumor?

(A) A receptor mutation results in activation of a cell-division pathway in the absence of the appropriate ligand.
(B) A mutation results in the loss of the ability to produce a tumor-suppressor protein.
(C) A defect in a cell-cycle checkpoint prevents a cell from entering the S phase.
(D) At the anaphase checkpoint, separation of chromatids occurs without all centromeres being attached to kinetochore microtubules from both poles.

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53. Which of the following statements is true regarding the movement of substances across cell membranes?

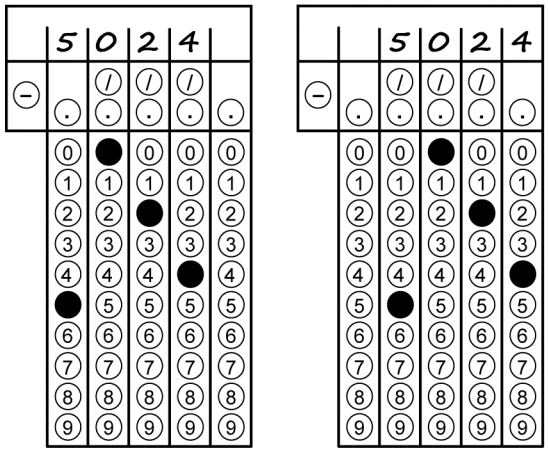
(A) Ions are unable to move through the phospholipid bilayer because the nonpolar tail regions of the phospholipids are hydrophobic.
(B) Ions are able to move through the phospholipid bilayer because the polar head regions of the phospholipids are charged.
(C) Water is able to move through the phospholipid bilayer because the nonpolar tail regions of the phospholipids are charged.
(D) Water is unable to move through the phospholipid bilayer because the polar head regions of the phospholipids are charged.

GO ON TO THE NEXT PAGE.

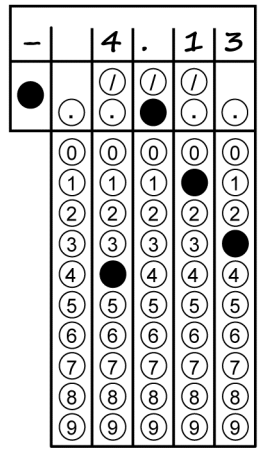
Directions: The next six questions, numbered 121–125, require numeric answers.
Determine the correct answer for each question and enter it in the grid on page 3 of the answer sheet.
Use the following guidelines for entering your answers.

- 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).

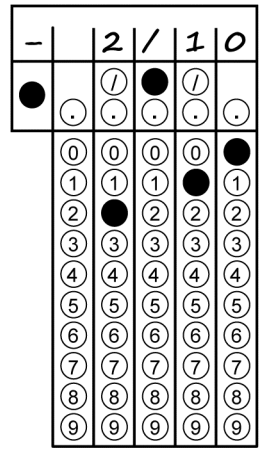
Integer answer: 5024
(either position is correct)



Decimal answer:
−4.13



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



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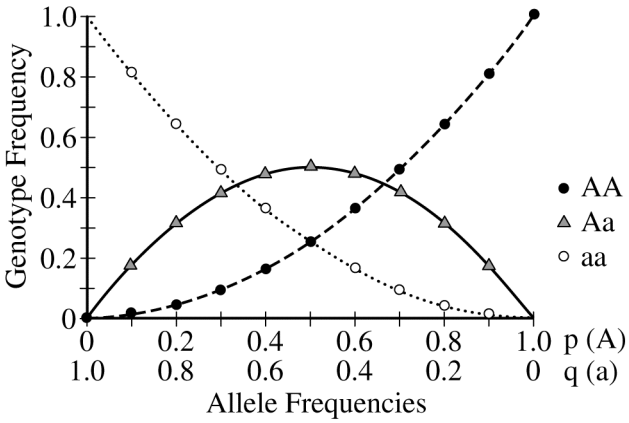
121. The internal temperature of different organisms was determined under various conditions, as shown in the table below.

Organism	Thermoregulation Strategy	Measurement Conditions	Internal Temperature
Butterfly	Ectotherm	Resting in the shade	15°C
Butterfly	Ectotherm	Flying in the sunlight	23°C
Horse	Endotherm	Resting in the shade	42°C
Horse	Endotherm	Galloping in a field	43°C
Goose	Endotherm	Sitting on a nest	41°C
Goose	Endotherm	Flying above treetops	??°C

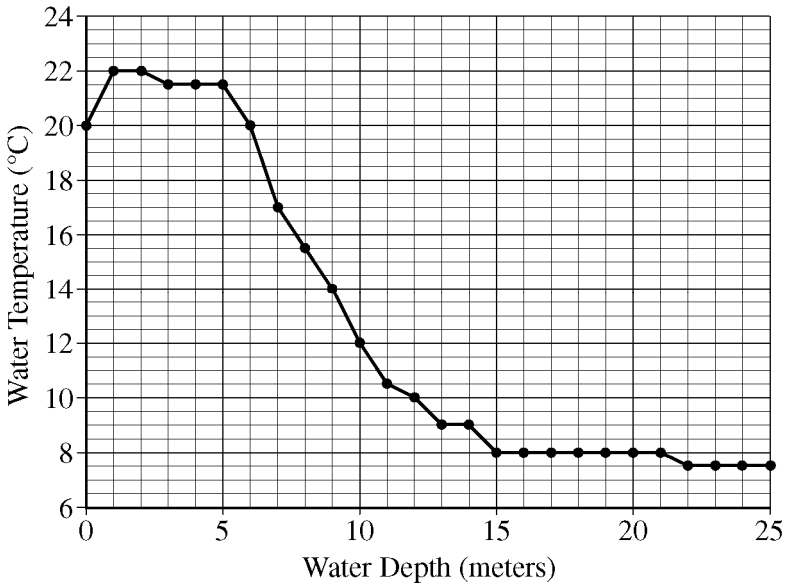
Predict the internal temperature (in °C) of a goose that is flying just above the treetops when the external temperature is 7°C. Give your answer to the nearest whole number.



122. The graph above shows the genotype frequencies for a particular genetic locus at different allele frequencies in a population. Using the graph, determine the frequency of the dominant allele in the population if the frequency of homozygous recessive individuals in the population is 0.75. Enter your answer as a value between zero and one to the nearest hundredth.

GO ON TO THE NEXT PAGE.

123. As part of a study investigating the temperature profile of a temperate-zone lake, water temperature measurements were made at different water depths at the same time on the same day. The results are presented in the graph below.



According to the data, a strict ectotherm that acclimates at 5 meters and again at 15 meters will be exposed to how many degrees change in temperature? Provide your answer to the nearest tenth of a degree.

124. Phenylketonuria (PKU) is an inherited disease caused by an autosomal recessive allele.

If two individuals who are carriers of PKU have two children, what is the probability that neither child will have PKU? Give your answer as a fraction or decimal.

GO ON TO THE NEXT PAGE.

125. The effect of temperature on the respiration rate of heterotrophic bacteria in a shallow, slow-moving freshwater stream was investigated by performing the following experiment. The water temperature of the stream was monitored over a continuous 24-hour period (starting at time = 0 hours). The respiration rates of bacteria living in the streambed were determined at 6 hours and at 9 hours. The results are presented below.

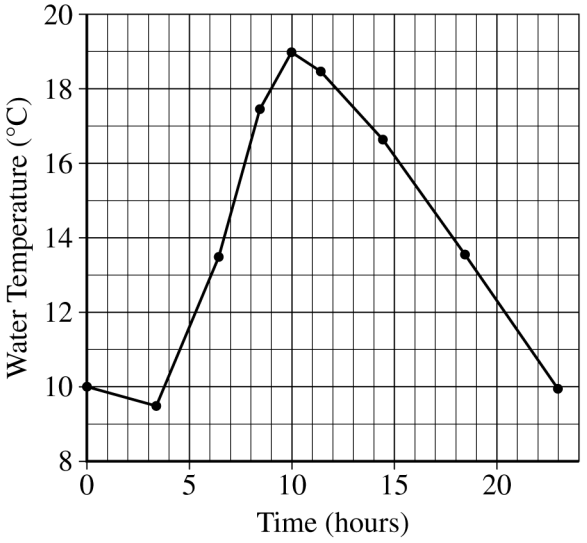


Figure 1. Water Temperature

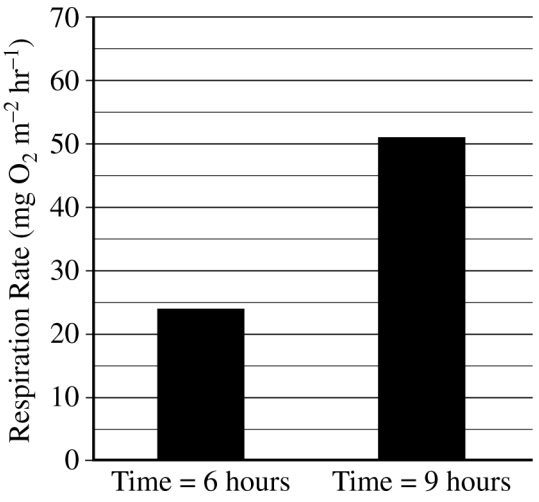


Figure 2. Respiration Rate

Based on the information provided, what was the change (in ºC) in water temperature associated with the change in respiration rate shown in Figure 2 ? Give your answer to one decimal place.

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 2015 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

2015

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.

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

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

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

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

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

$\bar{x}$ = 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.

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 Q_{10}

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

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

$$V = \ell w h$$

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

$A = \sum$ 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)

$$C_i V_i = C_f V_f$$

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)

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

BIOLOGY

Section II

8 Questions

Planning Time—10 minutes

Writing Time—80 minutes

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.

Question 1 is on the following page.

1. To determine the likelihood that a patient with a bacterial infection who is in the intensive care unit (ICU) of a hospital could be successfully treated with antibiotic therapies, researchers investigated the frequency of antibiotic resistance in bacteria isolated from patients in ICUs in the United States from 1994 to 2000. The data from the study are shown in the table, along with the overall change in the frequency of bacterial resistance in patient samples from 1994 to 2000.

INCIDENCE OF ANTIBIOTIC RESISTANCE IN PATIENTS ADMITTED TO ICUs FROM 1994 TO 2000

Antibiotic	Percent of All Samples Demonstrating Antibiotic Resistance in 2000	Overall Change in Percent Resistance to Antibiotics from 1994 to 2000
Ciprofloxacin	19	+10
Gentamicin	22	+6
Ampicillin	65	+3
Imipenem	11	+1
Tazobactam	22	0

(a) A patient was admitted to the ICU in December 2000 with an uncharacterized bacterial infection. Based on the data from the study, **identify** the following.

- The antibiotic that was most likely to be effective for treating the infection
- The antibiotic that was least likely to be effective for treating the infection

(b) Using the data, **provide justification** for the claim that antibiotic resistance may arise in bacterial species.

(c) **Describe** THREE different processes by which antibiotic resistance develops in individual bacterial cells.

(d) **Describe** TWO features of natural selection that lead to the spread of antibiotic resistance in a population over many generations. **Give ONE reason** that the development of antibiotic resistance is an example of evolution.

(e) Giving low doses of antibiotics to beef cattle to control the population sizes of intestinal bacteria can result in more efficient uptake of food materials by the cattle. **Pose** an ethical question that the Food and Drug Administration (FDA) should consider when deciding whether to approve this type of antibiotic use in beef cattle.

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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.

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PAGE FOR ANSWERING QUESTION 1

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

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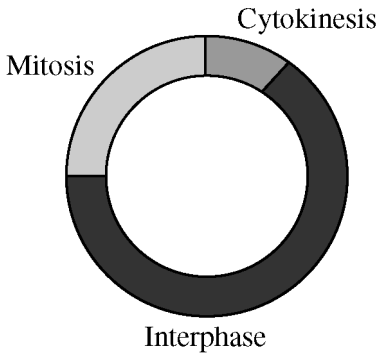
CELL CYCLE PHASES



2. Human cells divide every day for normal growth, replacement of cells, and tissue repair. The dividing cells proceed through the three phases of the cell cycle as shown in the figure. When a person experiences a cut, damaged skin cells secrete a protein called epidermal growth factor (EGF). Epidermal (skin) cells in the vicinity of the injury possess proteins in their cell membranes called epidermal growth factor receptors (EGFR)

   (a) **Identify** the THREE major stages of interphase, and **describe** the sequence in which they occur.

   (b) **Describe** the most likely role of EGF and the role of EGFR in a cell signaling pathway. **Describe** how the cellular response to EGF results in tissue repair.

   (c) Cancer can result from disruptions in cell cycle control. Mutations that increase the production of EGFR have been associated with skin cancer of the head and neck. **Describe** how a mutation outside of the coding region of a gene that encodes EGFR could lead to the overproduction of EGFR protein in a skin cell.

   (d) In cases of skin cancer that are associated with overproduction of EGFR, treatment with antibodies against the extracellular portion of EGFR has been successful. **Propose** a model to explain how the antibody therapy most likely interferes with the cell signaling pathway, and **give ONE reason** the therapy is effective for treating cancer.

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.

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PAGE FOR ANSWERING QUESTION 2

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

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DRY MASS OF CORN SEEDLINGS GROWN UNDER DIFFERENT CONDITIONS

Treatment Group	Treatment	Initial Dry Mass of 10 Plants (g)	Dry Mass of 10 Plants After One Week (g)	Change in Dry Mass of 10 Plants Over One Week (g)
I	None	14.8		
II	Light		32.8	+18
III	Dark		11.7	-3.1

3. Thirty corn seedlings of equal size were randomly assigned to one of three treatment groups. At the beginning of the experiment, the plants in group I were dried and the mass was determined. The plants in group II were maintained in light for a week. The plants in group III were maintained in the dark for a week. All conditions, other than light, were the same for groups II and III. At the end of the week, the plants in groups II and III were dried and the mass was determined. The experimental results are provided in the table.

   (a) To explain the increase in mass of the light-grown plants, **identify** ONE inorganic source of new plant mass and **connect** it to the cellular process underlying the increase in mass.

   (b) To explain the decrease in mass of the dark-grown plants, **identify** the overall chemical reaction that is occurring in the plant cells and **connect** it to the cellular process underlying the decrease in mass.

PAGE FOR ANSWERING QUESTION 3

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ADDITIONAL PAGE FOR ANSWERING QUESTION 3

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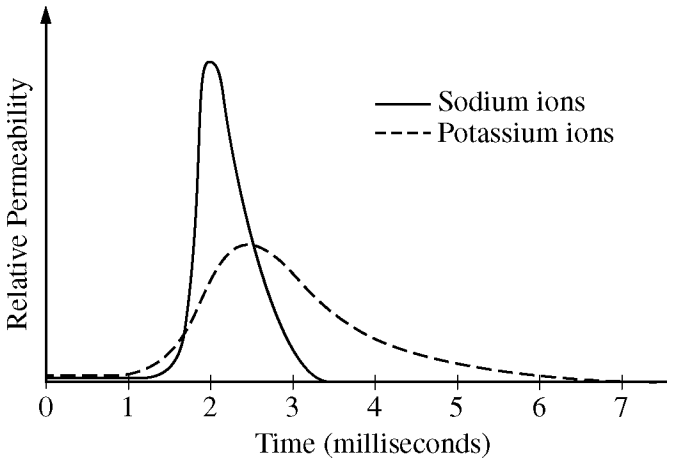

Figure 1. Membrane permeability to sodium and potassium ions during an action potential

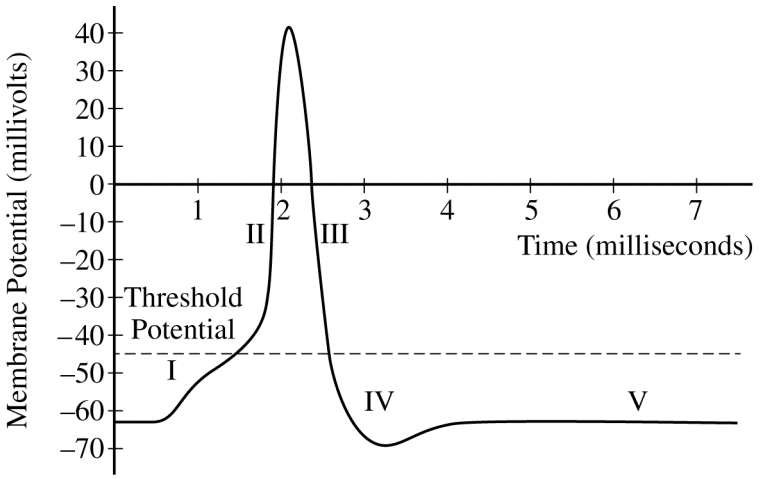

Figure 2. Membrane potential during an action potential

4. A scientist studying the effect of a stimulus on a motor neuron observed that the permeability of the plasma membrane of the neuron changes during an action potential. The curves in Figure 1 represent the changes in permeability of the membrane to sodium ions (Na^+) and potassium ions (K^+) during the action potential. The graph in Figure 2 represents the changes in membrane potential during an action potential.

   (a) **Identify** ONE difference between the Na^+ and K^+ permeability curves shown in Figure 1.

   (b) **Describe** ONE structural feature of the plasma membrane of the motor neuron that regulates the permeability of the plasma membrane to Na^+ and K^+ during an action potential.

   (c) **Connect** the relative membrane permeability data shown in Figure 1 with the changes in membrane potential during stages II and III of the action potential shown in Figure 2.

PAGE FOR ANSWERING QUESTION 4

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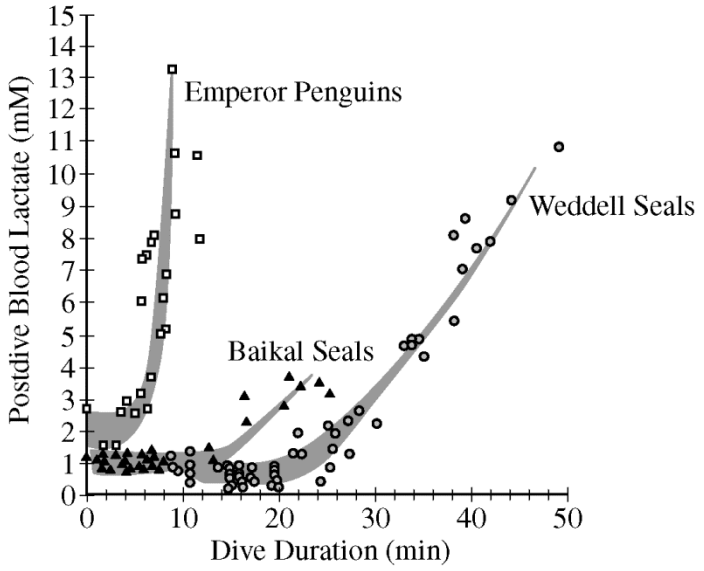

Figure 1. Blood lactate levels during underwater dives

5. Many aquatic animals can hold their breath and dive underwater for long periods of time. During long dives, lactic acid builds up in tissues of the organism. The graph above shows blood lactate levels following dives of different duration for three species. Lactate is produced when lactic acid is dissolved in the blood and becomes ionized.

   (a) Based on the data, **propose** a hypothesis to explain the change in blood lactate levels in Weddell seals for dives lasting longer than 20 minutes.

   (b) **Describe** the most likely shape of the curve if blood oxygen levels of Weddell seals were plotted rather than blood lactate levels. Include in your description the likely shape of the curve between 0 and 20 minutes and the shape of the curve after 20 minutes.

   (c) The data suggest that Baikal seals can sustain much longer dives than Emperor penguins. **Propose** a hypothesis that could explain the evolution of different dive responses in Emperor penguins and Baikal seals.

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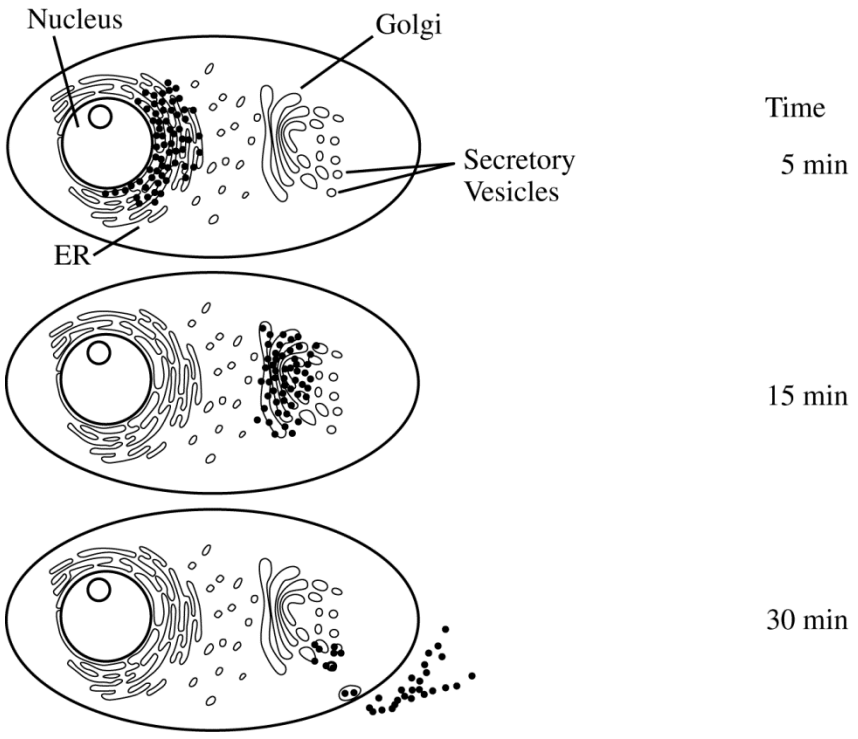

Figure 1. Radioactively labeled polypeptides

6. In an experiment investigating the mechanism of protein secretion, researchers tracked the movement of radioactively labeled polypeptides in pancreatic cells. At various times after the labeling, samples of the cells were observed using an electron microscope to determine the location of the radioactively labeled polypeptides. Figure 1 summarizes the results at 5 minutes, 15 minutes, and 30 minutes. The dark dots in the figure represent the radioactively labeled polypeptides.

   (a) Using the experimental results, **describe** the pathway that secretory proteins take from their synthesis to their release from the cell.

   (b) **Predict** what the results would be if mRNA were radioactively labeled instead of polypeptides. **Give reasoning** to support your prediction.

PAGE FOR ANSWERING QUESTION 6

ADDITIONAL PAGE FOR ANSWERING QUESTION 6

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7. In the early nineteenth century, Alexander von Humboldt observed that the distribution of plants up a mountainside mirrors the distribution of plants at increasing latitude. A number of modern studies have reinforced the idea that as the global climate warms, plant species are becoming redistributed to higher elevations or latitudes.

   However, in a separate large-scale study comparing historical (1930–1935) plant distributions with modern (2000–2005) distributions in the western United States, researchers observed that 72% of identified plant species shifted to lower elevations despite an associated increase in average temperature.

   Explain the observed shift of the plants to lower elevations by doing each of the following.

   - **Propose a hypothesis** about an environmental factor other than temperature that could be driving the shift to lower elevations.
   - **Describe** ONE piece of evidence that a researcher could use to support your hypothesis.
   - **Provide reasoning** to connect the evidence with the environmental factor you proposed.

PAGE FOR ANSWERING QUESTION 7

ADDITIONAL PAGE FOR ANSWERING QUESTION 7

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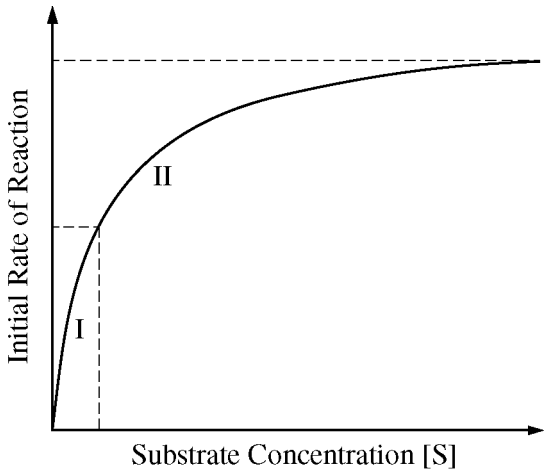

8. The graph above shows the initial rate of an enzyme-catalyzed reaction at different substrate concentrations in the presence of a constant concentration of the enzyme.

   (a) **Connect** the primary structure of the enzyme to its overall shape.

   (b) **Predict** the effect of adding a noncompetitive inhibitor to the reaction mixture on the rate of reaction at a high substrate concentration. **Support** your prediction by describing how a noncompetitive inhibitor affects the structure and function of an enzyme.

PAGE FOR ANSWERING QUESTION 8

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ADDITIONAL PAGE FOR ANSWERING QUESTION 8

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STOP

END OF EXAM

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

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 AND 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 ALL AP EXAMS YOU HAVE TAKEN THIS YEAR.**

Multiple-Choice and Grid-In Answer Key

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

Answer Key for AP Biology
Practice Exam, Section I

Question 1: B
Question 2: D
Question 3: C
Question 4: C
Question 5: A
Question 6: C
Question 7: D
Question 8: A
Question 9: B
Question 10: A
Question 11: B
Question 12: C
Question 13: B
Question 14: B
Question 15: C
Question 16: C
Question 17: B
Question 18: C
Question 19: B
Question 20: D
Question 21: D
Question 22: A
Question 23: C
Question 24: C
Question 25: B
Question 26: B
Question 27: D
Question 28: D
Question 29: *
Question 30: A
Question 31: B
Question 32: C
Question 33: A
Question 34: A
Question 35: B
Question 36: C
Question 37: A
Question 38: B
Question 39: B
Question 40: B
Question 41: B
Question 42: A
Question 43: A
Question 44: B
Question 45: C
Question 46: A
Question 47: B
Question 48: A
Question 49: C
Question 50: A
Question 51: B
Question 52: C
Question 53: A

Question 121: 40-44

Question 122: 0.12-0.17

Question 123: 13.5

Question 124: 9/16, .5625, .56, .562, .563

Question 125: 4.9-5.1

*Item 29 was not scored.

Free-Response Scoring Guidelines

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

AP® BIOLOGY
2015 SCORING GUIDELINES

Question 1

To determine the likelihood that a patient with a bacterial infection who is in the intensive care unit (ICU) of a hospital could be successfully treated with antibiotic therapies, researchers investigated the frequency of antibiotic resistance in bacteria isolated from patients in ICUs in the United States from 1994 to 2000. The data from the study are shown in the table, along with the overall change in the frequency of bacterial resistance in patient samples from 1994 to 2000.

INCIDENCE OF ANTIBIOTIC RESISTANCE IN PATIENTS ADMITTED TO ICUs FROM 1994 TO 2000

Antibiotic	Percent of All Samples Demonstrating Antibiotic Resistance in 2000	Overall Change in Percent Resistance to Antibiotics from 1994 to 2000
Ciprofloxacin	19	+10
Gentamicin	22	+6
Ampicillin	65	+3
Imipenem	11	+1
Tazobactam	22	0

(a) A patient was admitted to the ICU in December 2000 with an uncharacterized bacterial infection. Based on the data from the study **identify** the following.

- The antibiotic that was most likely to be effective for treating the infection.
- The antibiotic that was least likely to be effective for treating the infection.

Identification (2 points)

- Imipenem is the most effective
- Ampicillin is the least effective

(b) Using the data, **provide justification** for the claim that antibiotic resistance may arise in bacterial species.

Justification (1 point)

- Resistance to antibiotic(s) in the population is increasing for most of the antibiotics as shown by the overall change in percent resistance to antibiotics from 1994 to 2000.

(c) **Describe** THREE different processes by which antibiotic resistance develops in individual bacterial cells.

Description (3 points maximum)

- Random mutations lead to changes in DNA sequences
- Transformation is uptake of DNA from the environment to the bacteria
- Conjugation transfers DNA from one bacterium to another during mating
- Transduction introduces DNA to bacteria via viruses
- Horizontal gene transfer introduces new genes to the bacteria (*only if student has not earned a point for transformation, conjugation, or transduction)

Question 1 (continued)

(d) **Describe** TWO features of natural selection that lead to the spread of antibiotic resistance in a population over many generations. **Give ONE reason** that the development of antibiotic resistance is an example of evolution.

	Description (1 point per row, 2 points max)
Selective Advantage	• Variants with antibiotic resistance have higher survival rates • Variants without antibiotic resistance have lower survival rates
Reproductive Fitness	• Resistant individuals produce more offspring

Reasoning (1 point)

- Phenotypes/characteristics/traits in the population are changing over multiple generations
- Change in allele frequency in the population

(e) Giving low doses of antibiotics to beef cattle to control the population sizes of intestinal bacteria can result in more efficient uptake of food materials by the cattle. **Pose** an ethical question that the Food and Drug Administration (FDA) should consider when deciding whether to approve this type of antibiotic use in beef cattle.

Ethical question (1 point)

Question focus may include:

- Harm to humans; e.g. is it appropriate to give low doses of antibiotics to beef cattle if it causes harm to humans?
- Harm to cows; e.g. should we give low doses of antibiotics to beef cattle if it causes harm to the cows?
- Harm to society; e.g. is it okay to give low doses of antibiotics to beef cattle at the risk of spreading antibiotic resistance, and thereby making it more difficult to treat disease?
- Harm to environment; e.g. is it ethical to give low doses of antibiotic to beef cattle if the antibiotics kill environmental microorganisms, and thus disrupt ecosystem processes?

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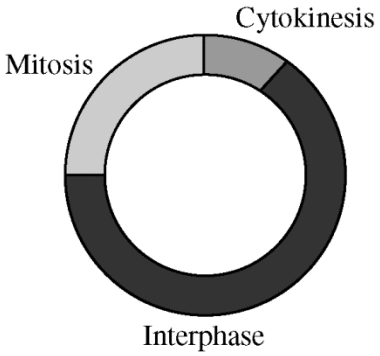
Question 2

CELL CYCLE PHASES



Human cells divide every day for normal growth, replacement of cells, and tissue repair. The dividing cells proceed through the three phases of the cell cycle as shown in the figure. When a person experiences a cut, damaged skin cells secrete a protein called epidermal growth factor (EGF). Epidermal (skin) cells in the vicinity of the injury possess proteins in their cell membranes called epidermal growth factor receptors (EGFR).

(a) **Identify** the THREE major stages of interphase, and **describe** the sequence in which they occur.

Identification (3 points maximum)

- Growth/G1
- DNA Synthesis/S
- Preparation for mitosis/G2

Description (1 point)

- Growth, DNA synthesis, preparation for mitosis/G1, S, G2

(b) **Describe** the most likely role of EGF and the role of EGFR in a cell signaling pathway. **Describe** how the cellular response to EGF results in tissue repair.

Description (3 points maximum)

- EGF is a ligand/binds to EGFR/activates the receptor
- Activated receptor (EGFR) initiates cell signaling pathway/internal signaling cascade
- Cellular response initiates cell cycle progression/cell division

Question 2 (continued)

(c) Cancer can result from disruptions in cell cycle control. Mutations that increase the production of EGFR have been associated with skin cancer of the head and neck. **Describe** how a mutation outside of the coding region of a gene that encodes EGFR could lead to the overproduction of EGFR protein in a skin cell.

Description (1 point)

- Mutation in regulatory sequence (promoter or enhancer) could increase rate of transcription of EGFR gene
- Mutation in transcription factor could increase production of mRNA, which would lead to production of more polypeptide
- Gene duplication may increase production of EGFR
- Gene translocation may inactivate repressor
- Mutation in repressor gene may remove controls on cell division
- Change in mRNA sequence may increase translation efficiency or mRNA stability

(d) In cases of skin cancer that are associated with overproduction of EGFR, treatment with antibodies against the extracellular portion of EGFR has been successful. **Propose** a model to explain how the antibody therapy most likely interferes with the cell signaling pathway, and **give ONE reason** the therapy is effective for treating cancer.

Proposed model (1 point)

- Antibody competes with/prevents ligand binding to EGFR
- Receptor activation is inhibited.

Reasoning (1 point)

- Inhibits cell cycle progression
- Blocks cell division

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Question 3

DRY MASS OF CORN SEEDLINGS GROWN UNDER DIFFERENT CONDITONS

Treatment Group	Treatment	Initial Dry Mass of 10 Plants (g)	Dry Mass of 10 Plants after One Week (g)	Change in Dry Mass of 10 Plants over One Week (g)
I	None	14.8		
II	Light		32.8	+18
III	Dark		11.7	–3.1

Thirty corn seedlings of equal size were randomly assigned to one of three treatment groups. At the beginning of the experiment, the plants in group I were dried and the mass was determined. The plants in group II were maintained in light for a week. The plants in group III were maintained in the dark for a week. All conditions, other than light, were the same for groups II and III. At the end of the week, the plants in groups II and III were dried and the mass was determined. The experimental results are provided in the table.

(a) To explain the increase in mass of the light-grown plants, **identify** ONE inorganic source of new plant mass and **connect** it to the cellular process underlying the increase in mass.

Identification (1 point)	**Connection (1 point)**
CO_2	CO_2 incorporated into carbohydrates by photosynthesis
H_2O	H_2O incorporated into carbohydrates by photosynthesis

(b) To explain the decrease in mass of the dark-grown plants, **identify** the overall chemical reaction that is occurring in the plant cells and **connect** it to the cellular process underlying the decrease in mass.

Identification (1 point)	**Connection (1 point)**
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_20$ sugar + oxygen → carbon dioxide + water	CO_2 released by cellular respiration

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2015 SCORING GUIDELINES

Question 4

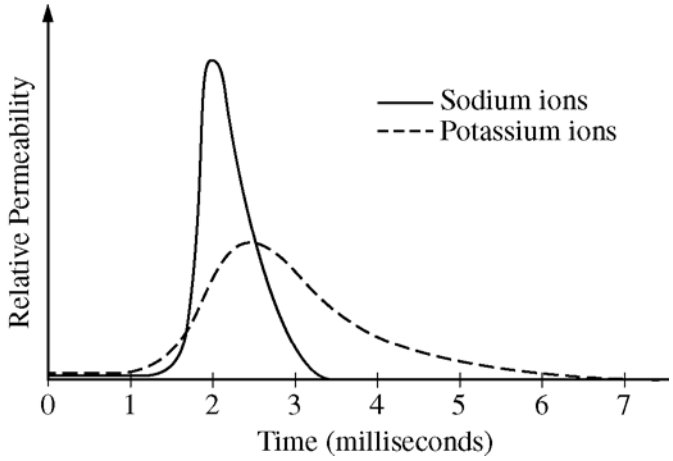

Figure 1. Membrane permeability to sodium and potassium ions during an action potential

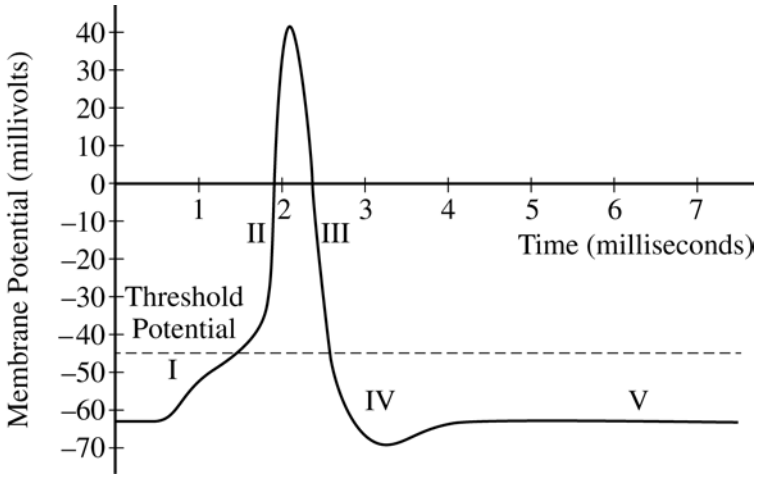

Figure 2. Membrane potential during an action potential

A scientist studying the effect of a stimulus on a motor neuron observed that the permeability of the plasma membrane of the neuron changes during an action potential. The curves in Figure 1 represent the changes in permeability of the membrane to sodium ions (Na^+) and potassium ions (K^+) during the action potential. The graph in Figure 2 represents the changes in membrane potential during an action potential.

Question 4 (continued)

(a) **Identify** ONE difference between the Na^+ and K^+ permeability curves shown in figure 1.

Identification (1 point)

- Peak membrane permeability to Na^+ precedes that of K^+
- Changes in membrane permeability to Na^+ are more rapid than those of K^+
- Changes in membrane permeability to Na^+ are of greater magnitude than those of K^+

(b) **Describe** ONE structural feature of the plasma membrane of the motor neuron that regulates the permeability of the plasma membrane to Na^+ and K^+ during an action potential.

Description (1 point)

- (Voltage-) Gated channels regulate Na^+ and K^+ movements across membranes
- Phospholipid bilayer prevents unregulated diffusion of Na^+/K^+ across membranes
- Na^+/K^+ pumps maintain membrane potential

(c) **Connect** the relative membrane permeability data shown in Figure 1 with the changes in membrane potential during stages II and III of the action potential shown in Figure 2.

Stage	Connection between permeability change and membrane potential (1 point per box; 2 points maximum)
II	• Increased permeability to Na^+ causes depolarization (cell becomes more positive)
III	• Increased permeability to K^+ causes repolarization (cell becomes more negative) • Decreased permeability to Na^+ causes repolarization (cell becomes more negative)

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Question 5

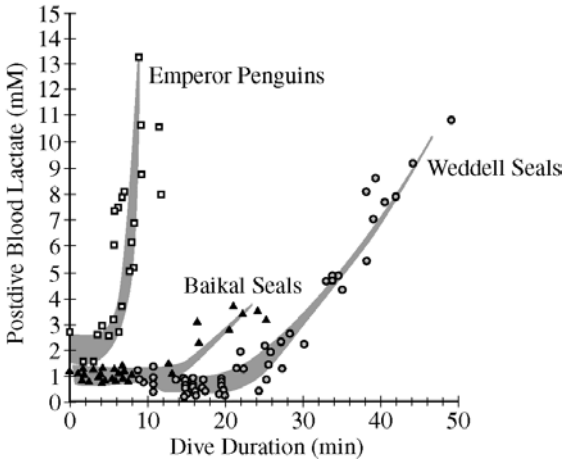

Figure 1. Blood lactate levels during underwater dives

Many aquatic animals can hold their breath and dive underwater for long periods of time. During long dives, lactic acid builds up in tissues of the organism. The graph above shows blood lactate levels following dives of different duration for three species. Lactate is produced when lactic acid is dissolved in the blood and becomes ionized.

(a) Based on the data, **propose** a hypothesis to explain the change in blood lactate levels in Weddell seals for dives lasting longer than 20 minutes.

Proposal (1 point)

- Increase in lactate levels are due to fermentation/anaerobic metabolism

(b) **Describe** the most likely shape of the curve if blood oxygen levels of Weddell seals were plotted rather than blood lactate levels. Include in your description the likely shape of the curve between 0 and 20 minutes and the shape of the curve after 20 minutes.

Description (2 points maximum; points may be earned from only one row)

0-20 min (1 point)	After 20 min (1 point)
Oxygen levels start high and decline steadily	Oxygen levels decline more slowly or remain flat
Oxygen levels start and remain high	Oxygen levels decline

(c) The data suggest that Baikal seals can sustain much longer dives than Emperor penguins. **Propose** a hypothesis that could explain the evolution of different dive responses in Emperor penguins and Baikal seals.

Proposal (1 point)

- The (genetic/heritable) capacity to sustain dives for longer periods of time provides selective/reproductive advantages (access to food/avoidance of predators) for seals but not for penguins.

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Question 6

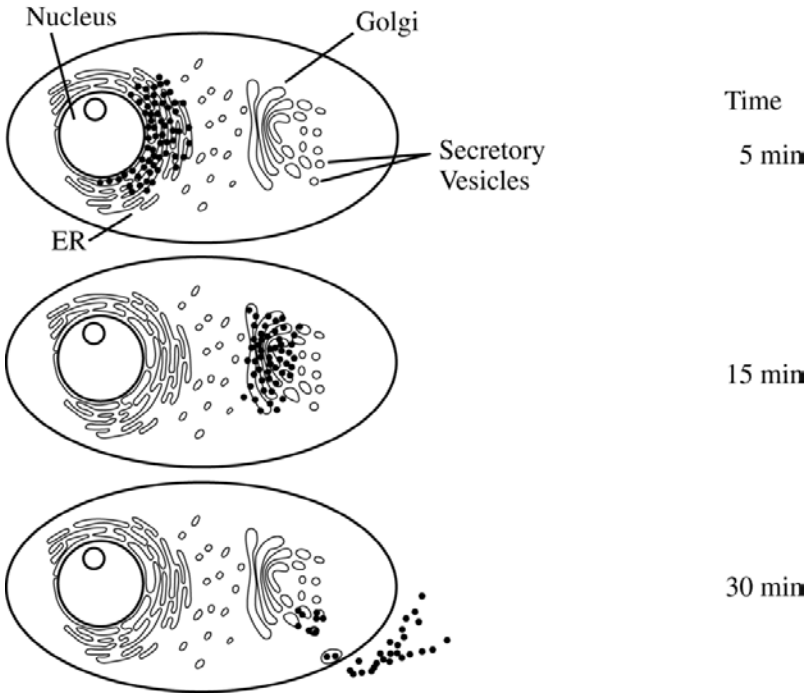

Figure 1. Radioactively labeled polypeptides

In an experiment investigating the mechanism of protein secretion, researchers tracked the movement of radioactively labeled polypeptides in pancreatic cells. At various times after the labeling, samples of the cells were observed using an electron microscope to determine the location of the radioactively labeled polypeptides. Figure 1 summarizes the results at 5 minutes, 15 minutes, and 30 minutes. The dark dots in the figure represent the radioactively labeled polypeptides.

(a) Using the experimental results, **describe** the pathway that secretory proteins take from their synthesis to their release from the cell.

Description (1 point)

(Rough) ER → (vesicle→) Golgi → Vesicle → Exocytosis/fusion with plasma membrane/outside cell

(b) **Predict** what the results would be if mRNA were radioactively labeled instead of polypeptides. **Give reasoning** to support your prediction.

Prediction (1 point)	**Reasoning (1 point)**
Labeled mRNA is in nucleus first and then moves to cytoplasm/ribosomes/ER (RER)	mRNA is transcribed in nucleus and then moves to cytoplasm for translation

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Question 7

In the early nineteenth century, Alexander von Humboldt observed that the distribution of plants up a mountainside mirrors the distribution of plants at increasing latitude. A number of modern studies have reinforced the idea that as the global climate warms, plant species are becoming redistributed to higher elevations or latitudes.

However, in a separate large-scale study comparing historical (1930–1935) plant distributions with modern (2000–2005) distributions in the western United States, researchers observed that 72% of identified plant species shifted to lower elevations despite an associated increase in average temperature.

Explain the observed shift of the plants to lower elevations by doing each of the following.

- **Propose a hypothesis** about an environmental factor other than temperature that could be driving the shift to lower elevations.
- **Describe** ONE piece of evidence that a researcher could use to support your hypothesis.
- **Provide reasoning** to connect the evidence with the environmental factor you proposed.

3 points maximum (Points may be earned from only one row)

Hypothesis (1 point)	**Evidence (1 point)** (Must be measurable and express comparison between lower and higher elevations)	**Reasoning (1 point)**
Water	Higher soil moisture/rainfall data/meteorological data at lower elevations	Low water availability at high elevation limits plant growth
CO_2	More CO_2 at low compared to high elevations	Low CO_2 levels at high elevation limit plant growth
Light (visible and/or UV)	Higher visible light at lower elevations	More photosynthesis with more visible light
	Lower UV light intensity at lower elevations	Less DNA/tissue damage with less UV light
Nutrients	More accessible nutrients in richer soil at lower elevations	Increased nutrient availability can enhance plant growth
Herbivore	More herbivores/herbivory at higher elevations	High herbivory prevents plants from migrating to higher elevations

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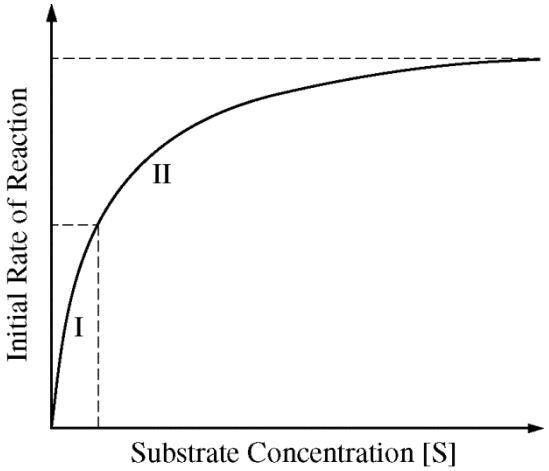
Question 8



The graph above shows the initial rate of an enzyme-catalyzed reaction at different substrate concentrations in the presence of a constant concentration of enzyme.

(a) **Connect** the primary structure of the enzyme to its overall shape.

Connection (1 point)

- The amino acid sequence determines the overall shape (of the polypeptide/protein/enzyme)
- R-groups interact and stabilize the structure

(b) **Predict** the effect of adding a noncompetitive inhibitor to the reaction mixture on the rate of reaction at a high substrate concentration. **Support** your prediction by describing how a noncompetitive inhibitor affects the structure and function of an enzyme.

Prediction (1 point)

- Noncompetitive/allosteric inhibitor will decrease the (initial) rate of reaction (at any substrate concentration)

Support (1 point)

- Inhibitor binding to site other than active site (allosteric site) changes shape of enzyme, which alters the interaction of substrate with active site

Scoring Worksheet

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

2015 AP Biology Scoring Worksheet

Section I: Multiple Choice and Grid-In

_____	× 1.0525 =	_____	
Number Correct (out of 57*)		Weighted Section I Score (Do not round)	

Section II: Free Response

Question 1	_____ (out of 10)	× 1.5000 =	_____ (Do not round)	
Question 2	_____ (out of 10)	× 1.5000 =	_____ (Do not round)	
Question 3	_____ (out of 4)	× 1.4285 =	_____ (Do not round)	
Question 4	_____ (out of 4)	× 1.4285 =	_____ (Do not round)	
Question 5	_____ (out of 4)	× 1.4285 =	_____ (Do not round)	
Question 6	_____ (out of 3)	× 1.4285 =	_____ (Do not round)	
Question 7	_____ (out of 3)	× 1.4285 =	_____ (Do not round)	
Question 8	_____ (out of 3)	× 1.4285 =	_____ (Do not round)	
		Sum =	_____ Weighted Section II Score (Do not round)	

Composite Score

_____	+	_____	=	_____
Weighted Section I Score		Weighted Section II Score		Composite Score (Round to nearest whole number)

AP Score Conversion Chart
Biology

Composite Score Range	AP Score
93-120	5
74-92	4
51-73	3
28-50	2
0-27	1

*Although 58 multiple-choice and grid-in items were administered in Section I, item 29 was not used in scoring.

AP Biology

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