Conceptual Elements Course Inventory

FOR MORE INFORMATION CONTACT:
Tawnya Cary & Janet Branchaw, University of Wisconsin - Madison
Conceptual Elements Course Inventory

Instructions: Indicate whether each conceptual element is addressed in the course in the Y/N column. If yes, then identify the specific topic or course content that is taught and at what scale(s).

| Course: PATHWAYS AND TRANSFORMATIONS OF ENERGY AND MATTER (PTEM) |
|---------------------------------------------------------------|
| **PTEM1**: Energy is neither created nor destroyed, but can be transformed from one form to another to generate biological activity. |
| Y / N | Topic/Course Content | Scale(s) |
| ☐ | | cell/molec |
| ☐ | | organismal |
| ☐ | | ecosystem |
| **PTEM2**: Input of energy, which can be from different sources, is needed to build and maintain biological entities, thereby lowering entropy in the system. |
| Y / N | Topic/Course Content | Scale(s) |
| ☐ | | cell/molec |
| ☐ | | organismal |
| ☐ | | ecosystem |
| **PTEM3**: Biological entities harness potential energy stored in electrochemical gradients and released from chemical reactions. |
| Y / N | Topic/Course Content | Scale(s) |
| ☐ | | cell/molec |
| ☐ | | organismal |
| ☐ | | ecosystem |
| **PTEM4**: Matter is recycled through the re-arrangement of chemical bonds in biological entities. |
| Y / N | Topic/Course Content | Scale(s) |
| ☐ | | cell/molec |
| ☐ | | organismal |
| ☐ | | ecosystem |
| **PTEM5**: Biological entities regulate the synthesis, storage and mobilization of biological compounds to meet energy demands. |
| Y / N | Topic/Course Content | Scale(s) |
| ☐ | | cell/molec |
| ☐ | | organismal |
| ☐ | | ecosystem |
| **PTEM6**: Many chemical elements can serve as electron donors and acceptors to drive biological processes. |
| Y / N | Topic/Course Content | Scale(s) |
| ☐ | | cell/molec |
| ☐ | | organismal |
| ☐ | | ecosystem |
| **PTEM7**: Matter can transfer between the abiotic and biotic components of biological systems. |
| Y / N | Topic/Course Content | Scale(s) |
| ☐ | | cell/molec |
| ☐ | | organismal |
| ☐ | | ecosystem |

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| Course: | Y / N | Topic/Course Content | Scale(s) |
|---------|-------|-----------------------|----------|
| INFORMATION FLOW, EXCHANGE AND STORAGE (IFES) | | | |
| IFES1: Information exists in many forms and is relayed within and across biological molecules, cells, tissues, organisms, populations and ecosystems. | ☐ | | cell/molec organismal ecosystem |
| IFES2: Genetic information is stored in nucleic acids (DNA and RNA); epigenetic information is stored in proteins that associate with DNA and in reversible DNA modifications. | ☐ | | cell/molec organismal ecosystem |
| IFES3: The process of protein synthesis results from the flow of genetic information through various pathways. | ☐ | | cell/molec organismal ecosystem |
| IFES4: Information from the environment regulates protein synthesis and activity, which control cellular processes and thereby organismal and population-level activity. | ☐ | | cell/molec organismal ecosystem |
| IFES5: Organisms transmit genes and epigenetic information to their offspring. | ☐ | | cell/molec organismal ecosystem |

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| Course: | Y / N | Topic/Course Content | Scale(s) |
|---------|-------|----------------------|----------|
| **STRUCTURE AND FUNCTION (SF)** | | | |
| SF1: Biological structures from the molecular to the ecosystem scale and their interactions are determined by chemical and physical properties that both enable and constrain function. | ☐ | | cell/molec organismal ecosystem |
| SF2: Individual structures can be arranged into organized units that enable more complex functions. | ☐ | | cell/molec organismal ecosystem |
| SF3: Structural features of biological entities undergo changes during development that are determined by the regulation of gene expression. | ☐ | | cell/molec organismal ecosystem |
| SF4: Structural features are dynamic and modifications can be made in response to environmental changes that are compensatory to restore lost function, or non-compensatory to eliminate functions that are no longer needed. | ☐ | | cell/molec organismal ecosystem |
| SF5: Comparable changes in structure can have small or large effects on function, depending on the spatial location. | ☐ | | cell/molec organismal ecosystem |

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| Course: | Y / N | Topic/Course Content | Scale(s) |
|---------|-------|----------------------|----------|
| **EVOLUTION (E)** |       |                      |          |
| E1: All living organisms share common ancestors at some time in the past. | ☐ | | cell/molec, organismal, ecosystem |
| E2: The phenotypes of living organisms result from the gain and loss of traits along their lineage. | ☐ | | cell/molec, organismal, ecosystem |
| E3: Genetic variation within a population can be generated by mutation, which results in the generation of novel traits, and by sexual recombination, endosymbiosis and horizontal gene transfer. | ☐ | | cell/molec, organismal, ecosystem |
| E4: Phenotypes, based upon underlying genotypes and environmental factors, can be subject to selective pressure. | ☐ | | cell/molec, organismal, ecosystem |
| E5: Organisms have greater fitness if they have a phenotype that increases their ability to survive and reproduce in a particular environment. | ☐ | | cell/molec, organismal, ecosystem |
| E6: Populations are composed of individual organisms that vary in their fitness, leading to differential rates of survival and reproduction and therefore changes in allele frequency over time. | ☐ | | cell/molec, organismal, ecosystem |
| E7: Evolution in a population may be due to events not related to fitness, including genetic drift and gene flow. | ☐ | | cell/molec, organismal, ecosystem |
| E8: The rate of evolutionary change varies and is influenced by many factors, including mutation rate, generation time, and environmental variation. | ☐ | | cell/molec, organismal, ecosystem |
| E9: Speciation occurs when subpopulations can no longer exchange genetic material, allowing them to diverge over time in their physiological and ecological traits. | ☐ | | cell/molec, organismal, ecosystem |

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| Course: | Y / N | Topic/Course Content | Scale(s) |
|---------|-------|----------------------|----------|
| **SYSTEMS** (S) | | | |
| S1: Biological entities interact through chemical and physical signals that can be transient, depend on spatial organization, and are influenced by environmental factors. | | | ☐ cell/molec ☐ organismal ☐ ecosystem |
| S2: Changes in one component of a biological system can affect or be regulated by other components of the same system. | | | ☐ cell/molec ☐ organismal ☐ ecosystem |
| S3: Biological systems can be defined at different scales, interact within and across scales, and together form complex networks. | | | ☐ cell/molec ☐ organismal ☐ ecosystem |
| S4: Biological systems include and are affected by biotic and abiotic factors in the environment. | | | ☐ cell/molec ☐ organismal ☐ ecosystem |
| S5: Interactions between and among biological entities can generate new system properties. | | | ☐ cell/molec ☐ organismal ☐ ecosystem |
Conceptual Elements Department Inventory
## Conceptual Elements Department Inventory

Instructions: Use individual course inventories to map the conceptual elements that are covered at each scale across the curriculum.

| Courses: |  |  |  |  |  |
|----------|---|---|---|---|---|
| **PATHWAYS AND TRANSFORMATIONS OF ENERGY AND MATTER (PTEM)** |  |  |  |  |  |
| PTEM1: Energy is neither created nor destroyed, but can be transformed from one form to another to generate biological activity. | ☐ | ☐ | ☐ | ☐ | ☐ |
| PTEM2: Input of energy, which can be from different sources, is needed to build and maintain biological entities, thereby lowering entropy in the system. | ☐ | ☐ | ☐ | ☐ | ☐ |
| PTEM3: Biological entities harness potential energy stored in electrochemical gradients and released from chemical reactions. | ☐ | ☐ | ☐ | ☐ | ☐ |
| PTEM4: Matter is recycled through the re-arrangement of chemical bonds in biological entities. | ☐ | ☐ | ☐ | ☐ | ☐ |
| PTEM5: Biological entities regulate the synthesis, storage and mobilization of biological compounds to meet energy demands. | ☐ | ☐ | ☐ | ☐ | ☐ |
| PTEM6: Many chemical elements can serve as electron donors and acceptors to drive biological processes. | ☐ | ☐ | ☐ | ☐ | ☐ |
| PTEM7: Matter can transfer between the abiotic and biotic components of biological systems. | ☐ | ☐ | ☐ | ☐ | ☐ |

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| Courses: | | | | |
|----------|---------|---------|---------|---------|

**INFORMATION FLOW, EXCHANGE AND STORAGE (IFES)**

| IFES1: Information exists in many forms and is relayed within and across biological molecules, cells, tissues, organisms, populations and ecosystems. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |

| IFES2: Genetic information is stored in nucleic acids (DNA and RNA); epigenetic information is stored in proteins that associate with DNA and in reversible DNA modifications. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |

| IFES3: The process of protein synthesis results from the flow of genetic information through various pathways. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |

| IFES4: Information from the environment regulates protein synthesis and activity, which control cellular processes and thereby organismal and population-level activity. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |

| IFES5: Organisms transmit genes and epigenetic information to their offspring. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |

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| Courses: |          |          |          |          |          |
|----------|----------|----------|----------|----------|----------|
| **STRUCTURE AND FUNCTION (SF)** |          |          |          |          |          |
| SF1: Biological structures from the molecular to the ecosystem scale and their interactions are determined by chemical and physical properties that both enable and constrain function. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| SF2: Individual structures can be arranged into organized units that enable more complex functions. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| SF3: Structural features of biological entities undergo changes during development that are determined by the regulation of gene expression. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| SF4: Structural features are dynamic and modifications can be made in response to environmental changes that are compensatory to restore lost function, or non-compensatory to eliminate functions that are no longer needed. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| SF5: Comparable changes in structure can have small or large effects on function, depending on the spatial location. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |

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| Courses: | | | | |
| --- | --- | --- | --- | --- |
| **EVOLUTION (E)** | | | | |
| E1: All living organisms share common ancestors at some time in the past. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| E2: The phenotypes of living organisms result from the gain and loss of traits along their lineage. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| E3: Genetic variation within a population can be generated by mutation, which results in the generation of novel traits, and by sexual recombination, endosymbiosis and horizontal gene transfer. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| E4: Phenotypes, based upon underlying genotypes and environmental factors, can be subject to selective pressure. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| E5: Organisms have greater fitness if they have a phenotype that increases their ability to survive and reproduce in a particular environment. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| E6: Populations are composed of individual organisms that vary in their fitness, leading to differential rates of survival and reproduction and therefore changes in allele frequency over time. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| E7: Evolution in a population may be due to events not related to fitness, including genetic drift and gene flow. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| E8: The rate of evolutionary change varies and is influenced by many factors, including mutation rate, generation time, and environmental variation. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |
| E9: Speciation occurs when subpopulations can no longer exchange genetic material, allowing them to diverge over time in their physiological and ecological traits. | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec | ☐ cell/molec |
| | ☐ organismal | ☐ organismal | ☐ organismal | ☐ organismal |
| | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem | ☐ ecosystem |

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| Courses: | | | | |
| --- | --- | --- | --- | --- |
| **SYSTEMS (S)** | | | | |
| S1: Biological entities interact through chemical and physical signals that can be transient, depend on spatial organization, and are influenced by environmental factors. | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec |
| | □ organismal | □ organismal | □ organismal | □ organismal | □ organismal |
| | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem |
| S2: Changes in one component of a biological system can affect or be regulated by other components of the same system. | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec |
| | □ organismal | □ organismal | □ organismal | □ organismal | □ organismal |
| | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem |
| S3. Biological systems can be defined at different scales, interact within and across scales, and together form complex networks. | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec |
| | □ organismal | □ organismal | □ organismal | □ organismal | □ organismal |
| | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem |
| S4: Biological systems include and are affected by biotic and abiotic factors in the environment. | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec |
| | □ organismal | □ organismal | □ organismal | □ organismal | □ organismal |
| | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem |
| S5: Interactions between and among biological entities can generate new system properties. | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec | □ cell/molec |
| | □ organismal | □ organismal | □ organismal | □ organismal | □ organismal |
| | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem | □ ecosystem |

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