The Advanced Placement Program® (AP®) Biology: Teacher Study

Section 1: An Introduction
Why We Are Changing AP Biology and Other AP Science Courses?

To Emphasize scientific inquiry and reasoning

To Respond to changes recommended by the National Research Council and the National Science Foundation

To Reduce the emphasis on broad content coverage and focus on depth of understanding

To Support teachers in their efforts to foster students’ deep understanding of science
Goals of the AP Biology Revision

Working Directly With Experts From Colleges and High Schools, the College Board Has Created a Revised AP Biology Course That:

- Reduces and defines the breadth of the required content so that teachers have more time to develop students’ deep conceptual understanding and to engage in inquiry-based lab experiences
- Allows teachers to select specific contexts for teaching key concepts in ways that are meaningful to their own strengths and preferences and to their students’ interests
- Makes knowing what will be on the AP Biology Exam completely transparent
Goals of the **AP Biology** Revision (continued)

*Working Directly With Experts From Colleges and High Schools, the College Board Has Created a Revised AP Biology Course That:*

- Supports the awarding of college credit/placement for qualifying student exam performance
- Provides students the opportunity to prepare for success in sequent college courses in biology
The New Course Was Created in Collaboration With College Faculty & AP Biology Teachers

Stacy Baker, Staten Island Academy
Spencer Benson, University of Maryland
Arnold Best, Tri-Cities HS
A. Malcolm Campbell, Davidson College
Robert Cannon, University of North Carolina
Elizabeth Carzoli, Castle Park HS
Liz Cowles, Eastern Connecticut University
Janice Earle, National Science Foundation
Kim Foglia, Division Ave HS
Michael Gaines, University of Miami
Pamela Gunter-Smith, Drew University
J.K. Haynes, Morehouse College
Doris R. Helms, Clemson University
John R. Jungck, Beloit College
Chasity Malatesta, West Salem HS
Pat Marsteller, Emory University
Sue Offner, Lexington HS
Jim Pellegrino, University of Illinois at Chicago
Jeanne Pemberton, University of Arizona
Jack Kay, Iolani HS
Sharon Radford, The Paideia School
Mark Reckase, Michigan State University
Peggy O’Neill Skinner, The Bush School
Nancy Songer, University of Michigan
Kathy Takayama, Brown University
Gordon Uno, University of Oklahoma
Brad Williamson, University of Kansas
Betty Ann Wonderly, Hockaday School
Bill Wood, University of Colorado
Julianne Zedalis, The Bishop’s School
What Has Changed?

**Current Course**

- Teachers have only a general topic outline in the AP Course Description and released exams to determine what to teach.

- Teachers feel the need to march through all textbook chapters associated with the general topics because no specific guidance was given.
What Has Changed?

**Revised Course**

- A detailed curriculum framework defines and articulates the scope of the course. Clear guidance is provided on what concepts, content and skills should be taught and will be assessed on the AP Exam.

- "Exclusion Statements" — clear indications in curriculum as to what teachers don’t have to teach.

- New emphasis on integrating inquiry and reasoning throughout the course and on quantitative skills.
The New Curriculum Framework Supports and Furthers Conceptual Knowledge

- **4 Big Ideas**
- **Enduring Understandings**
- **Essential Knowledge**
- **Science Practices: Science Inquiry & Reasoning**
- **Learning Objectives**
The process of evolution drives the diversity and unity of life.

Biological systems utilize energy and molecular building blocks to grow, reproduce, and maintain homeostasis.

Living systems retrieve, transmit, and respond to information essential to life processes.

Biological systems interact, and these interactions possess complex properties.
Building Enduring Understandings

For each of the four Big Ideas, there is a set of Enduring Understandings which incorporates core concepts that students should retain from these learning experiences.

**BIG IDEA 1**

The process of evolution drives the diversity and unity of life.

- **Enduring Understanding 1.A**: Change in the genetic makeup of a population over time is evolution.
- **Enduring Understanding 1.B**: Organisms are linked by lines of descent from common ancestry.
- **Enduring Understanding 1.C**: Life continues to evolve within a changing environment.
- **Enduring Understanding 1.D**: The origin of living systems is explained by natural processes.
Building Essential Knowledge

Each Enduring Understanding is followed by statements of the Essential Knowledge students must develop in the course.

**BIG IDEA 1**

The process of evolution drives the diversity and unity of life.

- **Enduring Understanding 1.A:** Change in the genetic makeup of a population over time is evolution.

- **Essential Knowledge 1.A.1:** Natural selection is a major mechanism of evolution.

  - **a.** According to Darwin’s Theory of Natural Selection, competition for limited resources results in differential survival. Individuals with more favorable phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations.

  - **b.** Evolutionary fitness is measured by reproductive success.

  - **c.** Genetic variation and mutation play roles in natural selection. A diverse gene pool is important for the survival of a species in a changing environment.
Emphasis on Science Practices

The science practices enable students to establish lines of evidence and use them to develop and refine testable explanations and predictions of natural phenomena.

1.0 The student can use representations and models to communicate scientific phenomena and solve scientific problems.

2.0 The student can use mathematics appropriately.

3.0 The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

4.0 Student can plan and implement data collection strategies in relation to a particular scientific question.

5.0 The student can perform data analysis and evaluation of evidence.

6.0 The student can work with scientific explanations and theories.

7.0 The student can connect and relate knowledge across various scales, concepts, and representations in and across domains.
Clearly Articulated Science Practices Underpin the Entire Course

- The student can work with scientific explanations and theories.
  - 6.1 The student can justify claims with evidence
  - 6.2 The student can construct explanations of phenomena based on evidence
  - 6.3 The student can articulate the reasons that scientific explanations and theories are refined or replaced.
  - 6.4 The student can make claims and predictions about natural phenomena based on scientific theories and models.
  - 6.5 The student can evaluate alternative scientific explanations
An Example of Integrating the Concept, Content, and the Science Practice

**Content**

**Essential Knowledge 1.B.2**
Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.

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**Science Practice 5.3**
The student connect phenomena and models across spatial and temporal scales.

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**Learning Objective (1.B.2 & 5.3)**
The student is able to evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation.
### The New Course Emphasizes Inquiry-Based and Student-Directed Labs

<table>
<thead>
<tr>
<th>Topic</th>
<th>Previously</th>
<th>Now</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Question</td>
<td>A primary question framed the lab</td>
<td>Students generate their own questions for investigation</td>
</tr>
<tr>
<td>Alignment to Big Ideas</td>
<td>Not as clearly tied to the curriculum</td>
<td>Labs are clearly tied to Big Ideas, enduring understandings, science practices, and the learning objectives</td>
</tr>
<tr>
<td>Experiments</td>
<td>Experiments were teacher-directed</td>
<td>Students design and conduct their own experiments, based on investigative questions they pose for themselves</td>
</tr>
<tr>
<td>Variables</td>
<td>Students are told which variables to investigate</td>
<td>Students choose which variables to investigate</td>
</tr>
<tr>
<td>Steps</td>
<td>Each lab provided clear steps to follow</td>
<td>Students design their own experimental procedures</td>
</tr>
<tr>
<td>Tables and Graphs</td>
<td>Tables and graphs were provided for the students to fill in</td>
<td>Students construct their own tables and graphs for presentations</td>
</tr>
<tr>
<td>Providing Conclusions</td>
<td>Students were given specific questions to answer</td>
<td>Students determine how to provide their conclusion</td>
</tr>
</tbody>
</table>
# AP Biology New Exam Design

<table>
<thead>
<tr>
<th>Section Information: Item Types &amp; Weight</th>
<th>Question Types and Distribution</th>
<th>Timing</th>
</tr>
</thead>
</table>
| Multiple Choice + Grid-ins (50% of exam weight) | 55 multiple choice  
5 grid-in questions  
(New type: mathematical manipulation/calculation. Students will write and bubble in numerated answer) | 90m               |

### Five Minutes Required Reading Time in Advance of the Free Response Section

<table>
<thead>
<tr>
<th>Free Response (50% of exam weight)</th>
<th>2 multi-part questions, 1 of which connects to the lab experience (25% of exam weight)</th>
<th>20-25 min per question</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 single-part questions (25% of exam weight)</td>
<td>3-10 min per question</td>
</tr>
</tbody>
</table>
Example of a Multiple Choice Question Integrating Concept, Content and Science Practice

Two flasks with identical medium containing nutrients and glucose are inoculated with yeast cells that are capable of both anaerobic and aerobic respiration. Culture 1 is then sealed to prevent fresh air from reaching the culture; culture 2 is loosely capped to permit air to reach the culture. Both flasks are periodically shaken.

Which of the following best predicts which culture will contain more yeast cells after one week, and most accurately justifies that prediction?

A. Culture 1, because fresh air is toxic to yeast cells and will inhibit their growth
B. Culture 1, because fermentation is a more efficient metabolic process than cellular respiration
C. Culture 2, because fresh air provides essential nitrogen nutrients to the culture
D. Culture 2, because oxidative cellular respiration is a more efficient metabolic process than fermentation
## Example of a Multiple Choice Question Integrating Concept, Content and Science Practice

<table>
<thead>
<tr>
<th>Animal</th>
<th>Jaws</th>
<th>Lungs</th>
<th>Claws Nails</th>
<th>Feathers</th>
<th>Fur/Mammary Glands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lizard</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mouse</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hagfish</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chimp</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Perch</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigeon</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Salamander</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

- **Jaws**: Presence or absence of jaws.
- **Lungs**: Presence of lungs.
- **Claws Nails**: Presence of claws or nails.
- **Feathers**: Presence of feathers.
- **Fur/Mammary Glands**: Presence of fur or mammary glands.

### Graphical Representation

- **Hagfish**: Presence of jaws and lung-like structures.
- **Perch**: Presence of lungs and claw-like structures.
- **Salamander**: Presence of lungs and claw-like structures.
- **Lizard**: Presence of jaws and claw-like structures.
- **Pigeon**: Presence of claws and feathers.
- **Chimp**: Presence of claws and feathers.
- **Mouse**: Presence of claws, feathers, and fur-like structures.

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Assume that the cladogram shows the correct ancestral relationships between the organisms listed. Which of the following describes an error in the data table?

A. Perch have swim bladders, and therefore the table should indicate the presence of lungs.

B. Salamanders should not show claws or nails in the data table.

C. Pigeons produce a nutritious milk-like substance for their young, and therefore the data table should indicate the presence of mammary glands.

D. Hagfish are the animals least like chimps, but since they are fish, the data table should indicate the presence of jaws.
Currently, all living organisms are classified into one of three domains: Bacteria, Archaea, and Eukarya.

In a sentence or two, provide two pieces of evidence that justify a common origin for the three domains.

Oxygen can diffuse into cells by passing between plasma membrane lipids.

In a sentence or two, explain why ions, such as Na\(^+\), cannot pass between membrane lipids.
The role of tRNA in the process of translation was investigated by the addition of tRNA with attached radioactive leucine to an in vitro translation system that included mRNA and ribosomes. The results are shown by the graph.

Describe in one or two sentences how this figure justifies the claim that the role of tRNA is to carry amino acids that are then transferred from the tRNA to growing polypeptide chains.
The activity rate of an enzyme was measured at various temperatures based on the amount of substrate, in micromoles, produced per square meter of reaction surface per second. The table below shows the data collected.

In two or three sentences, indicate the nature of the relationship between enzyme structure/function and environment temperature that explains the data shown in the table.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>10°C</th>
<th>25°C</th>
<th>40°C</th>
<th>85°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enzyme activity rate (μmol/m²/s)</td>
<td>0.2</td>
<td>1.0</td>
<td>3.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Grid-In Question Requiring Calculator Use

The data below demonstrate the frequency of tasters and non-tasters in an isolated population at Hardy-Weinberg equilibrium. The allele for non-tasters is recessive.

<table>
<thead>
<tr>
<th>Tasters</th>
<th>Non-tasters</th>
</tr>
</thead>
<tbody>
<tr>
<td>8235</td>
<td>4328</td>
</tr>
</tbody>
</table>

How many of the tasters in the population are heterozygous for tasting?
1. An experiment to determine the effect of sunlight on plant growth involved growing six plants, three in a sunny window and three in the shady corner of the classroom. The height of each plant was measured, and the results are shown in the chart below.

<table>
<thead>
<tr>
<th>Observation #:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant #</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Starting Height</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height on Tuesday AM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height on Wednesday PM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height on Friday AM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height on Monday AM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height on Monday PM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Light</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td>12</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>2 Light</td>
<td>4</td>
<td>8</td>
<td>18</td>
<td>19</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>3 Light</td>
<td>10</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>4 Shade</td>
<td>9</td>
<td>13</td>
<td>16</td>
<td>19</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>5 Shade</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>19</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>6 Shade</td>
<td>4</td>
<td>9</td>
<td>11</td>
<td>18</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>
Lab Free Response Question (continued)

A student’s representation of the data is shown in the graph above. When asked to draw a conclusion from the data, the student wrote, “I can conclude that whether a plant is in sun or shade makes very little difference, as the data shows that for three days the sunny plant grew the best, and for three days the shady plant grew the best, and all plants grew at the same steady rate.”

A. Describe what is wrong with the student’s graph and conclusion based on the purpose of the experiment.

B. Using the data in the table, construct a graph that shows the relationship between plant growth and exposure to sunlight.

C. Describe three potential sources of error in the design of the experiment.

D. Design an experiment to better test the hypothesis that “plants grown in the sun grow faster than plants in the shade.”
How the Curriculum Framework helps you focus and constrain breadth

- **Illustrative Examples** are suggested contexts for instructional purposes. The specific examples will not be assessed on the AP Biology exam. What is required is an understanding of the contexts/concepts that are illustrated.

- **Exclusion Statements** define the type and level of content which is excluded from the AP Biology course and exam.

- **Concept and Content Connections** indicate where an overlap, further clarification or application of concepts and content exist.
Breadth Reduction in the Curriculum Framework

1.C.1 SPECIATION Speciation and extinction have occurred throughout the Earth’s history.

A. Speciation rates can vary, especially when adaptive radiation occurs when new habitats become available.

B. Species extinction rates are rapid at times of ecological stress.

Students should be able to demonstrate understanding of the above concept by using an Illustrative example such as:

- Five major extinctions
- Human impact on ecosystems and species extinction rates

They do NOT need to know the names and dates of these extinctions.

Learning Objective (Pairing of Content + Science Practice)
Examples of Reduction of Breadth

*Campbell and Reece, Biology, 7th ed.*

Material in 20+ chapters does not need to be covered or needs much less coverage (See table below for examples of how content has been reduced)

<table>
<thead>
<tr>
<th>Type of Content Reduction</th>
<th>Examples of Chapters</th>
</tr>
</thead>
</table>
| I. Content is *prerequisite* or *eliminated* | Chapter 2: Chemical Context of Life *(Prerequisite)*  
Chapter 35: Plant Structure *(Eliminated)* |
| II. Content is substantially reduced  
*Only certain content is *required* and is specified in the AP Biology Curriculum Framework* | Chapters 40-49: Animal Form and Function *(“Organ of the Day” approach will no longer be needed.)*  
*Only *required* systems are immune, nervous, and endocrine, as specified in the AP Biology Curriculum Framework.*  
Chapters 8-10: Energy, Respiration, and Photosynthesis *(The *required* content is specified in the AP Biology Curriculum Framework)* |
| III. Content is primarily comprised of *illustrative examples* and is not *required.* | Chapters 27-34: Prokaryotes to Vertebrates *(“March of the Phyla”)* *(Content includes *illustrative examples* taught to support concepts and is not *required.*)* |
Reductions to the AP Biology Course Content Make Course Delivery Manageable

<table>
<thead>
<tr>
<th>AP Teacher</th>
<th>School Starts/Ends</th>
<th>Class Periods</th>
<th>Amount of Instructional Time Devoted to Each Big Idea</th>
</tr>
</thead>
</table>
| Julianne Zedalis            | Mid August/End of May | 50 minutes twice a week for class Two double periods for labs of 100 minutes each week | Big Idea 1: 17%  
Big Idea 2: 32%  
Big Idea 3: 31%  
Big Idea 4: 20% |
| The Bishop’s School, La Jolla, CA  
Number of AP Biology Students: 20 |                     |               |                                                       |

<table>
<thead>
<tr>
<th>AP Teacher</th>
<th>School Starts/Ends</th>
<th>Class Periods</th>
<th>Amount of Instructional Time Devoted to Each Big Idea</th>
</tr>
</thead>
</table>
| Sharon Radford              | Mid August/End of May | 50 minute classes five times per week | Big Idea 1: 17%  
Big Idea 2: 29%  
Big Idea 3: 29%  
Big Idea 4: 25% |
| The Padeia School, Atlanta, GA  
Number of AP Biology Students: 18 |                     |               |                                                       |

<table>
<thead>
<tr>
<th>AP Teacher</th>
<th>School Starts/Ends</th>
<th>Class Periods</th>
<th>Amount of Instructional Time Devoted to Each Big Idea</th>
</tr>
</thead>
</table>
| Elizabeth Carzoli           | Early September/End of June | 55 minute classes five times per week | Big Idea 1: 17%  
Big Idea 2: 31%  
Big Idea 3: 27%  
Big Idea 4: 25% |
| Castle Park High School, Chula Vista, CA  
Number of AP Biology Students: 27 |                     |               |                                                       |
Preparing for the New Course

- Visit apcentral.collegeboard.com->AP in 2011-2012 and Beyond for:
  - A free download of the AP Biology Curriculum Framework
  - Ongoing updates about the upcoming course and exam changes
  - Answers to any questions that you may have
  - Information about the new labs and other resources to support AP Biology.
Preparing for the New Course

- Professional development opportunities will help you transition your current content and activities to the new course
  - In spring 2011, online tutorials will be available
  - The 2011 AP Summer Institute will focus on the new labs

- The new lab manual will provide strategies for making your own labs inquiry based

- AP will share teacher-created pacing guides showing examples of how to teach the new course within an academic year and allocate instructional time to meet all of the learning objectives
Thank you!

On behalf of the Advanced Placement Program, thank you very much for your time to learn more about the upcoming changes to AP Biology.

We look forward to partnering with you as you build students’ success in biology in your classroom and for the future!