Current Pennsylvania Statewide Program-to-Program Articulation Agreements includes language that will be a barrier to student transfer from a Pennsylvania Community College to other TAOC partner institutions. Specifically, language in the Biology Agreement, and Chemistry Agreement (Approved by TAOC on June 16, 2011 Amended April 11, 2012) state that ***"All laboratories are required to be taught hands-on, with physical (not virtual) equipment in a laboratory setting."***

In light of the current public health emergency with COVID-19, and the necessity of online or remote instruction, this requirement could be a barrier for community college students seeking to transfer under the provisions of Pennsylvania's statewide articulation agreements.

Therefore, the Pennsylvania Commission for Community Colleges and the Office of the Chancellor of the State System of Higher Education recommend TAOC adopt the following waiver language:

"The requirement for laboratories to be taught hands-on, with physical (not virtual) equipment in a laboratory setting is waived beginning with the Spring 2020 semester through the end of the academic year concurrent with the end of the proclamation of disaster emergency related to COVID-19 issued by the Governor of Pennsylvania on March 6, 2020 and renewed on June 3, 2020."

Pennsylvania Department of Education
Transfer and Articulation Oversight Committee
Approved by TAOC on June 16, 2011
Amended April 11, 2012

PENNSYLVANIA STATEWIDE PROGRAM-TO-PROGRAM ARTICULATION AGREEMENT IN BIOLOGY

Overview

In accordance with Act 50 of 2009, institutions participating in Pennsylvania's statewide college credit transfer system agree to the following policies governing the transfer of credits from a participating associate-degree granting institution into a participating four-year college or university. This agreement specifically ensures that a student who successfully completes an Associate of Arts (AA) or Associate of Science (AS) degree in Biology or any AA or AS degree that incorporates the required competencies at a participating institution can transfer the full degree into a parallel bachelor degree program in Biology at a participating four-year institution.

In order for students to transfer the full associate degree into a parallel bachelor degree program at a participating four-year institution, all of the following criteria must be met:

- Successful completion of at least 30 credits of foundation courses from the Transfer Credit Framework.
- Successful completion of an associate's degree that includes at least 60 credits **and** all of the required major-specific content area competencies identified in this Agreement.
- Successful completion of four Chemistry courses with laboratories and at least four Biology courses with laboratories.
- The associate's degree must include a minimum of 14 and a maximum of 17 credits of Biology-specific coursework as outlined under Required Major-Specific Content Areas in this Agreement.

See Appendix A: Program-to-Program Articulation Model for Biology.

It is therefore understood that students meeting these requirements will be considered by both the associate degree granting institution and the receiving four-year institution to possess the knowledge, skills and abilities necessary for entry as a junior into a parallel bachelor degree program in Biology.

References to courses in all agreements designate competencies and are not to be construed as making a reference to a specific course at a specific institution. Course titles in the agreements are presented for guidance in advising students as to which coursework they should take even though the course at the student's college may not have the specific title mentioned in the agreement.[1]

REQUIRED Major-Specific Content Areas

Under this Agreement, a fully-transferable associate degree in the field of Biology must include competencies from three primary content areas:

1. **Biology - 14 credits minimum (17 credits maximum)**
   - A. **Principles of Biology - 8 credits**
     Students must meet competencies, acquired through both lecture and rigorous laboratory/field experiences, in two courses covering the Principles of Biology. See Appendix B: Competencies for Preparation in the Principles of Biology
   - **B. Program-Specific Content Areas – 6 to 9 credits**
     Students must meet competencies, acquired through both lecture and rigorous laboratory/field experiences, in **at least two, but not more than three**, of the following areas:
     - **a. Botany**
     - **b. Genetics**
     - **c. Microbiology**
     - **d. Ecology**
     - **e. Research Methods**

[1] Adopted by TAOC and added to the agreement on April 11, 2012.

2. Chemistry – 16 credits

A. General Chemistry – 8 credits

Students must meet competencies, acquired through both lecture and rigorous laboratory/field experiences, in two courses of General Chemistry. Students will fulfill this requirement by completing General Chemistry I for science majors and General Chemistry II for science majors within Category 4 of the 30 credit Transfer Credit Framework. See Appendix A: Program to Program Articulation Model for Biology, and Appendix J: Transfer Credit Framework.

B. Organic Chemistry – 8 credits

Students must meet competencies, acquired through both lecture and rigorous laboratory/field experiences, in two courses of Organic Chemistry. See Appendix H: Competencies for Preparation in Organic Chemistry, and Appendix I: Competencies for Preparation in Organic Chemistry Laboratory.

3. Mathematics - 6 to 8 credits

Students must meet competencies in two courses of Mathematics. At least one of the courses must be Pre-calculus or Calculus. Students will fulfill this requirement by taking two math courses within Category 3 of the 30 credit Transfer Credit Framework, provided that at least one of the courses is Pre-calculus or Calculus. See Appendix A: Program to Program Articulation Model for Biology, and Appendix J: Transfer Credit Framework.

1. Biology – 14 to 17 credits

A. Principles of Biology Competencies – 8 credits

Biology as a science is involved in a course of change that is quite remarkable. An information explosion has occurred that has created a challenge for the biology student who must fully understand universal concepts and principles. Thus, the growing complexity in the biological sciences makes it essential that the student be provided with fundamental principles and basic information that will serve as the basis for an understanding and appreciation of the many and varied sub-disciplines of biology. It is necessary that the student have an understanding of processes and interactions that occur at the molecular, cellular, organismal and population levels of organization. Students must also be prepared to appreciate the different aspects of plant and animal diversity, as well as the special adaptations and evolutionary relationships of these organisms.

Competencies in the following content areas within the Principles of Biology have been identified as essential for comparable preparation toward a Bachelor's Degree in Biology.

Competency area 1: Scientific Investigation
Competency area 2: Scientific literature
Competency area 3: Cell structure and function
Competency area 4: Energy transfer within biological systems
Competency area 5: Introduction to molecular genetics
Competency area 6: Basic principles of inheritance
Competency area 7: Evolution and natural selection
Competency area 8: Hierarchical organization of life
Competency area 9: Basic biochemistry
Competency area 10: Laboratory experiences
Competency area 11: Zoology

See Appendix B: Competencies for Preparation in the Principles of Biology.

B. Program-Specific Content Areas – 6 to a maximum of 9 credits

In addition to the required competencies listed above, students transferring into a bachelor degree program in Biology must also acquire competencies, acquired through both lecture and rigorous laboratory/field experiences, in at least TWO but not more than three of the following content areas:

a. **Botany**
b. **Genetics**
c. **Microbiology**
d. **Ecology**
e. **Research Methods**

a. Botany Competencies

An introductory understanding of botany is necessary for all students majoring in biology. These competencies provide students with the basic concepts of plant biology and a survey of the major groups of plants and plant-like organisms. It expands on many of the biological concepts introduced in Principles of Biology within the context of plants. These competencies, acquired through both lecture and rigorous laboratory/field experiences, also are intended to provide students with the fundamentals necessary to support upper level courses with a botanical content.

See Appendix C: Competencies for Preparation in Botany

b. Genetics Competencies

Organisms can be fully understood only by knowing how the hereditary material orchestrates the organism's development and behavior. Moreover, populations and species can be fully understood only by knowing how the hereditary material is recombined and transmitted through the generations. Thus genetics, the study of the hereditary material, is fundamental to all of biology, and few biologists, regardless of the scales of time and size at which they work, can do their work without knowing and applying genetics. These competencies, acquired through both lecture and rigorous laboratory/field experiences, are intended to provide students majoring in the life sciences with the thorough introduction to genetics that they will need for more advanced work in biology.

See Appendix D: Competencies for Preparation in Genetics

c. Microbiology Competencies

An introduction to microbiology is essential to provide knowledge about prokaryotic and other single celled organisms to students in the Biology major, the Environmental Science major, and the Medical Technology major. These competencies, acquired through both lecture and rigorous laboratory/field experiences, examine the structure and metabolism of microbes and emphasize the strategies employed by these organisms in their evolutionary successes.

See Appendix E: Competencies for Preparation in Microbiology

d. Ecology Competencies

Ecology is the study of the interaction of organisms with their environment. An introduction to ecology will provide students with a sense of how organisms respond to both living and non-living aspects of their environments. Knowledge of ecological principles, acquired through both lecture and rigorous laboratory/field experiences, will be useful to students by broadening their awareness of the richness and diversity by which organisms interact with and respond to natural environments.

See Appendix F: Competencies for Preparation in Ecology

e. Research Methods Competencies

A hands-on introduction to biological research is absolutely essential for the education of biological science majors. Students must learn about the process by which scientific knowledge is acquired while conducting their own research projects. Through both lecture and rigorous laboratory/field experiences, they must acquire the skills that are essential to the successful design and execution of biological research.

See Appendix G: Competencies for Preparation in Research Methods

2. Chemistry – 16 credits

A. General Chemistry – 8 credits

An understanding of general chemistry is essential for forming the basis for education in organic chemistry and biology. Students must meet competencies, acquired through both lecture and rigorous laboratory/field experiences, in two courses of General Chemistry. Students will fulfill this requirement by completing General Chemistry I for science majors and General Chemistry II for science majors within Category 4 of the 30 credit Transfer Credit Framework. See Appendix A: Program to Program Articulation Model for Biology, and Appendix J: Transfer Credit Framework.

B. Organic Chemistry – 8 credits

An understanding of organic chemistry is essential for a thorough education in biology. Living things are carbon-based and their biochemistry as well as their physiology and environmental interactions all rely at least in part on the chemistry of organic molecules.

Organic Chemistry is the study and application of reactions involving carbon-based molecules. The ACS classifies the first semester of Organic Chemistry as a foundation course and the second semester as an in-depth course. As such, Organic chemistry should include the fundamentals of nomenclature, reactions, mechanisms, and related concepts.

The following competencies have been identified as essential for a background in Organic Chemistry. Please note that the competencies do not need to be introduced in the order listed.

Competency area 1: Bonding
Competency area 2: Structure and Function
Competency area 3: Acid-Base Reactions
Competency area 4: Stereochemistry
Competency area 5: Nomenclature
Competency area 6: Spectroscopy
Competency area 7: Organic Reactions
Competency area 8: Organic Synthesis
Competency area 9: Macromolecules

See Appendix H: Competencies for Preparation in Organic Chemistry.

Organic Chemical reactions involve specialty glassware, equipment, and instrumentation that is different from many fields in Chemistry and Biology. Emphasis in the Organic Laboratory is on the synthesis and purification of compounds followed by the application of instrumentation in the analysis and identification of the products. Like all laboratories, safety practices, the keeping of a laboratory notebook, and report writing should also be incorporated. The competencies are based on the guidelines recommended by the American Chemical Society. Also, note that a wide variety of experiments satisfy these competencies. ***All laboratories are required to be taught hands-on, with physical (not virtual) equipment in a laboratory setting.***

The following competencies have been identified as essential for a background in Organic Chemistry Laboratory. Please note that the competencies do not need to be introduced in the order listed.

Competency area 1: Laboratory Safety and Laboratory Notebook
Competency area 2: Purification Techniques
Competency area 3: Spectroscopy
Competency area 4: Functional Group Interconversion
Competency area 5: Chromatography
Competency area 6: Statistical Analysis
Competency area 7: Computational

See Appendix I: Competencies for Preparation in Organic Chemistry Laboratory.

Appendix A: Program-to-Program Articulation Model for Biology

Major-Specific Content Areas – REQUIRED	Transfer Criteria
Principles of Biology	Successful completion of courses addressing the required competencies specified in this Agreement for Principles of Biology.
Program-Specific Content Areas ***Students must meet competencies in two, but not more than three, of the following areas:*** **a. Botany** **b. Genetics** **c. Microbiology** **d. Ecology** **e. Research Methods**	Successful completion of at least two, but not more than three, courses addressing the required competencies specified in this Agreement for Botany, Genetics, Microbiology, Ecology, and Research Methods.
Organic Chemistry	Successful completion of courses addressing the required competencies specified in this Agreement for Organic Chemistry.
Transfer Credit Framework*	**REQUIRED Framework Courses for Students Transferring under this Agreement**
Category 1	**1 course** to be selected by the student with the assistance of an advisor
Category 2	**1 course** to be selected by the student with the assistance of an advisor
Category 3	**2 courses**, at least one course must be Pre-Calculus or Calculus.
Category 4	**2 courses:** • General Chemistry I for science majors • General Chemistry II for science majors
Category 5	**2 courses** to be selected by the student with the assistance of an advisor
Category 6	**2 courses** to be selected by the student with the assistance of an advisor

*See Appendix J: Transfer Credit Framework

Appendix B: Competencies for Preparation in the Principles of Biology

Competency Area 1: *Scientific Investigation*
Behavioral Objectives: To obtain competency in this area, students should be able to

1.1 Define, describe, and implement the scientific method.
1.2 Describe implications of scientific or technological developments on ethical questions in biology.

Competency Area 2: *Scientific literature*
Behavioral Objectives: To obtain competency in this area, students should be able to

2.1 Locate and critically evaluate scientific information.
2.2 Write literature reviews and lab reports.

Competency Area 3: *Cell structure and function*
Behavioral Objectives: To obtain competency in this area, students should be able to

3.1 Describe the basic structure of a cell and define the functions of the organelles.
3.2 Describe the fluid mosaic model structure of biological membranes and the relationships between the membranes, the cytoskeleton, and the extracellular matrix.
3.3 Describe the functions of biological membranes, including transport, signal transduction, cell-cell recognition, enzymatic activity, and intercellular joining.
3.4 Explain the biochemistry of and factors involved in membrane transport.
3.5 Describe the transfer of information within a cell and between cells.
3.6 Describe the difference between prokaryotic and eukaryotic cell structure.
3.7 Describe the structure and function of chromosomes and their role in cell division.
3.8 Explain the concept of the cell cycle, how it is controlled, and how it relates to cell division.
3.9 Describe and differentiate between the mechanisms of mitosis and meiosis.
3.10 Explain the concepts of independent assortment, crossing over, and random fertilization, and relate these to the production of genetic variation within a population.

Competency Area 4: *Energy transfer within biological systems*
Behavioral Objectives: To obtain competency in this area, students should be able to

4.1 Explain the first and second laws of thermodynamics.
4.2 Explain the concept of free energy.
4.3 Define chemical reaction and contrast exergonic and endergonic reactions.
4.4 Explain the concepts of oxidation and reduction.
4.5 Describe the structure of ATP and explain how it powers cellular work.
4.6 Describe the process of photosynthesis.
4.7 Describe the processes of glycolysis, the citric acid cycle, and electron transport.
4.8 Describe the processes of anaerobic respiration/fermentation

Competency Area 5: *Introduction to molecular genetics*
Behavioral Objectives: To obtain competency in this area, students should be able to

5.1 Explain the processes controlling gene expression: gene regulation, transcription, and translation.
5.2 Describe the process of DNA replication in eukaryotes and bacteria.
5.3 Describe the concept of mutation and explain the various kinds of mutations.

Competency Area 6: *Basic principles of inheritance*
Behavioral Objectives: To obtain competency in this area, students should be able to

6.1 Explain Mendelian genetics and the expression of traits through the solution of simple monohybrid and dihybrid genetics problems.
6.2 Explain the concepts of complete dominance, incomplete dominance, and codominance, multiple alleles, pleiotropy, epistasis, and polygenic inheritance.

Competency Area 7: *Evolution and natural selection*
Behavioral Objectives: To obtain competency in this area, students should be able to

7.1 Describe the sources of genetic variation within a population and explain why variation is essential for evolution.
7.2 Define evolution and natural selection, mutation, sexual selection, gene flow and genetic drift.
7.3 Explain the basic principles of population genetics.
7.4 Discuss the biological species concept, reproductive isolation mechanisms, and the process of speciation.
7.5 Explain some of the mechanisms behind different scientific hypotheses concerning the origin of life forms.
7.6 Explain endosymbiosis and the origin of eukaryotic cells.
7.7 Discuss the advantages and disadvantages of multicellularity.
7.8 Describe the various lines of evidence for evolution including DNA and other molecular data, morphology and anatomy, developmental biology, biogeography, fossils, and radiometric dating.

Competency Area 8: *Hierarchical organization of life*
Behavioral Objectives: To obtain competency in this area, students should be able to

8.1 Describe the methods used in the classification of organisms.
8.2 Explain how phylogenetic trees are constructed.
8.3 Describe the principal characteristics of the major taxa such as Domains/Kingdoms.
8.4 Describe basic ecological concepts in regards to the hierarchical organization of life.

Competency Area 9: *Basic biochemistry*
Behavioral Objectives: To obtain competency in this area, students should be able to

9.1 Describe the fundamental properties of water in biological systems.
9.2 Describe the four major biomolecules: carbohydrate, lipid, nucleic acid, and protein; and explain their functions and importance in biological systems.
9.3 Draw and describe basic synthesis and degradation reactions of the four major biomolecules.
9.4 Describe basic enzyme structure and function.
9.5 Describe how biological systems are constrained by chemical and physical processes.

Competency Area 10: *Laboratory experiences*
Behavioral Objectives: To obtain competency in this area, students should be able to

10.1 Develop, implement and evaluate an experimental problem through data collection and analysis.
10.2 Properly use a microscope, balance, pipette, micropipettes, and other basic laboratory equipment.
10.3 Demonstrate the use of basic computer applications such as excel for creating graphs and running simple statistical analyses.
10.4 Demonstrate the proper technique for weighing and measuring materials using the metric system.
10.5 Calculate concentrations and convert units.
10.6 Demonstrate familiarity with basic biochemical analysis for organic molecule identification.
10.7 Demonstrate the use of spectrophotometric assay for various applications.

Competency Area 11: *Zoology*
Behavioral Objectives: To obtain competency in this area, students should be able to

11.1 Integrate the theory of evolution by natural selection into the phylogeny of the protists and the Kingdom Animalia.
11.2 Distinguish, by comparative biology, the following:
    a) the protists from the metazoa;
    b) the radiate animals from the bilateral animals;
    c) acoelomate, pseudocoelomate and coelomate animals;
    d) the invertebrates from the vertebrates.
11.3 List the distinguishing characteristics of selected groups of protists, and explain why protists are no longer recognized as a valid kingdom.
11.4 List the distinguishing characteristics of the Kingdom Animalia and be able to compare the phyla Porifera, Cnidaria, Platyhelminthes, Nematoda, Mollusca, Annelida, Arthropoda, Echinodermata, and Chordata.
11.5 Describe the basic characteristics and comparative biology of the major vertebrate classes.
11.6 Describe the physiology of organisms in each of the major phyletic groups.
11.7 Demonstrate the skills required of microscopic examination of animal tissues and gross animal dissection.
11.8 Identify and discuss issues relating to evolutionary events surrounding the rise of gross animal architecture.
11.9 Identify and discuss issues relating to the evolution of the main lines of animal phylogeny.

Appendix C: Competencies for Preparation in Botany

Behavioral Objectives: To obtain competency in this area, students should be able to

1. Explain the importance of botany as a past, present, and future science.
2. Describe and recognize plant cellular and subcellular structures.
3. Describe basic comparative plant anatomy and morphology.
    - Describe and recognize the distinguishing characteristics of simple and complex tissues.
    - Describe the characteristics and roles of primary and secondary meristems.
    - Describe and recognize distinguishing characteristics of typical monocot and dicot roots, stems, and leaves, and flowers.
    - Describe and recognize major types of fleshy and dry fruits.
4. Demonstrate the skills required for microscopic examination of plant cells, subcellular structures, and tissues.
5. Identify representative trees and shrubs of Pennsylvania.
6. Describe the mechanism and pathways involved in the transport of water, minerals, and nutrients in plants.
7. Describe basic soil characteristics and plant mineral nutrition.
8. Explain the basics of plant metabolism with an emphasis on photosynthesis.
    - Describe the differences in structure and function of photosynthetic pigments.
    - Describe the roles of photosystems I and II in the light reactions of photosynthesis.
    - Describe and understand the process of chemiosmosis and ATP synthesis in chloroplasts.
    - Describe the role and importance of the Calvin cycle.
    - Describe the impacts of photorespiration on productivity.
    - Describe C4 and CAM photosynthesis.
    - Review the process of aerobic cellular respiration as it relates to plant metabolism.
9. Describe the basic developmental processes in plants and the roles of plant hormones in growth and development.
10. Describe the roles of phytochrome in plants, photoperiodism, representative plant movements, and the effect of temperature on developmental processes.
11. Explain the basic concepts of plant biotechnology and plant genetic engineering.
12. Describe and recognize the distinguishing characteristics of diverse groups within the Plant Kingdom including bryophytes, ferns and fern allies, gymnosperms, and angiosperms.
13. Describe and recognize the distinguishing characteristics of non-plant but plant-like organisms such as some members of the Domain Bacteria, some protists, and some members of the Kingdom Fungi.
14. Discuss the major evolutionary advances in plant form and function.
15. Describe life cycles of representative algae, fungi, bryophytes, ferns and fern allies, gymnosperms, and angiosperms and relate to major evolutionary advances in plants and related organisms.
16. Discuss various anatomical and physiological adaptations of plants to diverse environments.
17. Explain the basic concepts of economic and medical botany.
18. Describe the distinguishing characteristics of representative plant families.
19. Explain concepts of plant ecology including pollination ecology, various symbioses, primary and secondary succession, biomes, nutrient cycling in ecosystems, human impacts on ecosystems, impacts of invasive species, and interactions between plants and other organisms.
20. Apply investigatory skills to develop, implement and evaluate experimental problems through data collection, analysis, and report writing.

Appendix D: Competencies for Preparation in Genetics

Behavioral Objectives: To obtain competency in this area, students should be able to

1. Explain the most important genetic principles, including those related to Mendelian genetics, chromosomal genetics, gene interactions, mutation, microbial genetics, molecular genetics, and evolutionary genetics.
2. Use current terminology to explain the modern understanding of eukaryotic chromosome structure.
3. Apply an understanding of genetic principles to the analysis of genetic problems and systems.
4. Apply basic probability theory and statistical hypothesis testing techniques to the analysis of genetic problems including linkage analysis.
5. Explain and discuss the importance of genetics to Biology as a whole and to certain human concerns such as medical and technological innovations including recombinant DNA technology, genetic engineering, and genetic testing.
6. Discuss how genes and the environment interact to produce a specific phenotype.
7. Explain the cellular activities of mitosis and meiosis as they relate to genetics.
8. Apply investigative laboratory skills relevant to basic genetics, including the production and analysis of genetic crosses, the microscopic study of chromosomes, electrophoresis, DNA isolation, the handling and genetic analysis of microbes, basic recombinant DNA techniques such as restriction digests and bacterial transformation, and the use of computers to access information from online databases, in data analysis and in the simulation of biological systems.
9. Design, conduct, statistically evaluate, and interpret the results of a genetic experiment, expanding on one, or more, of the laboratory techniques listed in the previous objective.
10. Explain evolution in terms of molecular genetics and population genetics.
11. Demonstrate understanding of population statistics, including Hardy-Weinberg equilibrium.
12. Explain perturbations to and deviations from Hardy-Weinberg equilibria and what they mean for the evolution of species.
13. Demonstrate an understanding of current applications in biotechnology, such as recombinant and transgenic methods in plants, animals, and microorganisms.
14. Demonstrate an understanding of genomics, including genome mapping strategies such as cytogenic, linkage, and physical mapping. Describe possible applications for data gained through genome projects.

Appendix E: Competencies for Preparation in Microbiology

Behavioral Objectives: To obtain competency in this area, students should be able to

Microbe classification

1. Describe the characteristics of the various groups of microbes including bacteria, archaea, fungi, protozoa, helminthes, viruses, prions and viroids.
2. Describe the criteria and techniques used to classify microbes and the challenges involved.

Prokaryotic structure

3. Describe the function of the cellular structures found in prokaryotes.

Growth, physiology and metabolism

4. Draw a typical growth curve and discuss factors that influence the growth of microorganisms.
5. Describe methods of microbial reproduction including binary fission and budding.
6. Describe metabolic pathways used by prokaryotes including the glycolytic pathway, the pentose-phosphate shunt, the Entner-Douderoff pathway, fermentations, and alternative strategies to electron transport and photosynthesis.

Bacterial genetics

7. Describe gene regulation and expression using the lac operon.
8. Differentiate the strategies used for genetic exchange by prokaryotes.
9. Describe DNA structure, organization and replication in prokaryotes.

Population biology

10. Describe the interactions microbes have with other organisms including mutualistic, parasitic, and commensal interactions.

Evolution

11. Describe and explain the major steps in the evolution of life on Earth, including symbioses that involved both prokaryotic and eukaryotic organisms and discuss an approximate time line for these events using ultrastructural, biochemical, molecular and fossil evidence as examples.
12. Describe how several factors, including: mutation, horizontal gene transfer mechanisms, large population sizes, short generation times—cause rapid evolution of microbial populations.

Importance of microbes

13. Describe the principles involved in common types of applied microbiology.
14. Describe in general terms, microbial roles in each of the following: decomposition/nutrient cycling, O2 production, production of industrial, commercial, and medical products.
15. Discuss the principles of antimicrobial chemotherapy.

Laboratory experiences

16. Demonstrate familiarity with different types of media (selective, differential, etc.) and their uses.
17. Use standard methods to enumerate and identify bacteria.
18. Use laboratory techniques to successfully identify an “unknown” organism.
19. Demonstrate safe laboratory practices and know how to aseptically handle and dispose of live microbes.
20. Demonstrate the basic principles of microscopy and the use of stains to enhance contrast in cells.

Appendix F: Competencies for Preparation in Ecology

Behavioral Objectives: To obtain competency in this area, students should be able to

Importance

1. Explain the historical importance of ecology and technology to human society.

Evolution

2. Explain how speciation occurs.
3. Explain how coevolution occurs and what its effects are.
4. Explain and describe the importance of the environment to evolution, natural selection and the maintenance of biodiversity.

Physiological ecology

5. Describe the physical, biological, and behavioral factors that influence an organism's ability to grow and reproduce in its habitat.

Population ecology

6. Explain and apply principles of population growth, population regulation, and population dynamics.

Community ecology

7. Describe the principles of community ecology.
8. Compare and contrast intraspecific and interspecific competition.
9. Explain the principle of character displacement and its relationship to competition.
10. Explain what predation and herbivory are, and how they influence populations.
11. Explain the concepts of parasitism, mutualism, and commensalism.
12. Describe succession.
13. Recognize similarities among ecological communities inhabiting similar types of environments, and the diverse evolutionary adaptations that influence a species' range, dispersal, and ability to survive in its environment.

Ecosystem ecology

14. Describe the major biotic and abiotic ecological characteristics that identify a given ecosystem.
15. Describe the biogeochemistry of an ecosystem and explain the cycles of nitrogen, carbon, phosphorous, and water.
16. Explain energy flow in ecosystems, photosynthesis, trophic levels, and biomass pyramids from an ecological perspective.
17. Discuss diverse adaptations for nutrient acquisition in ecosystems, the conversion of these nutrients into biologically useful forms, cycling of nutrients, and the indispensable roles of producers and decomposers.
18. Evaluate the impact of human behavior on earth's ecosystems, particularly as it relates to biological diversity, global climate change, and the ability of ecosystems to sustain life.
19. Recognize the continually changing nature of ecosystems, and discuss factors that impact ecosystems and the evolution of resident species through natural selection.

Environmental biology

20. Describe and explain the causes and consequences of pollution on the biosphere and the survival of all organisms.
21. Analyze a variety of timely environmental issues in light of their ecological, social, economic, ethical, or cultural implications.

Lab/Field experiences

22. Collect data and formulate valid scientific conclusions of an ecological nature.
23. Work as part of a team in field and laboratory investigations of ecological phenomena.
24. Collect ecological data and apply basic statistical skills for analyzing quantitative and qualitative data to formulate conclusions.

Appendix G: Competencies for Preparation in Research Methods

Behavioral Objectives: To obtain competency in this area, students should be able to

1. Describe the steps of the scientific method and discuss how the scientific method is used.
2. Distinguish between non-manipulative studies and experiments.
3. Identify flaws in experimental design.
4. Explain basic statistical concepts including Type I error, p-value, test statistic, null hypothesis.
5. Distinguish between descriptive and inferential statistics.
6. Distinguish between parametric and nonparametric statistics and explain the advantages and disadvantages of each.
7. Conduct effective and comprehensive scientific literature searches.
8. Read, understand and critique primary scientific journal articles.
9. Explain the process involved in getting scientific research published in a journal
10. Identify an original scientific research project to work on.
11. Write a scientific research project proposal.
12. Design and conduct a research project that will test a hypothesis or answer a given biological question
13. Determine which statistical test is appropriate for a given situation or set of data.
14. Draw a graph that clearly summarizes a particular data set.
15. Write a scientific paper, similar in scope and style to papers published in the scientific literature, based on original scientific research.
16. Present results of a scientific study in the form of an oral presentation and/or a poster presentation.

Appendix H: Competencies for Preparation in Organic Chemistry

Competency area 1: Bonding.
Behavioral Objectives: In order to attain this competency, students should be able to:
1.1 Understand topics in chemical bonding and the relationship between chemical structures and their reactivity.
1.2 Understand the concept of resonance.
1.3 Understand the concept of hybridization.

Competency area 2: Structure and Function.
Behavioral Objectives: In order to attain this competency, students should be able to:
2.1 Identify functional groups.
2.2 Correlate chemical structure with reactivity and function.
2.3 Understand how the behavior and properties of molecules depend on electronic, orbital and steric interactions.
2.4 Understand the importance of environmental context (solution phase, pure gas, liquid or solid) on predicting the structure and reactivity of organic molecules.

Competency area 3: Acid-Base Reactions.
Behavioral Objectives: In order to attain this competency, students should be able to:
3.1 Make predictions of behavior attributable to Lewis acid-base principles, and Bronsted-Lowry acid-base principles.
3.2 Understand the concept of pKa.

Competency area 4: Stereochemistry.
Behavioral Objectives: In order to attain this competency, students should be able to:
4.1 Understand all stereochemical principles (cis, trans, R, S, exo, endo) and their identification/relationships.
4.2 Make predictions regarding stability and reactivity of stereochemical molecules from conformational analysis.
4.3 Understand the importance of stereochemistry in specific reactions.

Competency area 5: Nomenclature.
Behavioral Objectives: In order to attain this competency, students should be able to:
5.1 Name alkanes, alkenes, alkynes, aromatics, alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amides, halides and amines.
5.2 Incorporate stereochemistry in nomenclature.

Competency area 6: Spectroscopy.
Behavioral Objectives: In order to attain this competency, students should be able to:
6.1 Analyze and interpret structural data obtained from laboratory experiments, spectroscopic analysis, and computational methods.
6.2 Understand the theory and analysis of Infrared Spectroscopy (IR) and Nuclear Magnetic Resonance Spectroscopy (NMR).

Competency area 7: Organic Reactions.
Behavioral Objectives: In order to attain this competency, students should be able to:
7.1 Understand the concept of “reaction mechanism” in organic chemistry.
7.2 Predict reaction outcomes based on mechanistic principles, in the areas of addition, substitution, elimination and rearrangement chemistry.
7.3 Recognize and understand the significance of reactive intermediates such as carbocations, radicals, carbanions and carbenes.
7.4 Understand how reaction rate, kinetics, and energy diagrams apply to organic reactions.

Competency area 8: Organic Synthesis.
Behavioral Objectives: In order to attain this competency, students should be able to:
8.1 Understand the design of organic syntheses.
8.2 Understand the synthesis and reactions of the major classes of organic molecules: alkanes, alkenes, alkynes, aromatics, alcohols, ethers, aldehydes, ketones, carboxylic acids, esters, amides, halides and amines.
8.3 Plan organic syntheses through the application of retrosynthetic analysis principles.

Competency area 9: Macromolecules.
Behavioral Objectives: In order to attain this competency, students should be able to:
9.1 Recognize the organic functionality of macromolecules.
9.2 Understand the synthesis of, and the structure-based behavior of, macromolecular species such as proteins, lipids, (mono- and) polysaccharides, and synthetic polymers.

Appendix I: Competencies for Preparation in Organic Chemistry Laboratory

Competency area 1: Laboratory Safety and Laboratory Notebook.
Behavioral Objectives: This competency applies to all laboratory competencies. Students should be instructed in: safe laboratory practices at the institutional level, safety protocols mandated by OSHA, proper use of equipment, proper practices in the acquisition of reagents for all experiments and proper disposal of waste. In addition, students should be instructed on how to keep a laboratory notebook for their experiments.

Competency area 2: Purification Techniques.
Behavioral Objectives: In order to attain this competency, students should be able to:
Isolate and purify organic materials; methods should include simple and fractional distillation of liquids, recrystallization of solids, column chromatography, and extraction of solutes in immiscible solvents. Identification of purified products by melting point, boiling point, refractive index (or polarimetry), or by spectroscopic analysis should be included.

Competency area 3: Spectroscopy.
Behavioral Objectives: In order to attain this competency, students should be able to:
Develop competence in the spectroscopic analysis of organic starting materials and synthetic products. Methods should include, at the very least, interpretation of IR and NMR spectra. It is recommended that GC/MS should also be included. Students should develop facility in deducing structures from spectra and be able to provide answers to questions involving data provided from 'unavailable' spectroscopic or computational sources.

Competency area 4: Functional Group Interconversion.
Behavioral Objectives: In order to attain this competency, students should be able to:
Correctly plan and carry out a broad variety of organic reactions based on functional group interconversions.

Competency area 5: Chromatography.
Behavioral Objectives: In order to attain this competency, students should be able to:
Perform an experiment that utilizes thin layer chromatography (TLC) and/or gas chromatography (GC). Examples include monitoring a reaction by observing both reactants and products and/or comparison of standards to unknowns.

Competency area 6: Statistical Analysis.
Behavioral Objectives: In order to attain this competency, students should be able to:
Perform a laboratory that applies statistical methods to the analysis of experimental data, real or simulated (this competency is recommended by the ACS but not required by the Chemistry or the Biology Articulation Agreement).

Competency area 7: Computational.
Behavioral Objectives: In order to attain this competency, students should be able to:
Understand the value of, and the limitations associated with, computational methods (this competency is recommended by the ACS but not required by the Chemistry or the Biology Articulation Agreement).

Appendix J: Transfer Credit Framework[2]

Students who successfully complete courses from the approved categories below can have their credits transferred and counted towards graduation at any of the participating PA TRAC colleges and universities. Please be aware that certain majors may have specific requirements prescribed by external agencies. It is the student's responsibility to work with an advisor to select appropriate courses as they relate to the major.

Category 1 (3-4 credits total)	Category 2 (3-4 credits total)	Category 3 (min. 3-4 credits; max. 6-8 credits)	Category 4 Must include lab (min. 3-4 credits; max. 6-8 credits)	Category 5 (min. 3-4 credits; max. 6-8 credits)	Category 6 (min. 3-4 credits; max. 6-8 credits)
English Composition	Public Speaking	Foundations of Mathematics	General Chemistry I (majors & non-majors courses)	General Psychology	Introduction to Music
		College Algebra	General Chemistry II (majors & non-majors courses)	Introduction to Sociology	Introduction to Philosophy
		Elementary Statistics	General Biology I (majors & non-majors courses)	American National Government	Elementary Spanish I
		Precalculus	General Biology II (majors & non-majors courses)	Educational Psychology	Elementary Spanish II
		Calculus I	General Physics I (non-calculus)	History of Western Civilization II	Painting I
			General Physics II (non-calculus)	Principles of Macroeconomics	Elementary French I
			Anatomy & Physiology I*	Principles of Microeconomics	Elementary French II
			Anatomy & Physiology II*	U.S. History I	Drawing I
			Introduction to Astronomy	U.S. History II	Ethics
				History of Western Civilization I	Introduction to Art
				Contemporary Social Problems	German I
				Introduction to Anthropology	German II
				Child Growth & Development	Introduction to Literature (may also be known as Introduction to Poetry, Interpreting Literature, Reading Literature, Theses in Literature, Topics in Literature, Current Themes in Literature)
				Child Psychology	Survey of American Literature
					Literature of the Western World
					World Literature
					American Literature
					Survey of English Literature
					Introduction to Theatre

*** Biology students are advised that Anatomy & Physiology I & II in Category 4 will not meet the requirements for separate anatomy and physiology courses required in most Bachelor's Degree programs.**

[2]Framework chart amended on April 11, 2012 to include Child Growth & Development and Child Psychology under Category 5.

ADDENDUM
GENERAL STATEWIDE PROGRAM-TO-PROGRAM ARTICULATION in PENNSYLVANIA
(Revised April 11, 2012)

WHEREAS, the General Assembly of the Commonwealth of Pennsylvania enacted Act 114 of 2006, which added to the Public School Code of 1949, Article XX-C entitled "Transfers of Credits Between Institutions of Higher Education" (referred to in this Agreement as the "Statewide Transfer System");

WHEREAS, Act 114 of 2006 requires all community colleges in Pennsylvania and Pennsylvania State System of Higher Education (PASSHE) universities to participate in the Statewide Transfer System;

WHEREAS, Act 114 of 2006 permits independent and state-related institutions of higher education in Pennsylvania, as each is defined in Article XX-C, to elect to participate in the Statewide Transfer System;

WHEREAS, the General Assembly of the Commonwealth of Pennsylvania enacted Act 50 of 2009, which requires institutions participating in the Statewide Transfer System to accept the transfer of Associate of Arts and Associate Science degrees into parallel baccalaureate programs and recognize all competencies attained within the associate degree program;

WHEREAS, Act 50 of 2009 defines an Associate of Arts (AA) or Associate of Science (AS) degree containing a minimum of 60 college-level credits and designed primarily for transfer to a baccalaureate institution;

WHEREAS, Act 50 of 2009 requires the Transfer Articulation Oversight Committee (TAOC), as established in section 2004-C of the Public School Code of 1949, to identify Associate of Arts and Associate of Science degree programs for transfer with full junior standing into parallel baccalaureate degrees annually; and,

WHEREAS, Act 50 of 2009 requires members of the Transfer Articulation Oversight Committee established in section 2004-C of the Public School Code of 1949, to identify modifications that may be required in existing associate or baccalaureate degrees to satisfy external accreditation or licensure requirement;

All Institutions participating in the Statewide Transfer System enter into this Articulation Agreement and mutually agree as follows:

1. The statewide program-to-program articulation agreement ensures that students who complete an AA or AS degree from a participating institution will have their coursework and credits transfer into a parallel baccalaureate program with full junior standing and without the need for course-by-course equivalency.

2. Students are subject to the admissions and transfer credit policies of the participating institutions. The admissions and transfer credit policies for all of the institutions participating in Pennsylvania's college credit transfer system can be found at www.PAcollegetransfer.com.

3. The AA or AS degree must include a minimum of 60 college-level credits designed and acceptable for transfer, not including developmental or remedial courses or career, technical or applied courses.

4. The transfer of coursework with a grade less than a C (2.0 on a 4.0 scale) in the AA or AS will be consistent with the policies of native students at the participating college or university.

5. Students and institutional personnel will be able to find out which institutions offer articulated programs by accessing a searchable database located at www.PAcollegetransfer.com. PDE will maintain this database through program information provided to TAOC by the individual participating institutions.

6. References to courses in all agreements designate competencies and are not to be construed as making a reference to a specific course at a specific institution. Course titles in the agreements are presented for guidance in advising students

as to which coursework they should take even though the course at the student's college may not have the specific title mentioned in the agreement.[3]

7. Responsibilities of Associate Degree Institutions

a. The AA or AS degree leading to a parallel bachelor degree will include the minimum number of credits and competencies of major-specific coursework as defined by the Agreement.

b. Any remaining AA or AS degree requirements will be accepted from arts and sciences electives designed and acceptable for transfer, not including developmental, remedial, career, technical or applied courses.

c. By awarding the AA or AS, the Associate Degree Institution is validating that the student has met the competency requirements outlined in the Agreement.

8. Responsibilities of Bachelor Degree Institutions

a. The Bachelor Degree Institution will recognize all competencies attained within the AA or AS degree and accept a transfer student who has earned the associate degree with full junior standing into a parallel baccalaureate degree program.

b. All decisions made with respect to the transfer process shall be based on the principle of equivalence of expectations and requirements for native and transfer students.

c. A transfer student's admission into the parallel baccalaureate degree will be subject to the Bachelor Degree Institution's specific requirements for admission to that major and be consistent with such requirements for native students.

9. Agreement Revision and Assessment

a. Once a statewide program-to-program articulation agreement has been approved by TAOC, no amendments to the agreement can be offered by any party within the initial six (6) months of the agreement. After that time, a TAOC member with a proposed amendment to an approved agreement should submit the change to PDE.

Amendments that are offered as clarifying or technical but do not alter the substantive portions or intent of the agreement must be forwarded to TAOC. TAOC representatives will have at least thirty (30) days to review, comment and approve or deny the proposed amendments.

Amendments that seek to alter the substantive nature or intent of the agreement in any part must be forwarded to the appropriate PAC for review and consideration. The PAC will then make a recommendation to the TAOC, and TAOC shall approve or deny the proposed amendments.[4]

b. PDE and TAOC will exercise responsibility for monitoring the effectiveness of the Agreement and its implementation.

c. PDE shall collect data annually from the participating institutions that will enable the Department and TAOC to assess the effectiveness of the implementation of the Agreement in fostering a seamless transfer process and the academic success of transfer students at the senior institutions.

10. Transfer Appeal Process

a. In accordance with Pennsylvania's Statewide Transfer System, each Bachelor Degree Institution shall have a procedure through which a transfer student can appeal a decision that he/she believes is not consistent with this Agreement.

[3] Adopted by TAOC and added to the agreement on April 11, 2012.
[4] Approved by TAOC and added to agreement on August 18, 2011.

b. The Transfer Appeal Process shall be published, at minimum, in the institution's catalog and posted to the Commonwealth's official website of the Statewide Transfer System, www.PAcollegetransfer.com.

11. Institutional Resolution of Disputes

a. In the event that an Associate Degree Institution considers the decision of a Bachelor Degree Institution to be inconsistent with this Agreement, the Associate Degree Institution shall consult directly with the Bachelor Degree Institution and attempt to resolve the matter.

b. If the institutions are unable to resolve the issue, the Associate Degree Institution may submit their concern to PDE for consideration by the TAOC Dispute Resolution Committee. The Dispute Resolution Subcommittee will act according to the policies and procedures developed by TAOC as part of the Statewide Transfer System. The determination made by the Dispute Resolution Subcommittee will be binding upon the parties.

12. **Implementation Date and Applicability**

Having fulfilled the requirements outlined in the Program-to-Program Articulation Agreement, students transferring with an AA or AS degree from a participating institution will be considered by the receiving baccalaureate degree institution to have received adequate preparation in the field of study at the foundation level and therefore eligible to transfer as a junior into advanced major coursework.

Participating institutions will enact the Agreement in accordance to the timeline outlined by the TAOC, but no later Fall 2013.[5]

Continuation of the agreement remains in effect until such time as all cooperating institutions of the Statewide Transfer System formally approve any revisions.

GLOSSARY OF TERMS

Articulation: The aligning of curriculum between institutions of higher education to ensure the efficient and effective movement of students among those institutions.

Associate of Arts (AA) and Associate of Science (AS) Degree: A degree consisting of at least 60 college-level credits and designed for transfer into a baccalaureate degree program.

Foundation Coursework: Courses at a level of comprehension usually associated with freshman and sophomore students and typically offered during the first half of a baccalaureate degree program. Such coursework typically does not have course prerequisites.

Native Student: A student who entered a given college or university without first matriculating at another college.

Parallel Baccalaureate Degree: A bachelor degree program in a comparable field of study and with similar foundation-level major-specific competencies as an associate degree program.

Receiving Institution: The college or university where a transfer student plans to enroll and to apply previously earned credit toward a degree program.

Transfer Credit: The credit granted by a college or university for college-level courses or other academic work completed at another institution.

Transfer Student: A student who enters a participating college or university after earning college-level credit at another college or university.

[5] Agreements approved by TAOC prior to August 31, 2011 must be implemented by the institutions by Fall 2012. Agreements approved by TAOC after August 31, 2011 but before May 1, 2012 must be implemented by the institutions by Fall 2013.

Transfer: The process by which a student moves from one postsecondary institution to another. Also refers to the mechanics of credit, course and curriculum exchange between institutions.

Advanced Coursework: Courses with advanced depth of content knowledge in the field of study and carry the expectation of more complex competencies identified in the expected student learning outcomes is referred to as advanced coursework. These courses often have prerequisites and are usually beyond the "Introduction to…" or "Foundation of…" level.