



**Texas Higher Education Coordinating Board**

***Making Opportunity Affordable in Texas:  
A Student-Centered Approach***



**Tuning of Biology**

**Texas Higher Education Coordinating Board**

**Austin, Texas**

***with grant support from***

**Lumina Foundation for Education**

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# Tuning Oversight Council for Engineering and Science

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## **Definition of Tuning**

“Tuning” is a faculty-led pilot project designed to define what students must know, understand, and be able to demonstrate after completing a degree in a specific field, and to provide an indication of the knowledge, skills, and abilities students should achieve prior to graduation at different levels along the educational pipeline – in other words, a body of knowledge and skills for an academic discipline in terms of outcomes and levels of achievement of its graduates.

Tuning provides an expected level of competency achievement at each step along the process of becoming a professional: expectations at the beginning of pre-professional study, at the beginning of professional study, and at the transition to practice. It involves seeking input from students, recent graduates, and employers to establish criterion-referenced learning outcomes and competencies by degree level and subject area. Through Tuning, students have a clear “picture” of what is expected and can efficiently plan their educational experience to achieve those expectations. The objective is not to standardize programs offered by different institutions, but to better establish the quality and relevance of degrees in various academic disciplines.

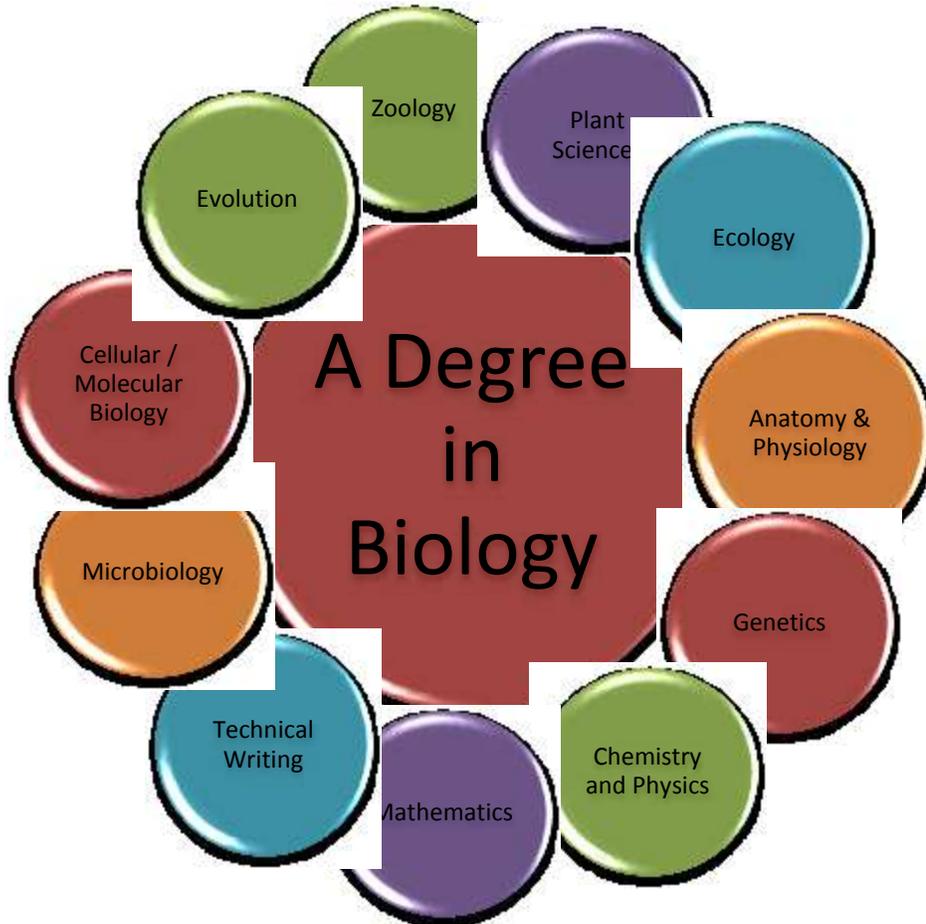
An overview of Lumina Foundation for Education’s “Tuning USA” Initiative is available at: [http://www.luminafoundation.org/goal\\_2025.html](http://www.luminafoundation.org/goal_2025.html); an overview of Tuning work to date in Texas is available at: <http://www.thecb.state.tx.us/tuningtexas>.

## **Definition of Biology**

Biology is the study of living organisms, living systems, and life processes.

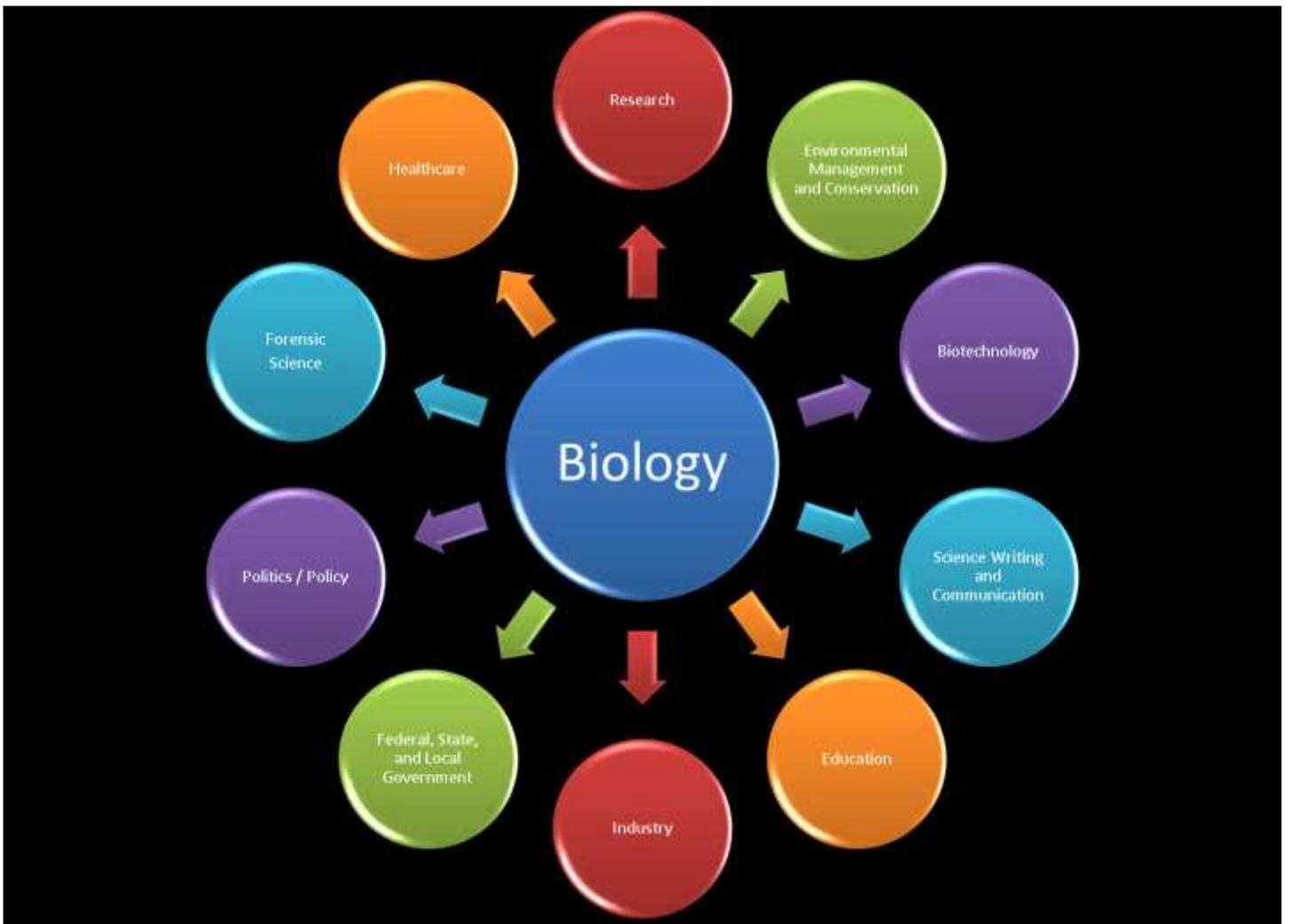
## Biology Expertise Profile

The expertise profile lists types of course topics included in typical baccalaureate degrees in biology. Note: General undergraduate degree requirements (e.g., the core curriculum) are not considered for the purpose of tuning biology and this report.



## Biology Employment Profile

The employment profile lists employment opportunities available to Biology graduates.



## **Biology Key Competency Tables and Learning Outcome Descriptions**

The Biology competency table has 11 learning outcome titles, one for each learning outcome description:

1. Evolution
2. Structure/Function
3. Information Flow
4. Transformation of Energy and Matter
5. Systems Biology
6. Physical Sciences
7. Mathematics
8. Experimentation/Problem Solving
9. Laboratory Skills
10. Communication
11. Science and Society

The competency table has four learning outcome categories (columns from left to right):

1. core competencies needed to enter higher education in biology (HS),
2. competencies gained during first two years of biology study (CC),
3. baccalaureate-level biology competencies (BS), and,
4. graduate-level biology competencies (G)

Learning outcome descriptions for each of the outcome titles of the competency table explain the knowledge, skills, and attitudes that should be achieved by the graduates.

## Biology Key Competencies Profile

Lumina Foundation Grant Biology Committee

Evaluation	<b>G</b>	<b>G</b>	<b>G</b>		<b>G</b>			<b>G</b>	<b>G</b>	<b>G</b>	<b>G</b>
Synthesis	<b>G</b>	<b>G</b>	<b>BS</b>	<b>G</b>	<b>G</b>			<b>BS</b>	<b>BS</b>	<b>BS</b>	<b>BS</b>
Analysis	<b>BS</b>	<b>BS</b>	<b>BS</b>	<b>G</b>	<b>BS</b>	<b>G</b>	<b>G</b>	<b>BS</b>	<b>BS</b>	<b>BS</b>	<b>BS</b>
Application	<b>BS</b>	<b>BS</b>	<b>BS</b>	<b>BS</b>	<b>CC</b>	<b>BS</b>	<b>BS</b>	<b>CC</b>	<b>CC</b>	<b>CC</b>	<b>CC</b>
Comprehension	<b>CC</b>	<b>CC</b>	<b>CC</b>	<b>CC</b>	<b>HS</b>	<b>CC</b>	<b>CC</b>	<b>CC</b>	<b>CC</b>	<b>HS</b>	<b>CC</b>
Knowledge	<b>HS</b>	<b>HS</b>	<b>HS</b>	<b>HS</b>	<b>HS</b>	<b>HS</b>	<b>HS</b>	<b>HS</b>	<b>HS</b>	<b>HS</b>	<b>HS</b>
	Evolution	Structure/Function	Information Flow	Transformations of Energy and Matter	Systems Biology	Physical Sciences	Mathematics	Experimentation/ Problem Solving	Laboratory Skills	Communication	Science and Society

<b>G</b>	<b>graduate-level competencies</b>
<b>BS</b>	<b>baccalaureate-level competencies</b>
<b>CC</b>	<b>biology fundamental competencies</b>
<b>HS</b>	<b>secondary education competencies</b>

## Evolution:

Evolution, in a broad sense, is the origin of entities possessing different states of one or more characteristics and changes in the proportions of those entities over time. Organic or biological evolution is a change over time in the proportions of individual organisms differing genetically in one or more traits. Such changes transpire by the origin and subsequent alteration of the frequencies of genotypes from generation to generation within populations, by alteration of the proportions of genetically differentiated populations within a species, or by changes in the numbers of species with different characteristics, thereby altering the frequency of one or more traits within a higher taxonomy.

The biology graduate must know the primary modes of speciation (e.g., allopatric, parapatric, and sympatric) as well as the differences and similarities of micro- and macroevolution. An understanding of these are accomplished by foundational knowledge of the mechanisms of evolution (natural selection, mutation, gene flow, and genetic drift; describing processes, differences, and examples), and evidence of evolution (e.g., extinction) as well as how this evidence is used to suggest evolutionary relationships. All skills will enable the biology graduate to interpret evolutionary data and relate evolutionary concepts to their own graduate school and/or job-related research.

EVOLUTION			
Core Competencies Needed to enter Higher Education in Biology	Competencies gained during first two years of Biology study	Baccalaureate-Level Biology Competencies	Post-Graduate/ Work Experience Biology Competencies
Knowledge	Comprehension	Application/Analysis	Synthesis/Evaluation
Know multiple categories of evidence for evolutionary change and how this evidence is used to infer evolutionary relationships among organisms.	Describe processes, differences, and examples of evolutionary mechanisms.	Compare and contrast microevolution with macroevolution, and understand the primary modes of speciation.	Critique published evolutionary research, interpret evolutionary data, and relate evolutionary concepts to their work.

## Structure/Function:

Cells are the basic structural unit of all living organisms and the smallest structures that have all of the properties of life. An understanding of biology requires an understanding of how cells carry out essential properties of life. Biologists must be able to describe major features that distinguish prokaryotes and eukaryotes; structures and functions of membranes and sub-cellular structures; and major features of cell cycles and cell reproduction.

A biology graduate understands how structures that compose cells permit specialization of cells, enable cells to carry out the properties of life, and allow for the continuity of life.

STRUCTURE/FUNCTION			
Core Competencies Needed to enter Higher Education in Biology	Competencies gained during first two years of Biology study	Baccalaureate-Level Biology Competencies	Post-Graduate/Work Experience Biology Competencies
Knowledge	Comprehension	Application/Analysis	Synthesis/Evaluation
Define the major structures of cells and describe how the structures allow the cells to carry out the basic properties of life.	Explain how components of cells interact so that cells can differentiate and carry out the properties of life.	Demonstrate and analyze the functions of cells individually and within context of tissues, organs, and organisms.	Explain and evaluate the structures of cells to ascertain their functions within the context of tissues, organs, and organisms.

## Information Flow:

Understanding information flow, the central dogma of molecular biology, is important for a biology student. Information flow includes the study of the molecules that store genetic information, how these molecules are replicated, and how the information flows from deoxyribonucleic acid (DNA) to ribonucleic acid (RNA) to protein. To gain knowledge in information flow, the student must differentiate between DNA and ribonucleic acid RNA and the information that they carry. They should understand the process through which DNA is copied (DNA Replication), the use of a DNA template to create an RNA molecule (Transcription), and the synthesis of a polypeptide using the information stored in a messenger RNA (Translation). Biologists must understand that regulation occurs at each level of gene expression, and that gene regulation is crucial since it determines cell differentiation, morphogenesis, and adaptability for an organism. It is necessary for a biologist to relate this knowledge to biotechnology and biomedical engineering (stem cells, cloning, etc.).

<b>INFORMATION FLOW</b>			
<b>Core Competencies Needed to enter Higher Education in Biology</b>	<b>Competencies gained during first two years of Biology study</b>	<b>Baccalaureate-Level Biology Competencies</b>	<b>Post-Graduate/Work Experience Biology Competencies</b>
<b>Knowledge</b>	<b>Comprehension and Application</b>	<b>Analysis/Synthesis</b>	<b>Evaluation</b>
Describe the molecular structure of DNA and RNA, DNA Replication, and Protein Synthesis.	Demonstrate and explain the structure and function of biological molecules, and generalize basic processes of gene expression.	Compare and contrast molecular structure of DNA, RNA, and proteins. Integrate the mechanisms of gene expression and genomic signaling processing to various techniques and tools.	Justify mechanisms of gene signaling and regulation, relating those mechanisms to biotechnology and scientific advancements.

## Transformation of Energy and Matter:

Processes involving Transformations of Energy and Matter are fundamental to life. Biology students should be well versed in mechanisms by which living organisms transform energy and matter from one form to another, including the roles of gradients, enzymes, energy pyramids, and trophic levels. They should also be able to explain how these processes are regulated (e.g., negative feed-back) and how perturbations of these mechanisms affect the rate of transformations and impact the viability of the organism.

<b>TRANSFORMATION OF ENERGY AND MATTER</b>			
<b>Core Competencies Needed to enter Higher Education in Biology</b>	<b>Competencies gained during first two years of Biology study</b>	<b>Baccalaureate-Level Biology Competencies</b>	<b>Post-Graduate/Work Experience Biology Competencies</b>
<b>Knowledge</b>	<b>Comprehension</b>	<b>Application</b>	<b>Analysis/Synthesis</b>
Describe the interdependence of organisms to one another and the flow of energy and matter within an ecosystem.	Explain the events that make up the processes of energy transformation reactions in general terms.	Predict the outcome of perturbations of the events of energy transformation reactions under a set of given circumstances.	Design an experiment and/or analyze results of experiments involving energy transformation reactions or flow of energy and matter within an ecosystem.

## Systems Biology:

Life exists at several interactive and interdependent levels of organization. Systems biology is the quantitative analysis of the interactions between components within and between biological levels, with the aim of constructing predictive models of the dynamic behavior of biological systems. The systems strategy begins with traditional reductionist biology: the identification of the components of a biological system. Systems biologists then determine the specific relationships between each component within that system. Finally, the network of interactions within a biological system can be mapped and visualized using mathematical models and computer software, and possible outcomes of disturbances of component interactions on a biological system can be predicted. Through such analysis, systems biologists seek to relate the outcomes of component interactions at one biological level to the emerging properties at higher biological levels.

The biology graduate is able to predict possible outcomes of disturbances in one system level at higher biological levels. The systems biology required for biology practice must be learned at the undergraduate level and should prepare students for subsequent courses in biology and biology practice.

SYSTEMS BIOLOGY			
Core Competencies Needed to enter Higher Education in Biology	Competencies gained during first two years of Biology study	Baccalaureate-Level Biology Competencies	Post-Graduate/Work Experience Biology Competencies
Knowledge/Comprehension	Application	Analysis	Synthesis/Evaluation
Identify and explain basic strategies and key concepts of systems biology.	Apply the strategies of systems biology and interpret the results of basic systems models.	Infer possible outcomes of disturbances in one system level at higher biological levels.	Develop and justify predictive models to examine complex biological problems.

## Physical Sciences:

A biology graduate must acquire a broad education within the physical sciences to support their understanding of biology. Depending on the student's area of focus, some of the physical sciences may include but are not limited to: physics, chemistry, earth science, and environmental science. Concepts in physics involve: basic understanding of matter, forces, thermodynamics, electromagnetism, and optics. Concepts in chemistry involve: matter and its properties, atomic structure, the periodic table, chemical bonding and reactions, thermochemistry, properties and behavior of gases and liquids and solids, and basic structure and function of biological molecules (proteins, carbohydrates, lipids, and nucleic acids). Concepts in earth and space sciences involve: understanding earth systems; sun, earth, and moon system; solar system; origin and structure of universe; plate tectonics; and energy transfer within and among systems. Concepts in environmental science include: understanding earth systems, energy, populations, economics and politics, and human practices and their impacts. A biologist should apply these concepts to biological problem solving.

PHYSICAL SCIENCES			
Core Competencies Needed to enter Higher Education in Biology	Competencies gained during first two years of Biology study	Baccalaureate-Level Biology Competencies	Post-Graduate/Work Experience Biology Competencies
Knowledge	Comprehension	Application	Analysis
Describe key concepts of physical sciences: physics, chemistry, earth science, and environmental sciences. Solve basic problems for each concept.	Explain key concepts of basic physics, chemistry, earth science, and environmental sciences. Apply knowledge to solve basic biological problems.	Use and summarize concepts of physical science related to their field of study.	Analyze key concepts of physical sciences: physics, chemistry, earth science, and environmental sciences. Debate proposed solutions to problems for each concept.

## Mathematics:

Mathematics is often called the language of science. Competency in mathematics provides a foundation for evaluating scientific concepts. Mathematics is fundamental to mastering physical sciences that support biology and used to analyze and describe experimental data.

The biology graduate uses basic algebraic expressions and mathematical approaches to solve problems. The graduate applies statistical analysis to data and selecting appropriate mathematical strategies to analyze such data in post-graduate or work environments.

<b>MATHEMATICS</b>			
<b>Core Competencies Needed to enter Higher Education in Biology</b>	<b>Competencies gained during first two years of Biology study</b>	<b>Baccalaureate-Level Biology Competencies</b>	<b>Post-Graduate/Work Experience Biology Competencies</b>
<b>Knowledge</b>	<b>Comprehension</b>	<b>Application</b>	<b>Analysis</b>
Solve, describe, and simplify algebraic expressions and equations. Read and interpret descriptive statistical output.	Explain, compute, and interpret descriptive and inferential statistical output.	Apply mathematical reasoning to solve problems. Generate and interpret statistical output.	Select the appropriate mathematical techniques to analyze biological problems.

## Experimentation/Problem Solving:

Problem solving and the use of experimental methods to study the living world is a cornerstone of the biological sciences. Biologists must be able to synthesize their content knowledge, laboratory skills, and mathematical analysis in order to identify biological problems to study and in order to determine the appropriate methods to apply.

The biology graduate uses a comprehensive base of and technical laboratory skills to develop, test, and evaluate hypotheses in regard to biological problems.

<b>EXPERIMENTATION/PROBLEM SOLVING</b>			
<b>Core Competencies Needed to enter Higher Education in Biology</b>	<b>Competencies gained during first two years of Biology study</b>	<b>Baccalaureate-Level Biology Competencies</b>	<b>Post-Graduate/Work Experience Biology Competencies</b>
<b>Knowledge</b>	<b>Comprehension/ Application</b>	<b>Analysis/Synthesis</b>	<b>Evaluation</b>
Interpret and outline key components of problem detection, configuration, and problem solving, including identification of a hypothesis/null hypothesis, related to biological applications.	Apply scientific reasoning as a primary form of problem solving, compose a working hypothesis, distinguish between independent and dependent variables, and analyze basic biological concepts within problems.	Design and conduct experiments using appropriate methodology, and analyze data to test working hypotheses.	Appraise and/or defend proposed solutions to advanced biological problems.

## Laboratory Skills:

Biology is a hands-on science, in which observation, collection, and interpretation of the data is critical in order to answer a problem. Students must be proficient in certain laboratory skills in order to conduct investigations. There are basic laboratory techniques that all biologists must know and other skills are “selective” to a certain field of biology.

All biology graduates must know how to maintain a safe laboratory environment, demonstrate an understanding of standard operation procedures, and be knowledgeable in the use of equipment and instrumentation. Biology graduates that specialize in specific areas must be knowledgeable in the proper techniques for that area.

LABORATORY SKILLS			
Core Competencies Needed to enter Higher Education in Biology	Competencies gained during first two years of Biology study	Baccalaureate-Level Biology Competencies	Post-Graduate/Work Experience Biology Competencies
Knowledge	Comprehension/ Application	Analysis/ Synthesis	Evaluation
Understand basic laboratory safety rules and precautions. Describe the proper use of basic biology equipment and protocols, and data presentation.	Demonstrate the proper use and care of research equipment. Collect data following proper laboratory protocols. Troubleshoot experimental failures.	Demonstrate the use of advanced research equipment, and proper techniques utilized within specific research areas. Collect data following proper laboratory protocols and analyze results. Troubleshoot and perform quality checks of equipment.	Design experiments utilizing advanced laboratory skills appropriate for a research-specific discipline. Evaluate research-specific methodologies. Collect data, analyze and evaluate the results. Demonstrate effective time management. Acquire, allocate, and utilize resources efficiently.

## Communication:

Biology students must master written communication skills to effectively produce funding proposals, experimental data, and scientific articles, and demonstrate the visual communication skills to generate graphs, images, and videos that are necessary for conveying scientific information. Communication skills also involve the ability to communicate in an oral format, such as for meetings and conferences. The biology graduate must possess clear and effective written, visual, and oral communication skills.

<b>COMMUNICATION</b>			
<b>Core Competencies Needed to enter Higher Education in Biology</b>	<b>Competencies gained during first two years of Biology study</b>	<b>Baccalaureate-Level Biology Competencies</b>	<b>Post-Graduate/Work Experience Biology Competencies</b>
<b>Knowledge/Comprehension</b>	<b>Application</b>	<b>Analysis/Synthesis</b>	<b>Evaluation</b>
Understand the proper use of punctuation and grammar in oral, written, and visual presentations. Demonstrate a basic understanding of commonly used scientific terms.	Properly cite scientific sources; apply the proper use of punctuation and grammar in oral, written, and visual presentations. Apply commonly used technical and scientific terms. Restate biological concepts in own words.	Create and deliver effective oral presentations. Define and explain commonly used technical and scientific terms. Produce written material using appropriate technical styles. Read technical and scientific articles.	Evaluate scientific information and convey in a manner appropriate to audience. Effectively present material at conferences and by way of scientific journals. Organize and convey instructions leading to obtaining research goals.

## Science and Society:

To appreciate the interaction of science (biology), technology, and society, it is essential that students recognize these important connections. It is crucial that the distinction between science and technology be clearly seen and the impact of applying technology to the sciences be easily seen. Next, the interplay of societal issues and biology (sciences) are a critical part of this large area. Lastly, the history of science provides both a view of how science is done and how knowledge in science grows. At first, it may be just identifying potential issues and key figures in biology. As this knowledge grows, then an understanding of influences and a true distinction between science and technology can be developed. At increasingly higher levels, the student begins to access, analyze, and devise solutions for these societal scientifically based problems.

SCIENCE AND SOCIETY			
Core Competencies Needed to enter Higher Education in Biology	Competencies gained during first two years of Biology study	Baccalaureate-Level Biology Competencies	Post-Graduate/Work Experience Biology Competencies
Knowledge	Comprehension/ Application	Analysis/ Synthesis	Evaluation
Identify an example of the impact of technology, a controversial issue, and an historical figure in the biological sciences.	Describe how technology impacts biology. Relate biology as a social enterprise and identify the impact of humans on all other organisms. Identify the ways of knowing in biology such as empirical requirements, logical arguments, and the requirement of evidence.	Experiment with different proposed solutions. Analyze solutions to complicated interactions between biology and society. Compare and contrast the impact of individuals on key advances in biology. Interpret proposed empirical data and reasoning patterns involved in biological research.	Formulate designs, applicability, and tests for technological applications in biology. Compose proposals for funding for biological research. Evaluate the impact of societal decisions on the health and well-being of humans and other organisms. Formulate scientific explanations based on empirical measures, logical arguments, and a standard of intellectual questioning.

## Community College Program of Study for Transfer to a Biology Program

### FRESHMAN YEAR

#### First Semester (Fall)

	Course	SCH
	1306 or Biology for Science Majors I or	
BIOL	1311 General Botany <sup>1</sup>	3
	1106 or Biology for Science Majors Laboratory I	
BIOL	1111 or General Botany Laboratory <sup>1</sup>	1
CHEM	1311 General Chemistry I	3
CHEM	1111 General Chemistry I Laboratory	1
MATH	#### Mathematics Option <sup>3</sup>	3-5
XXXX	#### Texas Core Curriculum Requirement	3
<b>Semester Credit Hours</b>		<b>14-16</b>

#### Second Semester (Spring)

	Course	SCH
	1307 or Biology for Science Majors II or	
BIOL	1313 General Zoology <sup>1</sup>	3
	1107 or Biology for Science Majors Laboratory II	
BIOL	1113 or General Zoology Laboratory <sup>1</sup>	1
CHEM	1312 General Chemistry II	3
CHEM	1112 General Chemistry II Laboratory	1
	Mathematics Option <sup>3</sup> or Texas Core	
MATH	#### Requirement (if math complete)	3
XXXX	#### Texas Core Curriculum Requirement	3
<b>Semester Credit Hours</b>		<b>14</b>

### SOPHOMORE YEAR

#### First Semester (Fall)

	Course	SCH
BIOL	#### Biology Sophomore option <sup>2</sup>	3
BIOL	#### Biology Sophomore Laboratory option <sup>2</sup>	1
CHEM	2323 Organic Chemistry I	3
CHEM	2123 Organic Chemistry Laboratory I	1
	Mathematics Option <sup>3</sup> or Texas Core	
MATH	#### Requirement (if math complete)	3
XXXX	#### Texas Core Curriculum Requirement	3
<b>Semester Credit Hours</b>		<b>14</b>

#### Second Semester (Spring)

	Course	SCH
BIOL	#### Biology Sophomore option <sup>2</sup>	3
BIOL	#### Biology Sophomore Laboratory option <sup>2</sup>	1
CHEM	2325 Organic Chemistry II	3
CHEM	2125 Organic Chemistry Laboratory II	1
PHYS	1301 College Physics I	3
PHYS	1101 College Physics Laboratory I	1
XXXX	#### Texas Core Curriculum Requirement	3
<b>Semester Credit Hours</b>		<b>15</b>

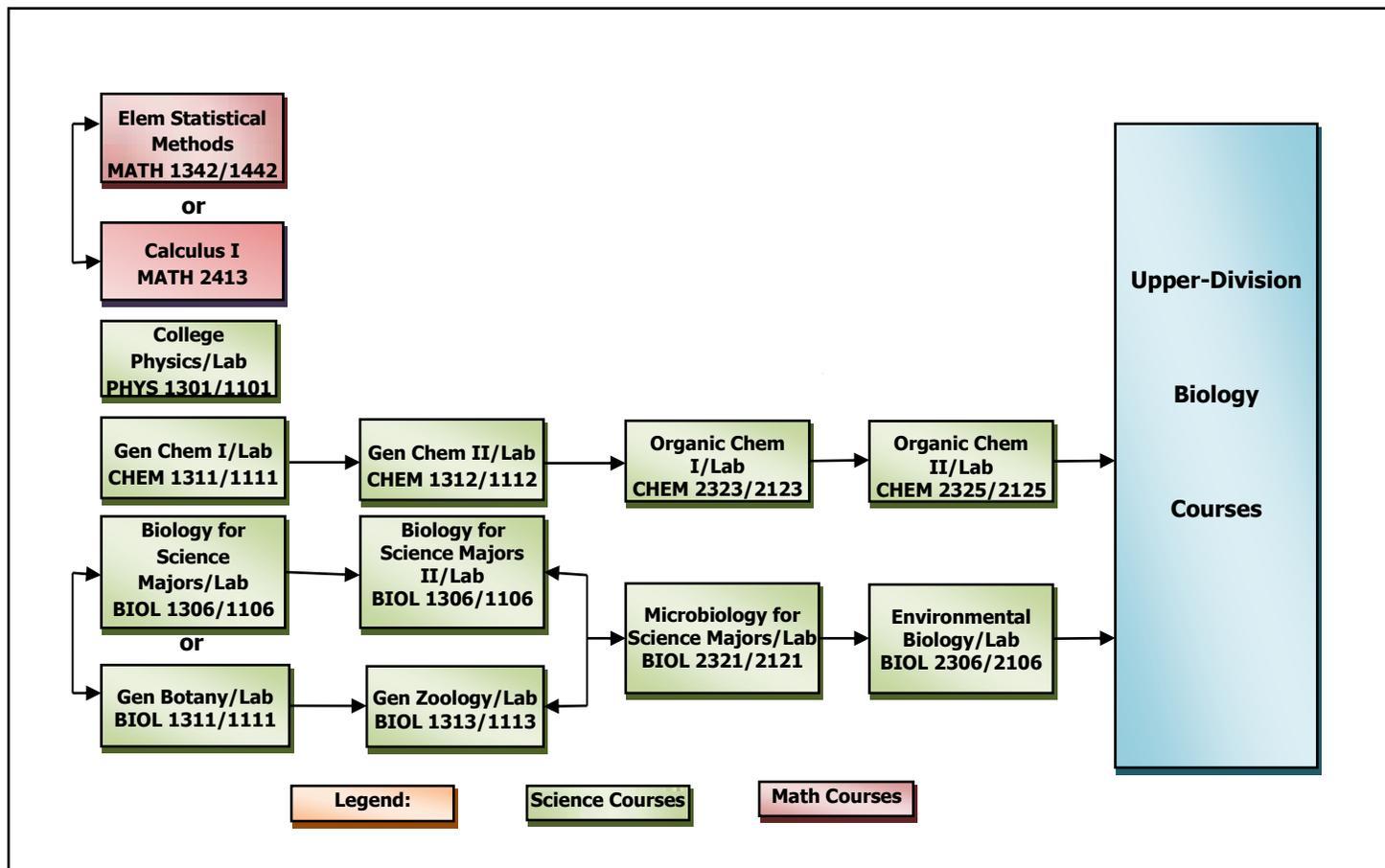
#### NOTES:

<sup>1</sup>Students must complete either the BIOL 1306/1106 and 1307/1107 sequence or the BIOL 1311/1111 and 1313/1113 sequences. Courses from these sequences may not be combined.

<sup>2</sup>Sophomore courses chosen from: BIOL 2306/2106 and BIOL 2321/2121

<sup>3</sup>Begin mathematics coursework according to placement by initial institution. Maintain continuous enrollment until final mathematics level is achieved. Complete through MATH 1342 or 1442 or 2342 or 2442 Elementary Statistical Methods, or MATH 2313 or 2413 or 2513 Calculus I as determined by four-year degree program. The student is advised to check with the school to which he or she intends to transfer for specific requirements and applicability of the mathematics course to the biology major at that institution.

### Community College Prerequisite Flowchart for Biology



## Resources

American Association for the Advancement of Science. (2011). *Vision and Change in Undergraduate Biology Education: A Call to Action*. Washington D.C.

Futuyma, D. J. (2009). *Evolution* (2<sup>nd</sup> Edition). Sinauer Associates, Inc. Sunderland, MA.

Texas Essential Knowledge and Skills for Science, High School, Subchapter C., Section 112.34, Biology

Texas Higher Education Coordinating Board and Texas Education Agency. (2009). *Texas College and Career Readiness Standards*. Retrieved from <http://www.thecb.state.tx.us/files/dmfile/CCRS081009FINALUTRevisions.pdf>

Texas Higher Education Coordinating Board and Texas Education Agency, (2012) *Lower-Division Academic Course Guide Manual*. Retrieved from <http://www.thecb.state.tx.us/AAR/UndergraduateEd/WorkforceEd/acgm>

