PROPOSED

PENNSYLVANIA STATEWIDE PROGRAM-TO-PROGRAM ARTICULATION AGREEMENT IN ENVIRONMENTAL GEOSCIENCE

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 Environmental Geoscience 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 Environmental Geoscience 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.
- 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 required competencies.

See Appendix A: Program-To-Program Articulation Agreement for Environmental Geosciences

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 Environmental Geoscience.

Students studying Environmental Geoscience are concerned primarily with the composition and structure of the Earth, surficial Earth processes, the control of Earth systems on environmental issues, the impact of human activities on Earth systems, and thoughtful stewardship of our natural resources. Requirements for Environmental Geoscience degrees vary widely, and may permit students to focus in one of a number of different areas such as atmosphere, ground water, or marine science. No professional organization or accrediting body provides guidelines for Environmental Geoscience degrees; however, a solid understanding of the fundamentals of geology as well as mathematics and the physical and biological sciences provides the necessary background for success in a wide variety of advanced coursework in the major.

To that end, it is recommended that the associate degree in Environmental Geoscience include coursework in Geology, Calculus, Physics, Chemistry and Biology. It is the intent of the Physical Sciences Program Articulation Committee that the competencies for prerequisite subjects such as Physics and Chemistry match competencies listed in the appropriate major Program Articulation Agreements.

REQUIRED Major-Specific Content Areas

Under this Agreement, a fully transferable associate degree in the field of Environmental Geoscience must include competencies in the following content areas:

1. **Geology**
2. **Calculus**
3. **Physics**
4. **Chemistry**
5. **Biology**

Institutions may determine how the competencies identified in these primary content areas are met. For example, one institution may choose to embed the geology competencies in one 4-credit course that includes both lecture and laboratory sections, or a three-credit lecture and one-credit independent laboratory course. 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.

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

1. Geology

An environmental geoscientist needs an excellent understanding of the materials from which the Earth is made, the processes acting on and within the Earth, and Earth structures. The student should also have learned the history of the changing Earth through time, and how the rock record can be interpreted to provide evidence of these changes.

The following competency areas will allow majors to identify and solve problems in the geosciences:

Competency Area 1: Formation Of The Solar System And Earth
Competency Area 2: Plate Tectonics And Earthquakes
Competency Area 3: Minerals
Competency Area 4: Igneous Rocks And Environments
Competency Area 5: Weathering, Soil, And Mass Wasting
Competency Area 6: Sedimentary Rocks And Environments
Competency Area 7: Metamorphic Rocks And Environments
Competency Area 8: Deformation And The Continents
Competency Area 9: Surface Water And Groundwater
Competency Area 10: Climate, Glaciers, Wind, And Coastal Processes
Competency Area 11: Geologic Time And Rock Correlation
Competency Area 12: Stratigraphy
Competency Area 13: Sedimentary Environments
Competency Area 14: Origin And Diversity Of Life
Competency Area 15: Evolution
Competency Area 16: The Precambrian
Competency Area 17: Early Paleozoic Life And Earth History
Competency Area 18: Late Paleozoic Life And Earth History
Competency Area 19: Mesozoic Life And Earth History
Competency Area 20: Cenozoic Life And Earth History
Competency Area 21: Primate And Human Evolution

Competency areas #1-11 are often taught as part of a Physical Geology course. Additional competencies in #11-21 are often taught as part of a Historical Geology course.

See Appendix C: Competencies for Preparation in Geology.

2. Calculus

The world around us is constantly changing. Calculus is the branch of mathematics that has been developed to study changes. Therefore, the following competencies provide geologists with the tools for understanding the changes that occur in the Earth, oceans, and atmosphere, and enable them to solve geologic problems.

Competency 1: Utilize the concept of limit.
Competency 2: Differentiate functions.
Competency 3: Use differential calculus to sketch curves and to solve applied problems.
Competency 4: Integrate functions by approximation and by use of antiderivatives.

See Appendix D: Competencies for Preparation in Calculus.

3. Physics

Physics is concerned with the nature and properties of matter and energy. Environmental Geoscientists must understand the underlying physical principles of gravity, kinetic energy, friction, strain, magnetism, refraction, force, and convection, for example, to fully grasp the materials, structure, and processes they study.

Behavioral Objectives: Students will demonstrate competency by:

- Demonstrating how forces cause a change in motion.
- Describing Newton's three laws of motion and law of universal gravitation.
- Demonstrating understanding on impulse and momentum.
- Describing the conservation of momentum.
- Explaining how friction affects the changes of motion.
- Demonstrating how equilibrium is achieved.
- Locating the center of gravity of an object.
- Explaining the different conditions for equilibrium.
- Describing the laws governing planetary motion.
- Differentiating between mass and weight.
- Explaining the concepts of stress and strain, pressure and Archimedes principle.
- Explaining the relationship between force, work, power and energy.
- Describing the laws governing the conservation of energy.
- Describing the nature of waves as energy carriers and the wave properties of reflection, refraction, diffraction and interference.
- Explaining how sound waves are produced, transmitted and propagated.
- Describing the laws of thermodynamics.
- Applying the above-mentioned competencies in a collaborative laboratory environment.

Behavioral Objectives: Students will demonstrate competency by:

- Explaining how electric charges interact.
- Describing the concept of electric field.
- Differentiating between current, voltage and resistance.
- Describing ohm's law.
- Explain the nature of magnetism.
- Describing the contributions of faraday and oersted to electromagnetic theory.
- Describing the structure and function of simple integrated circuits.
- Appreciating the properties of electromagnetic waves and explaining how they are produced, transmitted and used.
- Applying the above-mentioned competencies in a collaborative laboratory environment.

The reader is referred to the Pennsylvania Statewide Program-to-Program Articulation Agreement in Physics for more detailed descriptions of competencies.

4. Chemistry

Earth scientists use chemistry in their study of earth materials and processes ranging from soil development, to climate change, to the composition of the planets.

Competency 1: Introduction to Chemistry.
Competency 2: Measurement.
Competency 3: Atoms, Ions and Compounds.
Competency 4: Chemical Reactions.
Competency 5: Calculations with Formulas and Equations.
Competency 6: Gaseous State.
Competency 7: Thermochemistry.
Competency 8: The Periodic Table and Atomic Structure.
Competency 9: Bonding.
Competency 10: States of Matter: Liquids and Solids.
Competency 11: Solutions.
Competency 12: Kinetics.
Competency 13: Chemical Equilibrium.
Competency 14: Acid-Base Equilibria.
Competency 15: Solubility and Complex Ion Equilibria.
Competency 16: Thermodynamics.
Competency 17: Electrochemistry.

See Appendix E: Competencies for Preparation in General Chemistry

Competencies for preparation in General Chemistry Laboratory are as follows:

Competency 1: Laboratory Safety and Laboratory Notebook.
Competency 2: Dimensional Analysis.
Competency 3: Empirical Formula.
Competency 4: Chemical Reactions.
Competency 5: Titration.
Competency 6: Calorimetry.
Competency 7: Spectroscopy.
Competency 8: Kinetics.
Competency 9: pH.
Competency 10: Buffers.
Competency 11: Density and Other Physical Properties.
Competency 12: Gas Laws.
Competency 13: Chromatography
Competency 14: Chemical Equilibrium.
Competency 15: Electrochemistry.
Competency 16: Molecular Geometry
Competency 17: Colligative Properties.
Competency 18: Solubility

See Appendix F: Competencies for Preparation in General Chemistry Laboratory.

5: Biology

Environmental scientists specifically address the effect of biota on Earth systems and vice versa.

Competency 1: Scientific Investigation
Competency 2: Scientific literature
Competency 3: Cell structure and function
Competency 4: Energy transfer within biological systems

Competency 5: Introduction to molecular genetics
Competency 6: Basic principles of inheritance
Competency 7: Evolution and natural selection
Competency 8: Hierarchical organization of life
Competency 9: Basic biochemistry
Competency 10: Laboratory experiences
Competency 11: Zoology
Competency 12: Botany

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

RECOMMENDED General Content Areas

In addition to the required major competencies listed above, students transferring into a bachelor degree program in Environmental Geosciences would also benefit from acquiring competencies in at least ONE of the following content areas:

1. **Calculus – additional skills/knowledge**
2. **Elementary Statistics**
3. **Geographic Information Systems**

Students will not be penalized for not completing competencies in one or all of these areas of study, though exposure to these additional mathematical principles and geographic information systems would greatly benefit an Environmental Science major transferring at the junior level. If a student chooses to enroll in coursework that includes additional competencies from Calculus or competencies in Elementary Statistics, a minimum grade of C (equivalent of a 2.0 GPA on a 4.0 scale) or better in that coursework is required. See Appendix A: Program-to-Program Articulation Model for Environmental Geosciences.

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 B: Transfer Credit Framework, or http://www.pacollegetransfer.com/Student/TransferCreditFramework/tabid/323/Default.aspx.

Through the Transfer Credit Framework, the commonwealth's Transfer and Articulation Oversight Committee identified six categories of foundation-level coursework that is common among the participating institutions. Each category consists of multiple course options. However, some Framework courses are more relevant to the field of Environmental Geoscience than others. A list of highly recommended courses in each category is included in Appendix A: Program-to-Program Articulation Model for Environmental Geoscience. It is important to note that many worthwhile and useful courses, such as an introductory course in geographic information systems (GIS), may not be part of that The Transfer Credit Framework, so we do **not** recommend that students take **only** Transfer Credit Framework courses, but rather that they confer with a counselor both at the 2-yr and intended 4-yr transfer institution to determine the best possible courses.

Under this Agreement, students should select additional courses according to the criteria indicated for Framework Category 1 (3 credits), Category 2 (3 credits), Category 5 (9 credits) and Category 6 (9 credits).

In Framework Category 3, students may apply a maximum of 4 credits (1 course) completed as part of the Required General Content Area of Calculus.

Likewise, a maximum of 8 credits (2 courses) in Chemistry, a Required General Content Area, may be

used to satisfy the requirements of Framework Category 4. See Appendix A: Program-to-Program Articulation Model for Environmental Geoscience.

The Program Articulation Committee for Physical Sciences urges TAOC to consider adding more courses in Math (Calculus II) and the Physical Sciences (Physical and Historical Geology, Physics II, Calculus-based Physics I and II, Meteorology) to the Transfer Credit Framework, benefiting majors and non-majors alike. Students at two-year colleges may be less likely to take courses that are not part of the framework, and consequently 1) may be less likely to find a good "fit" for their interests, since they may pass over an intriguing course in favor of one listed in the Framework and 2) may consequently be at a disadvantage when they start work toward a four-year degree, if their interests lie in the physical sciences.

These courses are recommendations only. They are not required as part of the major or the articulation Agreement. Students will not be penalized for not completing the recommended courses prior to transferring. The courses listed are merely suggestions that could enhance a student's academic frame of reference as an environmental science major.

Students are advised to work closely with an advisor to select courses related to their associate degree program, transfer major and personal interests. Contact should be made with an advisor at the expected four-year institution to as soon as possible during Associate's degree coursework to ensure that the four-year institution's general education requirements are appropriately woven into the student's associate degree curriculum.

Appendix A: Program-To-Program Articulation Agreement for Environmental Geosciences

Major-Specific Content Areas – REQUIRED	Transfer Criteria
Geology	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 Geology.
Calculus	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 Calculus.
Physics	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 Physics.
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 Chemistry.
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 Biology.
General Content Areas – RECOMMENDED	**Transfer Criteria**
Calculus II or **Elementary Statistics** is suggested. One course in **Geographic Information Systems** is also recommended	Student should consult an advisor before enrolling in the recommended coursework.
REQUIRED Transfer Grade Point Average	**Transfer Criteria**
Overall grade Point Average	Equivalent of a 2.0 GPA on a 4.0 scale

Transfer Credit Framework Category	Framework Requires Students to Take…^	Environmental Geoscience Majors are REQUIRED to Take…	Environmental Geoscience Majors are RECOMMENDED to Take…
Category 1	1 course (3-4 credits)		**One course** selected in consultation with an advisor
Category 2	1 course (3-4 credits)		**One course** selected in consultation with an advisor
Category 3^^	2 courses (6-8 credits)	**1. Calculus I***	2. One additional math course such as **Calculus II^^** or **Elementary Statistics.** ****Minimum grade of C (equivalent of a 2.0 GPA on a 4.0 scale)
Category 4^^	2 courses (6-8 credits)	**1. Chemistry I**** **2. Chemistry II**	Competencies associated with four additional courses (**Physics I and II, Biology I and II)** are among the General Content Area Requirements for Environmental Geoscience^^. **Minimum grade of C equivalent of a 2.0 GPA on a 4.0 scale)
Category 5	2 courses (6-8 credits)		**2 courses** to be selected in consultation with an advisor.
Category 6	2 courses (6-8 credits)		**1. Ethics** **2. One additional course** to be selected in consultation with an advisor.

^Students are advised not to exceed the credit number indicated in each Framework Category. Credit requirements are presented as a range since actual credit number may vary by specific course and institution.
^^Adding courses in math (Calculus II), and the physical sciences (Physical and Historical Geology, Physics II, Calculus-based Physics I and II, Meteorology) to the Transfer Credit Framework would benefit many students in the physical sciences.
* Environmental Geoscience majors may use up to 4 credits of coursework from the Required Content Area of Calculus to satisfy Category 3 requirements.
** Environmental Geoscience majors may use up to 8 credits of coursework from the Required Content Area of Chemistry to satisfy Category 4 requirements.

Appendix B: 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

Appendix C: Competencies for Preparation in Geology

Competency area 1: Formation of the solar system and Earth
Behavioral Objectives: Students will demonstrate competency by:

- Describing current hypotheses for the formation of the solar system, Earth, and moon
- Explaining the internal structure and composition of the Earth

Competency area 2: Plate tectonics and earthquakes
Behavioral Objectives: Students will demonstrate competency by:

- Explaining the evidence for continental drift
- Explaining the evidence for plate tectonics
- Describing the energy sources and forces driving plate tectonics
- Describing the theory of plate tectonics
- Defining convergent, divergent, and transform plate boundaries and discussing geologic features associated with each.
- Describing the process by which energy is stored as strain and released as seismic waves to create an earthquake
- Describing and explaining the distribution of earthquake epicenters
- Listing the types of seismic waves and describing how they travel through/around the earth.
- Being able to locate the epicenter of an earthquake
- Discussing the methods and effectiveness of both short-term and long-term earthquake prediction

Competency area 3: Minerals
Behavioral Objectives: Students will demonstrate competency by:

- Defining mineral
- Discussing the basic building blocks of minerals, and the types of bonds that hold minerals together
- Identifying common rock-forming minerals based on characteristic physical properties
- Listing the major mineral families and providing examples of each

Competency area 4: Igneous rocks and environments
Behavioral Objectives: Students will demonstrate competency by:

- Identifying and classifying common intrusive and extrusive igneous rocks based on composition and texture
- Describing common intrusive and extrusive igneous environments, processes, and landforms
- Discussing magma evolution
- Explaining Bowen's reaction series

Competency area 5: Weathering, soil, and mass wasting
Behavioral Objectives: Students will demonstrate competency by:

- Explaining the difference between physical and chemical weathering
- Describing physical and chemical weathering processes
- Defining soil and explaining the formation of an idealized soil profile.
- Explaining the development of common broad soil classes
- Discussing the primary controls and triggers of mass wasting and subsidence
- Listing and describing the different types of mass wasting

Competency area 6: Sedimentary rocks and environments
Behavioral Objectives: Students will demonstrate competency by:

- Describing common sedimentary environments, processes, and structures
- Identifying and classifying common clastic and chemical sedimentary rocks based on composition and texture

Competency area 7: Metamorphic rocks and environments
Behavioral Objectives: Students will demonstrate competency by:

- Describing common metamorphic environments and processes
- Identifying and classifying common foliated and non-foliated metamorphic rocks based on composition and texture
- Explaining the processes by which one rock can be changed into another in the Rock Cycle.

Competency area 8: Deformation and the continents
Behavioral Objectives: Students will demonstrate competency by:

- Explaining the difference between stress and strain
- Discussing environments in which rocks experience strain
- Defining and being able to identify different types of faults and folds.
- Explaining how the attitude of rocks can be described with strike and dip.
- Identifying a wide variety of structures such as folds, faults, and unconformities on block diagrams.
- Explaining how mountain building events connect with the Wilson Cycle
- Defining isostasy
- Discussing the patterns of continental development through time

Competency area 9: Surface water and groundwater
Behavioral Objectives: Students will demonstrate competency by:

- Identifying the reservoirs in which water is stored, and describing both the processes that move water from one reservoir to another and the sources of energy driving water's movement through the hydrologic cycle.
- Discussing the most important factors influencing work (erosion, transport, deposition) done by streams
- Describing erosional and depositional stream-shaped landforms
- Identifying drainage patterns and relating patterns to geologic setting
- Explaining the occurrence and movement of groundwater
- Discussing issues of groundwater availability and contamination
- Explaining the development of karst

Competency area 10: Climate, glaciers, wind, and coastal processes
Behavioral Objectives: Students will demonstrate competency by:

- Differentiate between weather and climate
- Discussing the distribution of heat by air and water
- Explaining the main controls on climate, including possible causes of ice ages
- Explaining the greenhouse effect, and discus anthropogenic influence on climate
- Discussing use of temperature proxies
- Describing the location and movement of glaciers
- Identifying and explaining the origin of erosional and depositional glacial landforms
- Discussing the role of water and weathering in arid climates
- Identifying landforms common in arid climates
- Describing wave erosion and the landforms produced by wave erosion.
- Discussing shoreline erosional problems and solutions.

Competency area 11: Geologic time and rock correlation
Behavioral Objectives: Students will demonstrate competency by:

- Explaining the key principles of relative age dating
- Listing the three types of unconformities and Describing how each forms
- Determining the order of events in a cross section or landscape based on principles of relative age dating.
- Explaining the principles underlying radiometric dating.
- Explaining at least one line of evidence for the age of the Earth
- Knowing the names and age ranges of the major eons and eras of the geologic time scale
- Using the principle of faunal succession to determine relative age and correlate rock units.
- Discussing how relative age dating was used to create the early geologic time scale

- Explaining or demonstrating how relative and radiometric dating can be sued together to constrain the timing of geologic events
- Explaining at least three lines of evidence for the age of the Earth
- Knowing the names and age ranges of the eons, eras, and periods.

Competency area 12: Stratigraphy
Behavioral Objectives: Students will demonstrate competency by:

- Describing the different types of fossil preservation
- Using the principle of faunal succession to determine relative age and correlate rock units
- Defining Walther's Law and using it to interpret facies changes in a stratigraphic sequence
- Describing transgression and regression, and identifying them in a stratigraphic sequence
- Comparing and contrasting the various ways in which rock units can be correlated.

Competency area 13: Sedimentary environments
Behavioral Objectives: Students will demonstrate competency by:

- Discussing common depositional environments.
- Interpreting characteristics and features of sedimentary rocks (grain size, sorting, shape, mineralogy, sedimentary structures, and color) to determine the subaerial or subaqueous environment in which they were deposited.

Competency area 14: Origin and diversity of life
Behavioral Objectives: Students will demonstrate competency by:

- Discussing theories of the origin of life
- Listing and identifying distinguishing characteristics of the six kingdoms of life

Competency area 15: Evolution
Behavioral Objectives: Students will demonstrate competency by:

- Discussing the development of Evolutionary Theory
- Explaining the theory of evolution
- Comparing macroevolution and microevolution
- Describing evidence for evolution

Competency area 16: The Precambrian
Behavioral Objectives: Students will demonstrate competency by:

- Describing evidence from the rock record for changing geologic processes throughout the Precambrian.
- Discussing the development of and evolution of Precambrian life
- Describing the Precambrian evolution of the atmosphere and oceans.

Competency area 17: Early Paleozoic life and Earth history
Behavioral Objectives: Students will demonstrate competency by:

- Describing evidence from the rock record for geologic and climate processes that operated during the Early Paleozoic.
- Explaining the significance of the Sauk sequence
- Describing the orogenic events affecting North America during the Late Paleozoic
- Discussing evidence for development of and evolution of Early Paleozoic life,
- Describing the Precambrian evolution of the atmosphere and oceans.

Competency area 18: Late Paleozoic life and Earth history
Behavioral Objectives: Students will demonstrate competency by:

- Describing evidence from the rock record for geologic and climate processes that operated during the Late Paleozoic.
- Describing the orogenic events affecting North America during the Late Paleozoic
- Discussing evidence for development of and evolution of Late Paleozoic life, including development of including the development of plants and land animals
- Explaining possible causes of the end Permian mass extinction

Competency area 19: Mesozoic life and Earth history
Behavioral Objectives: Students will demonstrate competency by:

- Describing evidence from the rock record for geologic and climate processes that operated during the Mesozoic
- Describing the orogenic events affecting North America during the Mesozoic
- Discussing the evolution of Mesozoic life
- Explaining evidence for possible causes of the end Cretaceous mass extinction

Competency area 20: Cenozoic life and Earth history
Behavioral Objectives: Students will demonstrate competency by:

- Explaining the influence of plate tectonics on global climate
- Describing the orogenic events affecting North America during the Cenozoic
- Discussing the evolution of Cenozoic life, including the spread of mammals
- Describing climate changes that occurred during the Cenozoic, and their effect on terrestrial and marine life.

Competency area 21: Primate and human evolution
Behavioral Objectives: Students will demonstrate competency by:

- Discussing the evolutionary history of primates

Appendix D: Competencies for Preparation in Calculus

Competency 1: Utilize the concept of limit.
Behavioral Objectives: Students will demonstrate competency by:

1.1 determining limits using a table of values or graph.
1.2 evaluating limits of polynomial, rational, and trigonometric functions by direct substitution.
1.3 where substitution yields an indeterminate form, finding limits by cancellation and rationalization techniques or by the use of identities.
1.4 using L'Hopital's Rule to find limits of indeterminate forms.
1.5 evaluating limits using the Squeeze Theorem.
1.6 using limit theorems involving sums, differences, products, and quotients of functions.
1.7 indicating whether a function is continuous or discontinuous; if discontinuous, give all points of discontinuity.
1.8 determining limits at infinity.

Competency 2: Differentiate functions.
Behavioral Objectives: Students will demonstrate competency by:

2.1 defining and interpreting the derivative of a function.
2.2 computing derivatives of functions using the definition.
2.3 obtaining the derivatives of sums, products, quotients, and powers of polynomial, trigonometric, and transcendental functions using the general formulas for differentiation.
2.4 using the chain rule to differentiate the composition of functions.
2.5 finding differentials.
2.6 differentiating implicitly.
2.7 finding higher order derivatives.
2.8 evaluating derivatives.

Competency 3: Use differential calculus to sketch curves and to solve applied problems.
Behavioral Objectives: Students will demonstrate competency by:

3.1 finding the intervals on which a function is increasing or decreasing and the intervals on which a function is concave upward or concave downward.
3.2 determining relative minima, relative maxima, and points of inflection, if any, and sketch the graph of a function.
3.3 finding the equations of lines tangent and normal to a curve at a given point.
3.4 finding the point(s) on a curve where the tangent line has a given slope.
3.5 using differentials to approximate values of non-linear functions.
3.6 approximating a solution for an equation using Newton's Method.
3.7 given a position function, calculating the velocity and acceleration of a particle and analyzing its motion.
3.8 applying Rolle's Theorem and the Mean Value Theorem to a function.
3.9 solving applied related rate problems.
3.10 solving applied maximum-minimum problems.
3.11 applying the Extreme Value Theorem to a function.

Competency 4: Integrate functions by approximation and by use of antiderivatives.
Behavioral Objectives: Students will demonstrate competency by:

4.1 defining the indefinite and definite integral of a function.
4.2 finding antiderivatives by using the power rule and substitution.
4.3 integrating algebraic and trigonometric functions.
4.4 determining the constant of integration given sufficient conditions.
4.5 using the Fundamental Theorem of Calculus to evaluating definite integrals.
4.6 approximating an integral by the Trapezoidal Rule or Simpson's Rule.
4.7 using the 2nd Fundamental Theorem of Integral Calculus
4.8 expressing the limit of a Riemann sum as a definite integral.

Appendix E: Competencies for Preparation in General Chemistry

Competency 1: Introduction to Chemistry.
Behavioral Objectives: Students will demonstrate competency by:
- 1.1 Presenting the scientific method.
- 1.2 Classifying matter on the basis of physical and chemical properties.
- 1.3 Classifying matter on the basis of physical and chemical changes.

Competency 2: Measurement.
Behavioral Objectives: Students will demonstrate competency by:
- 2.1 Listing the common SI units of measurement, the values of selected prefixes, and the use of dimensional analysis to interconvert units of measurement.
- 2.2 Learning to use the rules for significant figures for calculation problems.

Competency 3: Atoms, Ions and Compounds.
Behavioral Objectives: Students will demonstrate competency by:
- 3.1 Describing the structure of the atom in terms of subatomic particles; write the isotopic symbol for any isotope of a given element or ion.
- 3.2 Describing the basic features of the periodic table.
- 3.3 Writing formulas of ionic or covalent compounds from their names and from their names write their formulas.

Competency 4: Chemical Reactions.
Behavioral Objectives: Students will demonstrate competency by:
- 4.1 Writing and balancing a chemical reaction.
- 4.2 Being able to classify reactions into various types such as combination, decomposition, single replacement, double replacement, oxidation-reduction, acid-base, precipitation and gas forming reactions.

Competency 5: Calculations with Formulas and Equations.
Behavioral Objectives: Students will demonstrate competency by:
- 5.1 Using mole concept to calculate the molar mass, the number of moles from the mass of a sample, the number of atoms or molecules and molarity of solutions.
- 5.2 Applying the mole concept to the determination of mass %, empirical and molecular formulas.
- 5.3 Applying the mole concept to reaction stoichiometry calculations including limiting reagent and percent yield.

Competency 6: Gaseous State.
Behavioral Objectives: Students will demonstrate competency by:
- 6.1 Using kinetic molecular theory to account for the properties of gases and the gas laws (Boyles, Charles, Avogadro, etc.).
- 6.2 Using gas laws to calculate the pressure, volume, temperature or number of moles from appropriate data.
- 6.3 Using the Ideal gas law to determine the density or molar mass of a gas and the stoichiometry of reactions involving gases.
- 6.4 Calculating the partial pressure or mole fractions from the appropriate data of gas mixtures.
- 6.5 Explaining how the properties of real gases differ from an Ideal Gas.

Competency 7: Thermochemistry.
Behavioral Objectives: Students will demonstrate competency by:
- 7.1 Explaining the role of heat in chemical reactions (Thermodynamic Laws).
- 7.2 Perform calorimetric calculations and use enthalpy tables or Hess's Law to determine the heat of a reaction.

Competency 8: The Periodic Table and Atomic Structure.
Behavioral Objectives: Students will demonstrate competency by:

8.1 Explaining the relationships between the properties of electromagnetic radiation with respect to wavelength, frequency, energy and spectral region and be able to calculate the energy, frequency or wavelength from appropriate data.
8.2 Comparing and contrasting the Bohr and quantum theories of atomic structure and how they account for location of electrons in atoms and spectral lines.
8.3 Explaining the characteristics of atomic orbitals and the quantum numbers associated with them.
8.4 Writing the electronic configuration of atoms and ions.
8.5 Using the periodic table to predict the physical and chemical properties of elements, including atomic radii, ionization energy and electron affinity.

Competency 9: Bonding.
Behavioral Objectives: Students will demonstrate competency by:

9.1 Writing Lewis structures for neutral atoms, ions, ionic and covalent compounds.
9.2 Using Lewis structures and VSPER theory to predict electronic and molecular geometries.
9.3 Using the principle of electronegativity to describe the characteristics of polar covalent bonds.
9.4 Using the polar and covalent bonds and VSEPR to determine the overall polarity of a molecule.
9.5 Using valence bond theory and molecular geometry to determine the hybridization of atoms.
9.6 Comparing and contrasting valence bond, molecular orbital and metallic bonding theories and how each accounts for molecular structures and properties.

Competency 10: States of Matter: Liquids and Solids.
Behavioral Objectives: Students will demonstrate competency by:

10.1 Comparing the differences between the state of matter and the changes of state that occur.
10.2 Describing the major types of intermolecular forces and using them to explain the properties of solids and liquids such as boiling point, melting point, surface tension and viscosity.
10.3 Describing how intermolecular forces determine solubility of polar and nonpolar substances.

Competency 11: Solutions.
Behavioral Objectives: Students will demonstrate competency by:

11.1 Calculating the concentration of solutions in molarity, molality, normality, mole fraction, or percent by mass and be able to interconvert between them.
11.2 Listing the colligative properties of solutions (freezing point depression, boiling point elevation, vapor pressure lowering and osmotic pressure) and performing calculations involving them.

Competency 12: Kinetics.
Behavioral Objectives: Students will demonstrate competency by:

12.1 Determining rate laws and order of a reaction from experimental data using the initial rates or graphical methods.
12.2 Using collision theory to explain the concept of activation energy and the effect of temperature on reaction rates and use the Arrhenius equation to calculate the activation energy.
12.3 Learning to use elementary steps to link the mechanism of a reaction to the rate law.
12.4 Explaining how a catalyst affects a reaction.

Competency 13: Chemical Equilibrium.
Behavioral Objectives: Students will demonstrate competency by:

13.1 Stating and applying LeChatlelier's Principle to a reaction at equilibrium.
13.2 Calculating the value of an equilibrium constant from experimental data and using equilibrium constants to predict quantities of all species at equilibrium.

Competency 14: Acid-Base Equilibria.
Behavioral Objectives: Students will demonstrate competency by:

14.1 Stating and applying the Arrenhius, Bronsted-Lowry and Lewis acid-base theories to acid-base reactions.
14.2 Performing equilibrium calculations for pH, Ka and buffer systems.

Competency 15: Solubility and Complex Ion Equilibria.
Behavioral Objectives: Students will demonstrate competency by:

15.1 Explaining the concept of solubility product constant, complex ion equilibrium, the common ion effect and writing the Ksp and Keq expressions.
15.2 Calculating the molar solubility of a species and determine if a precipitate will form.

Competency 16: Thermodynamics.
Behavioral Objectives: Students will demonstrate competency by:

16.1 Discussing the fundamental laws of thermodynamics, free energy and entropy.
16.2 Performing thermodynamics calculations to predict the spontaneity of a chemical reaction and its equilibrium constant.

Competency 17: Electrochemistry.
Behavioral Objectives: Students will demonstrate competency by:

17.1 Discussing and applying the principles of electrochemistry including writing and balancing redox reactions.
17.2 Calculating cell potentials.
17.3 Calculating free energy and equilibrium constants from cell potentials.

Appendix F: Competencies for Preparation in General Chemistry Laboratory

Competency 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 2: Dimensional Analysis.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that emphasizes dimensional analysis and use of significant figures.

Competency 3: Empirical Formula.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that involves the calculation of empirical formula.

Competency 4: Chemical Reactions.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that involves a synthesis and limiting reactant calculation.

Competency 5: Titration.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that involves titration analysis that utilizes the concept of oxidation reduction reactions, acid-base reactions or complex ion reactions.

Competency 6: Calorimetry.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment involving calorimetry to measure specific heat or heat of reaction.

Competency 7: Spectroscopy.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that utilizes a UV-Visible spectrometer in the construction of a calibration curve and analysis of an unknown.

Competency 8: Kinetics.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that involves the application of kinetic calculations (first order, second order, or pseudo-first order, etc.) using the method of initial rates or a graphical approach.

Competency 9: pH.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that utilizes a pH meter and demonstrates changes in equilibria in a pH titration.

Competency 10: Buffers.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment involving buffers.

Competency 11: Density and Other Physical Properties.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that determines the density of substances or other physical properties.

Competency 12: Gas Laws.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that uses the Ideal Gas Law to determine the stoichiometry of a gas forming reaction or the molar mass of a gas or measures the physical properties of gases.

Competency 13: Chromatography
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that demonstrates how a mixture is separated by chromatography and the components identified or measured.

Competency 14: Chemical Equilibrium.
B Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that illustrates LeChatalier's Principle or where an equilibrium constant is determined.

Competency 15: Electrochemistry.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that determines the potentials for voltaic cells or uses electrolytic cells to run chemical reactions.

Competency 16: Molecular Geometry
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that determines the molecular geometry of molecules using computer or molecular models.

Competency 17: Colligative Properties.
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that determines the colligative property of a solution.

Competency 18: Solubility
Behavioral Objectives: Students will demonstrate competency by:
Performing an experiment that determines solubility rules or measures the solubility product constant of a compound.

Appendix G: Competencies for Preparation in Principles of Biology

Competency 1: Scientific Investigation
Behavioral Objectives: Students will demonstrate competency by:

1. Defining, describing, and implementing the scientific method.
2. Describing implications of scientific or technological developments on ethical questions in biology.

Competency 2: Scientific literature
Behavioral Objectives: Students will demonstrate competency by:

3. Locating and critically evaluating scientific information.
4. Writing literature reviews and lab reports.

Competency 3: Cell structure and function
Behavioral Objectives: Students will demonstrate competency by:

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

Competency 4: Energy transfer within biological systems
Behavioral Objectives: Students will demonstrate competency by:

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

Competency 5: Introduction to molecular genetics
Behavioral Objectives: Students will demonstrate competency by:

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

Competency 6: Basic principles of inheritance
Behavioral Objectives: Students will demonstrate competency by:

16. Understanding and describing 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: Students will demonstrate competency by:

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

Competency 8: Hierarchical organization of life
Behavioral Objectives: Students will demonstrate competency by:

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

Competency 9: Basic biochemistry
Behavioral Objectives: Students will demonstrate competency by:

24. Describing the fundamental properties of water in biological systems.
25. Describing the four major biomolecules, carbohydrate, lipid, nucleic acid, and protein. Be able to explain their functions and importance in biological systems.
26. Drawing and describing basic synthesis and degradation reactions of the four major biomolecules.

27. Describing basic enzyme structure and function.
28. Describing how biological systems are constrained by chemical and physical processes.

Competency 10: Laboratory experiences
Behavioral Objectives: Students will demonstrate competency by:

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

Competency 11: Zoology
Behavioral Objectives: Students will demonstrate competency by:

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. Listing the distinguishing characteristics of the protists and selected phyla within the kingdom.
37. Listing 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. Understanding the basic characteristics and comparative biology of the major vertebrate classes.
39. Describing the primary physiologies of major phyletic groups.
40. Demonstrating the skills required of microscopic examination of animal tissues.
41. Demonstrating the skills required of gross animal dissection.
42. Identifying and discussing issues relating to evolutionary events surrounding the rise of gross animal architecture.
43. Identifying and discussing issues relating to the evolution of the main lines of animal phylogeny.

Competency 12: Botany
Behavioral Objectives: Students will demonstrate competency by:

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