# IB Environmental Systems and Societies

## Unit 1 Systems and Models

### “Nautre Does nothing uselessly” Aristotle (384 – 322 BC)

| | Assessment statement | Teacher’s notes |
|---|---|---|
| 1.1.1 | Outline the concept and characteristics of systems. | The emphasis will be on ecosystems but some mention should be made of economic, social and value systems. |
| 1.1.2 | Apply the systems concept on a range of scales. | The range must include a small-scale local ecosystem, a large ecosystem such as a biome, and Gaia as an example of a global ecosystem. |
| 1.1.3 | Define the terms *open system*, *closed system* and *isolated system*. | These terms should be applied when characterizing real systems.<br>• An open system exchanges matter and energy with its surroundings (for example, an ecosystem).<br>• A closed system exchanges energy but not matter; the “Biosphere II” experiment was an attempt to model this. Strictly, closed systems do not occur naturally on Earth, but all the global cycles of matter, for example, the water and nitrogen cycles, approximate to closed systems.<br>• An isolated system exchanges neither matter nor energy. No such systems exist (with the possible exception of the entire cosmos). |
| 1.1.4 | Describe how the first and second laws of thermodynamics are relevant to environmental systems. | The first law concerns the conservation of energy. The second law explains the dissipation of energy that is then not available to do work, bringing about disorder. The second law is most simply stated as: “In any isolated system entropy tends to increase spontaneously.” This means that energy and materials go from a concentrated into a dispersed form (the availability of energy to do work diminishes) and the system becomes increasingly disordered.<br><br>Both laws should be examined in relation to the energy transformations and maintenance of order in living systems. |

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|---|---|---|
| 1.1.5 | Explain the nature of equilibria. | A steady-state equilibrium should be understood as the common property of most open systems in nature. A static equilibrium, in which there is no change, should be appreciated as a condition to which natural systems can be compared. (Since there is disagreement in the literature regarding the definition of dynamic equilibrium, this term should be avoided.) Students should appreciate, however, that some systems may undergo long-term changes to their equilibrium while retaining an integrity to the system (for example, succession). The relative stability of an equilibrium—the tendency of the system to return to that original equilibrium following disturbance, rather than adopting a new one— should also be understood. |
| 1.1.6 | Define and explain the principles of *positive feedback* and *negative feedback*. | The self-regulation of natural systems is achieved by the attainment of equilibrium through feedback systems.<br>• Negative feedback is a self-regulating method of control leading to the maintenance of a steady-state equilibrium—it counteracts deviation, for example, predator–prey relationships.<br>• Positive feedback leads to increasing change in a system—it accelerates deviation, for example, the exponential phase of population growth.<br>Feedback links involve time lags. |
| 1.1.7 | Describe transfer and transformation processes. | Transfers normally flow through a system and involve a change in location.<br>Transformations lead to an interaction within a system in the formation of a new end product, or involve a change of state. Using water as an example, run-off is a transfer process and evaporation is a transformation process. Dead organic matter entering a lake is an example of a transfer process; decomposition of this material is a transformation process. |
| 1.1.8 | Distinguish between flows (inputs and outputs) and storages (stock) in relation to systems. | Identify flows through systems and describe their direction and magnitude. |
| 1.1.9 | Construct and analyse quantitative models involving flows and storages in a system. | Storages, yields and outputs should be included in the form of clearly constructed diagrammatic and graphical models. |
| 1.1.10 | Evaluate the strengths and limitations of models. | A model is a simplified description designed to show the structure or workings of an object, system or concept. In practice, some models require approximation techniques to be used. For example, predictive models of climate change may give very different results. In contrast, an aquarium may be a relatively simple ecosystem but demonstrates many ecological concepts. |

*1.1.1 Outline the concepts and characteristics of systems.*

A system is an assemblage of parts and the relationships between them which together constitute an entity or whole.

Systems consist of:

- Storages (of matter or energy)
- Flows (inputs into the system, outputs from the system)
- Processes (which transfer or transform energy or matter)
- Feedback mechanisms that maintain stability and equilibrium

*1.1.2 Apply the systems concept on a range of scales*

Using the characteristics of a system it is easy to identify different systems at different levels. For example, a park in a city could be seen as a system. It has storage of Carbon, Carbon Dioxide, Ammonia, Nitrogen, Sulphur and a variety of other elements. The trees absorb carbon dioxide and produce oxygen and glucose.

*1.1.3 Define the terms open system, closed system and isolated system.*

Systems can be divided into three different types, each depend on the flow of energy and matter between the system and their environments.

**Open Systems** – in an open system both energy and matter are exchanged across the boundaries of a system. Open systems must interact with their environment to take in new matter and energy and dispose of waste.

**Closed Systems** – in a closed system only energy is exchanged across boundaries of a system.

**Isolated Systems** – in an isolated sytem neither energy or matter is exchanged. Therefore the only feasible isolated system that is present is the Universe. As we think of there being no transfer of matter or energy beyond our entire universe.

*1.1.4* Describe how the first and second laws of thermodynamics are relevant to environmental systems.

First of all you must understand what the two main laws of thermodynamics are, prior to applying them to an environmental system.

"The first law states that energy can neither be created nor destroyed: it can only change forms."[1] Therefore the amount of energy present in the universe is constant. However, the energy can change its form. For example most energy, with regards to ecosystems, enters the system through sunlight and consequently converted from light energy to chemical through photosynthesis. This way the energy is then transported through the trophic levels from one species to another. As a result of the transferal of energy, and not the disposal of energy, the amount of energy that remains in the ecosystem (although not in the same form as it enetered) stays constant.

'The second law of thermodynamics states that energy goes from a concentrated form (e.g. the sun) into a dispersed form (ultimately heat): the availability of energy therefore diminishes and the system becomes increasingly disordered'[2] Essentially, this tells us that as energy is passed through trophic levels each transfer enables loss of energy to occur through heat. This new energy cannot be used in the same way to transfer the energy further up the trophic levels. As a result, an increase in the amount of disorder (entropy) and subsequently decrease in available energy to restabilise the system.

*1.1.5* Explain the nature of equilibria.

Equilibrium, quite simply, is life in balance. This relationship between populations and ecosystems is exceptionally finely tuned and susceptible to constant threat. The fluctuations within a system are within the confines of bearable conditions for whichever species in question. However, what happens when these fluctuations exceed these parameters.

There are two types of equilibria that you need to learn for the examination. These are as follows:

- Steady State Equilibrium is where fluctuations occur within a systems inputs and outputs, although the stability of a habitat or ecosystem remains the same.
- Static Equilibrium is where there are no inputs or outputs of energy or matter and therefore there is no change over time.

[1] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.5.
[2] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.5.

Whilst these two types of equilibrium exist, they can both be described as either stable or unstable. 'If a system returns to the original equilibrium after a disturbance, it is said to be stable. Systems that do not return to the same equilibrium but form a new equilibrium are described as unstable.'[3]

*1.1.6* Define and explain the principles of *positive feedback* and *negative feedback*.

'Systems are continually affected by information from outside and inside the system. Feedback loops can be positive or negative. Feedback mechanism either change a system to a new state or change it to its original state.' [4]

'Positive feedback occurs when a change in the state of a system leads to additional and increased change.'[5]

'Negative feedback mechanisms work by reducing the eddect of one of the system's components. This is a self-regulating method of control leading to the maintenance of a steady-state equilibrium.'[6]

*1.1.7* Describe transfer and transformation processes.

Transfer within a system maintains the states of matter and energy as they move through any system. This contrasts transformations which change the state of matter and energy. Think of the transfers and transformations of water in the hydrological cycle.

*1.1.8* Distinguish between flows (inputs and outputs) and storages (stock) in relation to systems.

'Inputs and outputs from systems are called flows and are represented by arrows in system diagrams. The stock held within a system is called storage and is represented by boxes.'[7]

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[3] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.6.
[4] Jill Rutherford, 'Environmental Systems and Societies Course Companion', (Oxford University Press, Oxford, 2009), p. 79.
[5] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.7.
[6] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.7.
[7] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.10.

*1.1.9* Construct and analyse quantitative models involving flows and storages in a system.

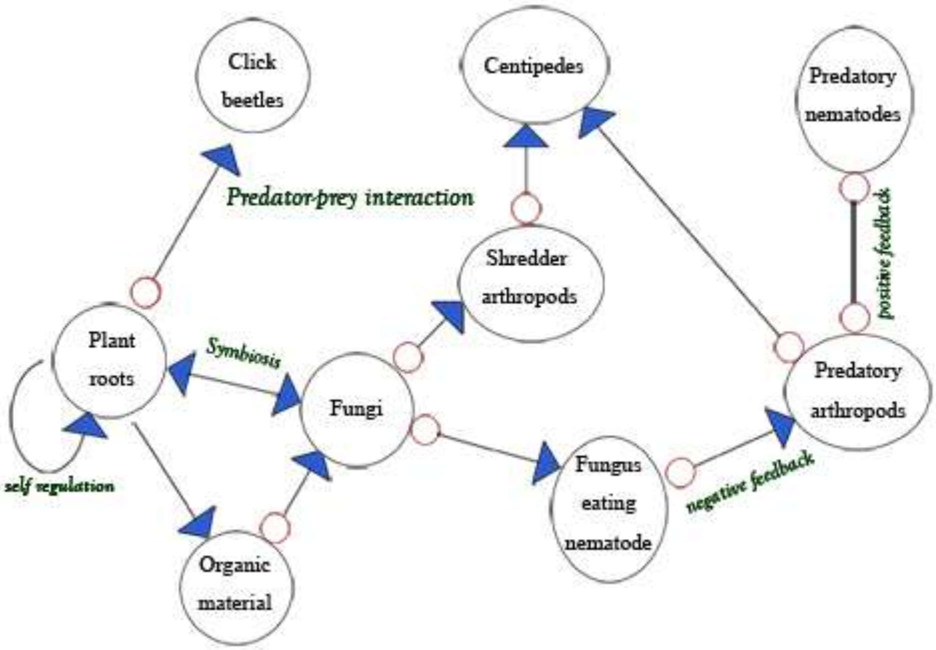


**Figure A An Example of a quantitive model**[8]

*1.1.10* Evaluate the strengths and limitations of models.

Models are exceptionally useful to conceptualise complex matters to ensure that they are more accessible. However, in the simplication of information, accuracy is often lost. There has been criticism on many models for misleading the reader, as the model can only be as accurate as the input data, this is obviously a variable. Although models are frequently used to predict change without the change happening. Equally though, many predictions can be made using the same data but different information.

[8] 'Qualitative vs Quantitative Models', Ecoplexity. 2010. ,Web. 23.04.2012 <http://ecoplexity.org/def_qual_quant_model>

## Bibliography

Andrew Davis and Garrett Nagle, ‘Environmental Systems and Societies’, (Pearson Education Limited, New Jersey, 2010), pp 5 - 10.

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‘Qualitative vs Quantitative Models’, Ecoplexity. 2010. ,Web. 23.04.2012 <http://ecoplexity.org/def_qual_quant_model>