DRAFT

STATEWIDE PROGRAM-TO-PROGRAM ARTICULATION IN

BIOLOGY

In Pennsylvania, Statewide Program-to-Program Articulation is intended to provide students with a seamless pathway from an Associate of Arts or Associate of Science degree into a bachelor degree in a similar field of study without loss of academic progress or credit.

A committee of faculty and personnel from the colleges and universities that participate in the Commonwealth's college credit transfer system has developed the following DRAFT articulation agreement and are requesting members of the participating institutions provide them with feedback before finalizing the agreement May 20, 2011.

SUBMITTING COMMENTS
Comments must be submitted using the electronic form available on the Pennsylvania Transfer and Articulation Center website located at www.PAcollegetransfer.com.

Before submitting feedback, individuals are advised to visit the PA TRAC website to gain a better understanding of the purpose of statewide articulation and the process being used to develop this agreement.

DEADLINE
Comments on this DRAFT articulation agreement may be submitted online **starting April 20 and ending midnight on May 8, 2011**.

QUESTIONS?
Questions concerning this DRAFT articulation agreement should be submitted as a comment using the online form mentioned above.

Questions concerning the statewide articulation process and college credit transfer system in Pennsylvania may be emailed to the Pennsylvania Department of Education at ra-patrac@state.pde.us.

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 an associate degree that includes all of the required major competencies identified in this Agreement.
- The associate degree includes, at maximum, 16 credits of Biology-specific coursework as outlined under Required Major-Specific Content Areas in this Agreement.
- Successful completion of at least 30 credits of foundation courses from the Transfer Credit Framework.
- A minimum grade of C or better (equivalent of a 2.0 GPA on a 4.0 scale) in all major-specific competencies.

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.

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**
   - **A. Principles of Biology**
   - **B. Program-Specific Content Areas**
     Students must meet competencies in at least one, but not more than two, of the following areas:
     - **a. Microbiology**
     - **b. Genetics**
     - **c. Ecology**
     - **d. Research Methods**
2. **Organic Chemistry**

How an institution incorporates the competencies into the associate degree program does not affect the transferability of the associate degree under this Agreement so long as all of the competencies are met and the student has completed four Biology courses and four Chemistry courses with laboratories.

Students are required to earn a minimum grade of C (equivalent of a 2.0 GPA on a 4.0 scale) or better in courses addressing the required competencies specified in each content area. See Appendix A: Program-to-Program Articulation Model for Biology.

1. Biology

A. Principles of Biology Competencies – (Minimum of 8 credits; Maximum of 12 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*
Competency area 12: *Botany*

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

Historically these competencies have been met by two or three courses with laboratories (4 credits each), for example, Principles of Biology I & II or Principles of Biology I, Botany, and Zoology; but each institution can determine the format in which these competencies will be met.

B. Program-Specific Content Areas – (Minimum 3 credits; Maximum of 8 credits)

In addition to the required competencies listed above, students transferring into a bachelor degree program in Biology must also acquire competencies in at least ONE but not more than two of the following content areas:

a. Genetics
b. Microbiology
c. Ecology
d. Research Methods

a. 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. This course is 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 C: Competencies for Preparation in Genetics

b. 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. This course will examine the structure and metabolism of these organisms and will emphasize the strategies employed by these organisms in their evolutionary successes. Students will be given an overview of disease process and various diseases as well as an introduction to the applied areas of food, soil, and water microbiology. Laboratory will emphasize techniques and will integrate the students' experiences with a project. After taking this course students have an opportunity to take upper level specialty microbiology courses.

See Appendix D: Competencies for Preparation in Microbiology

c. 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 and field methods 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 E: Competencies for Preparation in Ecology

d. 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. They must acquire the skills that are essential to the successful design and execution of biological research.

See Appendix F: Competencies for Preparation in Research Methods

2. Organic Chemistry

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 on at least in part on the chemistry of organic molecules.

See Appendix G: Competencies for Preparation in Organic Chemistry

Transfer Credit Framework

Under Act 114 of 2006, the Commonwealth's statewide college credit transfer system includes an advising tool called the "Transfer Credit Framework". The Framework allows students to seamlessly transfer up to 30 credits of foundation courses from one participating college or university to another and have those courses count toward graduation. See Appendix H: Transfer Credit Framework.

The Framework consists of a menu of courses that fall within six broad categories: English, public speaking, math, science, fine arts and humanities, and the behavioral and social sciences. To fully benefit from the Framework, students are advised to select a range of courses according to the criteria for each category.

Under this Articulation Agreement for Biology, students may select courses according to the criteria indicated for Framework Categories 1, 2, 5 and 6. In Framework Category 3, students are required to take a minimum of 3 credits (1 course) at the Precalculus or higher level of mathematics. In Category 4, students are required to take a minimum of 8 credits in General Chemistry I and II for science majors. (See Table 1 below.)

Students are advised to work with an advisor to select courses related to their associate degree program, transfer major and personal interests.

Table 1: Transfer Credit Framework Requirements for Biology

Transfer Credit Framework Category	Transfer Credit Framework Requirement	REQUIRED Framework Courses for Students Transferring Under this Agreement
Category 1	1 course	**1 course** to be selected by the student with the assistance of an advisor
Category 2	1 course	**1 course** to be selected by the student with the assistance of an advisor
Category 3	1-2 courses	**2 courses**, at least one course must be Pre-Calculus or higher math
Category 4	1-2 courses	**2 courses:** 1. General Chemistry I for science majors 2. General Chemistry II for science majors
Category 5	1-2 courses	**2 courses** to be selected by the student with the assistance of an advisor
Category 6	1-2 courses	**2 courses** to be selected by the student with the assistance of an advisor

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

Major-Specific Content Areas – REQUIRED	Transfer Criteria
Principles of Biology	Minimum grade of C (equivalent of a 2.0 GPA on a 4.0 scale) or better in courses addressing the required competencies specified in this Agreement for Principles of Biology.
Program-Specific Content Areas ***Students must meet competencies in <u>one, but not more than two,</u> of the following areas:*** **a. Microbiology** **b. Genetics** **c. Ecology** **d. Research Methods**	Minimum grade of C (equivalent of a 2.0 GPA on a 4.0 scale) or better in at least one but not more than two courses addressing the required competencies specified in this Agreement for Microbiology, Genetics, Ecology, or Research Methods.
Organic Chemistry	Minimum grade of C (equivalent of a 2.0 GPA on a 4.0 scale) or better in courses addressing the required competencies specified in this Agreement for Organic Chemistry.
Transfer Credit Framework* - REQUIRED	**Transfer Criteria**
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 higher math
Category 4	**2 courses:** 1. General Chemistry I for science majors 2. 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 H: Transfer Credit Framework

Appendix B: Competencies for Preparation in the Principles of Biology

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

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

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

3. Locate and critically evaluate scientific information.
4. Write literature reviews and lab reports.

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

5. Describe the basic structure of a cell and define the functions of major organelles.
6. Describe biological membranes and the factors involved in membrane transport.
7. Describe the transfer of information within a cell and between cells.
8. Describe the difference between prokaryotic and eukaryotic cell structure
9. Describe the structure and function of chromosomes and their role in cell division.
10. Describe and differentiate between the mechanisms of mitosis and meiosis.

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

11. Describe the process of photosynthesis.
12. Describe the processes of glycolysis, the citric acid cycle, and electron transport.
13. Describe the processes of anaerobic respiration/fermentation

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

14. Explain the processes controlling gene expression: gene regulation, transcription, and translation.
15. Describe the process of DNA replication in eukaryotes and bacteria.

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

16. Understand and describe Mendelian genetics and the expression of traits through the solution of simple monohybrid and dihybrid genetics problems.

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

17. Define evolution and natural selection, mutation, sexual selection, gene flow and genetic drift.
18. Understand and describe population genetics within the process of evolution.
19. Discuss the biological species concept, reproductive isolation mechanisms, and the process of speciation.
20. Understand and describe some of the mechanisms behind different scientific theories concerning the origin of life forms.

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

21. Describe the methods used in the classification of organisms.
22. Describe the principal characteristics of the major taxa such as Domains/Kingdoms.
23. Describe basic ecological concepts and explain how they relate to biological systems.

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

24. Describe the fundamental properties of water in biological systems.
25. Describe the four major biomolecules, carbohydrate, lipid, nucleic acid, and protein. Be able to explain their functions and importance in biological systems.
26. Draw and describe basic synthesis and degradation reactions of the four major biomolecules.
27. Describe basic enzyme structure and function.
28. Describe how biological systems are constrained by chemical and physical processes.

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

29. Develop, implement and evaluate an experimental problem through data collection and analysis.
30. Properly use a microscope, balance, pipette, micropipettes, and other basic laboratory equipment.
31. Demonstrate the use of basic computer applications such as Excel for creating graphs and running simple statistical analyses.
32. Demonstrate the proper technique for weighing and measuring materials using the metric system. Be able to calculate concentrations and convert units.
33. Demonstrate familiarity with basic molecular biology techniques such as DNA isolation, restriction digests or PCR, and gel electrophoresis.

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

34. Integrate the theory of evolution by natural selection into the phylogeny of the Protists and the Kingdom Animalia.
35. Distinguish, by comparative biology, the following:
    a) the protists from the metazoa;
    b) the lower metazoa from the higher metazoa;
    c) the radiate animals from the bilateral animals;
    d) acoelomate, pseudocoelomate and coelomate animals;
    e) the invertebrates from the vertebrates.
36. List the distinguishing characteristics of the protists and selected phyla within the kingdom.
37. 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.
38. Understand the basic characteristics and comparative biology of the major vertebrate classes.
39. Describe the primary physiologies of major phyletic groups.
40. Demonstrate the skills required of microscopic examination of animal tissues.
41. Demonstrate the skills required of gross animal dissection.
42. Identify and discuss issues relating to evolutionary events surrounding the rise of gross animal architecture.
43. Identify and discuss issues relating to the evolution of the main lines of animal phylogeny.

Competency 12: *Botany*
Behavioral Objectives: To obtain competency in this area, students should be able to:

44. Describe plant cellular structure and basic comparative plant anatomy and morphology.
45. Describe basic transport processes and pathways within plants.
46. Describe basic developmental processes in plants and the roles of plant hormones in growth and development.
47. Describe the ways plants respond to their environments.
48. Describe the distinguishing characteristics, basic modes of nutrition, patterns of reproduction, life cycles and ecology of plants and related organisms.
49. Explain the basic concepts of plant evolution and discuss various anatomical, physiological, and behavioral adaptations of plants to diverse environments.
50. Describe the evolutionary relationships among green algae and plants with emphasis on adaptive strategies
51. Explain basic concepts in plant ecology such as various symbioses, primary and secondary succession, and invasive species.

Appendix C: 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. Apply an understanding of genetic principles to the analysis of genetic problems and systems.
3. Apply basic probability theory and statistical hypothesis testing techniques to the analysis of genetic problems including linkage analysis.
4. 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.
5. Discuss how genes and the environment interact to produce a specific phenotype.
6. Apply investigatory skills relevant to basic genetics, including the production and analysis of genetic crosses, the microscopic study of chromosomes, 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.
7. Explain the cellular activities of mitosis and meiosis as they relate to genetics.
8. Design, conduct, statistically evaluate, and interpret the results of a genetic experiment.
9. Demonstrate understanding of population statistics, including Hardy-Weinberg equilibrium.
10. Demonstrate an understanding of modern biotechnology.

Appendix D: Competencies for Preparation in Microbiology

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

1. Describe the function of the cellular structures found in prokaryotes.
2. Draw a typical growth curve and discuss factors that influence the growth of microorganisms.
3. 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.
4. Describe gene regulation and expression using the lac operon.
5. Differentiate the strategies used for genetic exchange by prokaryotes.
6. Describe the interactions microbes have with other organisms including mutualistic, parasitic, and commensal interactions.
7. Describe the principles involved in common types of applied microbiology.
8. Demonstrate familiarity with different types of media (selective, differential, etc.) and their uses.
9. Use standard methods to enumerate and identify bacteria.
10. Use laboratory techniques to successfully identify an “unknown” organism.
11. Describe the characteristics of the various groups of microbes including bacteria, archaea, fungi, protozoa, helminthes, viruses, prions and viroids.
12. Demonstrate safe laboratory practices and know how to aseptically handle and dispose of live microbes.
13. Describe the criteria and techniques used to classify microbes and the challenges involved.
14. Describe methods of microbial reproduction including binary fission and budding.
15. Describe DNA structure, organization and replication in microbes.
16. Explain the basic principles of microscopy and the use of stains to enhance contrast in cells.
17. Describe in general terms, microbial roles in each of the following: decomposition/nutrient cycling, O2 production, production of industrial, commercial, and medical products.
18. Describe the general timing of the advent of various types of life on earth.
19. Discuss the principles of antimicrobial chemotherapy.
20. Describe how several factors — including mutation, horizontal gene transfer mechanisms, large population sizes, short generation times — cause rapid evolution of microbial populations.

Appendix E: Competencies for Preparation in Ecology

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

1. Explain the historical importance of ecology and technology to human society.
2. Describe the flow of energy and recycling of nutrients through ecosystems and the biosphere.
3. Explain and describe the importance of the environment to evolution, natural selection and the maintenance of biodiversity.
4. Describe and explain the causes and consequences of pollution on the biosphere and the survival of all organisms.
5. Collect data and formulate valid scientific conclusions of an ecological nature.
6. Work as part of a team in field and laboratory investigations of ecological phenomena.
7. Understand and apply principles of population growth, population regulation, and population dynamics.
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. Understand the principles of community ecology.
13. Describe succession.
14. Explain how speciation occurs.
15. Explain how coevolution occurs and what its effects are.
16. Describe the major biotic and abiotic ecological characteristics that identify a given ecosystem.
17. Describe the biogeochemistry of an ecosystem.
18. Collect ecological data and apply basic statistical skills for analyzing quantitative and qualitative data to formulate conclusions.
19. Describe the physical, biological, and behavioral factors that influence an organism's ability to grow and reproduce in its habitat.
20. 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.
21. Explain energy flow in ecosystems, photosynthesis, trophic levels, and biomass pyramids from an ecological perspective.
22. 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.
23. 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.
24. Recognize the continually changing nature of ecosystems, and discuss factors that impact ecosystems and the evolution of resident species through natural selection.
25. Analyze a variety of timely environmental issues in light of their ecological, social, economic, ethical, or cultural implications.

Appendix F: Competencies for Preparation in Research Methods

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

1. Write a research project proposal.
2. Conduct effective and comprehensive literature searches.
3. Read, understand and critique primary journal articles.
4. Identify a research project to work on.
5. Develop an experimental design for the research project.
6. Conduct the experiments and/or collect the data for the research project.
7. Analyze data using statistical tests when appropriate.
8. Write a scientific paper.
9. Present results of a scientific study in the form of an oral presentation and/or a poster presentation.

Appendix G: Competencies for Preparation in Organic Chemistry

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

NOTE: The competencies for Organic Chemistry will be aligned with those identified in the Statewide Program-to-Program Articulation Agreement for Chemistry, which is currently being developed.

Appendix H: Transfer Credit Framework

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)	Category 2 (3-4 credits)	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
					Introduction to Literature (may also known as Introduction to Poetry, Interpreting Literature, Reading Literature, Theses in Literature, Topics in Literature, Current Themes in Literature)
					Survey of American Literature
					Literature of the Western World
					World Literature
					American Literature
					Survey of English Literature
					Introduction to Theatre

*** Biology students please 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.**