**Understandings, Applications and Skills** (This is what you may be assessed on)

**Significant ideas**

* A systems approach can help in the study of complex environmental issues
* The use of systems and models simplifies interactions but may provide a more holistic view without reducing issues to single processes

**Big questions**

* What strengths and weaknesses of the systems approach and the use of models have been revealed through this topic?
* How does a systems approach facilitate a holistic approach to understanding?
* What are the strengths and weaknesses of the systems you have examined in this section?
* What have you learned about models and how they can be used, for example, to predict climate change? Do their benefits outweigh their limitations?

|  | **Statement** | **Guidance** |
| --- | --- | --- |
| 1.2.U1 | A systems approach is a way of visualizing a complex set of interactions which may be ecological or societal. | A systems approach should be taken for all the topics covered in the ESS course |
| 1.2.U2 | These interactions produce the emergent properties of the system |  |
| 1.2.U3 | The concept of a system can be applied at a range of scales. | Biosphere refers to the part of the Earth inhabited by organisms that extends from the upper parts of the atmosphere to deep within the Earth’s crust. |
| 1.2.U4 | A system is comprised of storages and flows |  |
| 1.2.U5 | The flows provide inputs and outputs of energy and matter. |  |
| 1.2.U6 | The flows are processes that may be either transfers (a change in location) or transformations (a change in the chemical nature, a change in state or a change in energy |  |
| 1.2.U7 | In system diagrams, storages are usually represented as rectangular boxes and flows as arrows, with the direction of each arrow indicating the direction of each flow. The size of the boxes and the arrows may be representative of the size/magnitude of the storage or flow. | Students should interpret given system diagrams and use data to produce their own for a variety of examples, such as carbon cycling, food production and soil systems |
| 1.2.U8 | An open system exchanges both energy and matter across its boundary while a closed system exchanges only energy across its boundary. |  |
| 1.2.U9 | An isolated system is a hypothetical concept in which neither energy nor matter is exchanged across the boundary. |  |
| 1.2.U10 | Ecosystems are open systems; closed systems only exist experimentally, although the global geochemical cycles approximate to closed systems. |  |
| 1.2.U11 | A model is a simplified version of reality and can be used to understand how a system works and to predict how it will respond to change. |  |
| 1.2.U12 | A model inevitably involves some approximation and therefore loss of accuracy. |  |
| 1.2.A1 | Evaluate the use of models as a tool in a given situation, for example, climate change predictions. |  |
| 1.2.S1 | Construct a system diagram or a model from a given set of information. |  |

1.2.U1 A systems approach is a way of visualizing a complex set of interactions which may be ecological or societal.

1.2.U2 These interactions produce the emergent properties of the system

1.2.U3 The concept of a system can be applied at a range of scales.

1. Define the following terms
   1. system
   2. emergent properties
2. Compare reductionism with the systems approaches to scientific research.
3. *Complete the table below using* ***THREE examples of systems***

| **Example of a system** | **Behaviour of parts taken separately** | **Behaviour of parts as a whole system** |
| --- | --- | --- |
| Bicycle | Wheel spin in circles  Pedals move up and down | Bicycle moves forward |
|  |  |  |
|  |  |  |
|  |  |  |

1. Describe the 3 main systems
   1. Environmental Systems
   2. Social Systems
   3. Earth as a System – Watch <https://youtu.be/BnpF0ndXk-8>
2. Gaia Hypothesis - *Watch* [*https://www.youtube.com/watch?v=K0h5CS-w778*](https://www.youtube.com/watch?v=K0h5CS-w778) *and summarize the Gaia hypothesis in your own words. We will look at this in more detail in class.*

1.2. U4 A system is comprised of storages and flows

1.2.U5 The flows provide inputs and outputs of energy and matter.

1.2. U6 The flows are processes that may be either transfers (a change in location) or transformations (a change in the chemical nature, a change in state or a change in energy

1.2.U7 In system diagrams, storages are usually represented as rectangular boxes and flows as arrows, with the direction of each arrow indicating the direction of each flow. The size of the boxes and the arrows may be representative of the size/magnitude of the storage or flow.

1.2.S1 Construct a system diagram or a model from a given set of information.

1. Systems consists of:
   1. Input –
      1. these are represented as a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
      2. they are describe as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. Output –
      1. these are represented as a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
      2. they are described as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   3. Storage –
      1. these are represented as a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
      2. they are described as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   4. Flows –
      1. these are represented as a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
      2. they are described as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   5. Boundary –
      1. it is represented as a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
      2. it is described as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Flows can be categorized into two distinct types depending on whether the matter/energy is changed or just moved. State and describe what these categories are.



1. Look at the processes below. Copy each one into the correct column of the following table, depending on whether they are a transfer or a transformation.

| **Transfers** | **Transformations** |
| --- | --- |
|  |  |



1. State how energy can be lost in a system.
2. Create a systems diagram here, showing the inputs, outputs, storages, flows, transfers, and transformations within a single leaf of a *Pinus sylvestris.* (Pine tree)

1.2.U8 An open system exchanges both energy and matter across its boundary while a closed system exchanges only energy across its boundary.

1.2.U9 An isolated system is a hypothetical concept in which neither energy nor matter is exchanged across the boundary.

1.2.U10 Ecosystems are open systems; closed systems only exist experimentally, although the global geochemical cycles approximate to closed systems.

1. Watch the video on [Biosphere 2](https://youtu.be/a7B39MLVeIc) <https://youtu.be/a7B39MLVeIc>.
2. State whether the following are open, closed or isolated systems.

| **Type of system** | **Description** |
| --- | --- |
|  | plants fix energy from light entering the system during photosynthesis |
|  | nitrogen cycle |
|  | Biosphere 2 |
|  | a fish bowl |
|  | birds migrating to a remote oceanic island |
|  | a thermoflask |

1.2.U11 A model is a simplified version of reality and can be used to understand how a system works and to predict how it will respond to change.

1.2.U12 A model inevitably involves some approximation and therefore loss of accuracy.

1.2.A1 Evaluate the use of models as a tool in a given situation, for example, climate change predictions.

There are a number of types of model such as:

* Physical models
* Computer simulations
* Mathematical models (often using computers if they are very complex)
* Diagrams (e.g. systems diagrams)

1. Define models
2. Explain why a systems diagram is considered to be a model
3. Identify the advantages and disadvantages of models. Use the points to guide you.
   1. Simplifying a complex reality
   2. Predicting future changes
   3. Identifying patterns
   4. Visualising small or large systems

| Advantages | Disadvantages |
| --- | --- |
|  |  |
|  | If there are no figures on the models it gives a false impression. Food webs just show the patterns of feeding and no figures. |
|  |  |
| Can study things that are either too small or too large for us to deal with. E.g. Atoms and our solar system. |  |

1. Below are 5 different climate model simulations. You should be able to discuss the strengths and weaknesses of each of these models. Which model do you believe is the best for understanding climate change? Justify your reasoning!

* Concord Consortium Climate Model (https://learn.concord.org/resources/627/what-is-the-future-of-earth-s-climate)
* Window to the Universe Climate Model (https://www.windows2universe.org/?page=/earth/climate/cli\_model.html)
* Koshland Science Museum Climate Model (https://www.koshland-science-museum.org/explore-the-science/earth-lab/modeling)
* UCAR Climate Model (https://scied.ucar.edu/simple-climate-model)
* Java Climate Model (http://jcm.climatemodel.info/)

**Theory of knowledge:**

1. Models are simplified constructions of reality—in the construction of a model, how can we know which aspects of the world to include and which to ignore?

ESS can be like learning a new language. So many words are not commonly used in everyday English. This can be challenging. To help you keep up with ESS Terms, you will need to create your own ESS DICTIONARY. You should add to this over the year and keep it in your notebook or on a page file THAT YOU CAN UPDATE AND ADD TO EASILY. Most of the vocabulary words can be found either on your STUDY GUIDE or at mrgscience.com.

You will be responsible for learning the words and their meaning. Periodic quizzes will be given on the words. So, make your dictionary creative and you will remember the words more easily.

**KEY TERMS**

synergy

Gaia hypothesis

biosphere

system

closed system

emergent properties

models

flows

inputs

outputs

reductionist approach

energy transfer

ecosystem

functional

​transfers

storage

processes

assemblage

matter

transformation

open system

flows

stock

boundaries

​isolated system