"For Nation's Greater Heights"

Republic of the Philippines
SURIGAO STATE COLLEGE OF TECHNOLOGY
Narciso Street, Surigao City

LEARNING MODULE

GE Envi Sci Eng'g – Environmental Science Engineering

CONTENTS:

Module 1 – Science and the Environment

Module 2 - The Spheres of the Earth and Environmental Systems

Module 3 - Environmental Problems / Issues

Module 4 - Environmental Worldviews and Ethics

Module 5 - Sustainable Development and Sustainability

Module 1 - SCIENCE AND THE ENVIRONMENT

(By Gheleene Sering-Buenaflor)

Time Frame: 2 hours

Introduction

One of the greatest challenges since the 20th century is the deterioration of our environment. We have become familiar with various forms of environmental problems in our air, water, and land. Natural resources such as our forests, fisheries, and wildlife have been greatly reduced with increase in human consumption & exploitation. Industrial processes have resulted in pollution of our air, water bodies, and land, and some even causing health impacts.

Because of these recent issues, environmental science has developed as a separate field of study in the recent decades. From your field of study, why is it important for you to know about environmental science? Read along as you learn about environmental science and its relevance to YOUR field of specialization!

Objectives:

At the end of this lesson, the students should be able to:

- describe environmental science as a discipline
- develop awareness of environmental interactions of day-to-day activities
- explain the principles of environmental science
- verbally express how environmental science is related to students' field of study

Answer the following before proceeding to the next pages:

-----cut along this line and return to your instructor when you meet face-to-face------

Pre-test

Name: ____ Course/Year/Section:_________

- What is environmental science?

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  ____

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- Can you give examples of principles of environmental science?

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Learning Activities

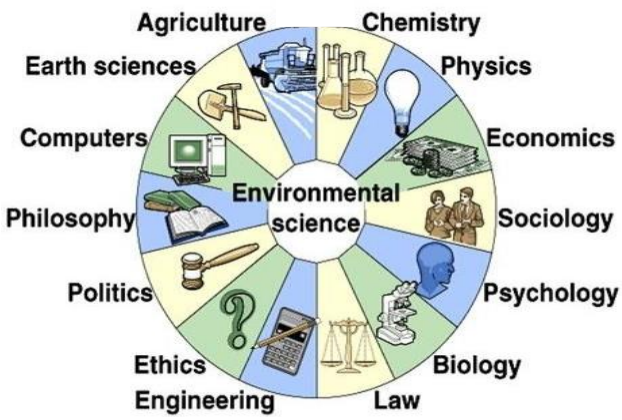
A. Environmental Science as a Discipline

What is the environment? It is the totality of what surrounds us. Outside our bodies, we have the living (biotic) component of the environment, such as plants and animals, and the non-living (abiotic) component composed of the air, water, sunlight, land, etc. Of course, these components interact with each other. For example, birds (biotic component), fly through the air (abiotic component). Microorganisms (biotic component) live within our soils (abiotic component).

Environmental Science (ES) is the "systematic study of our environment and our place in it" (Cunningham & Cunningham, 2013). ES is an inter-disciplinary field of study of the biological and physical sciences. By "inter-disciplinary", it integrates concepts from the fields of biology, chemistry, physics, mathematics, statistics, ecology, and geology, among other scientific fields, in order to analyze and solve problems concerning our environment (Figure 1).

Figure 1

Field of Environmental Science

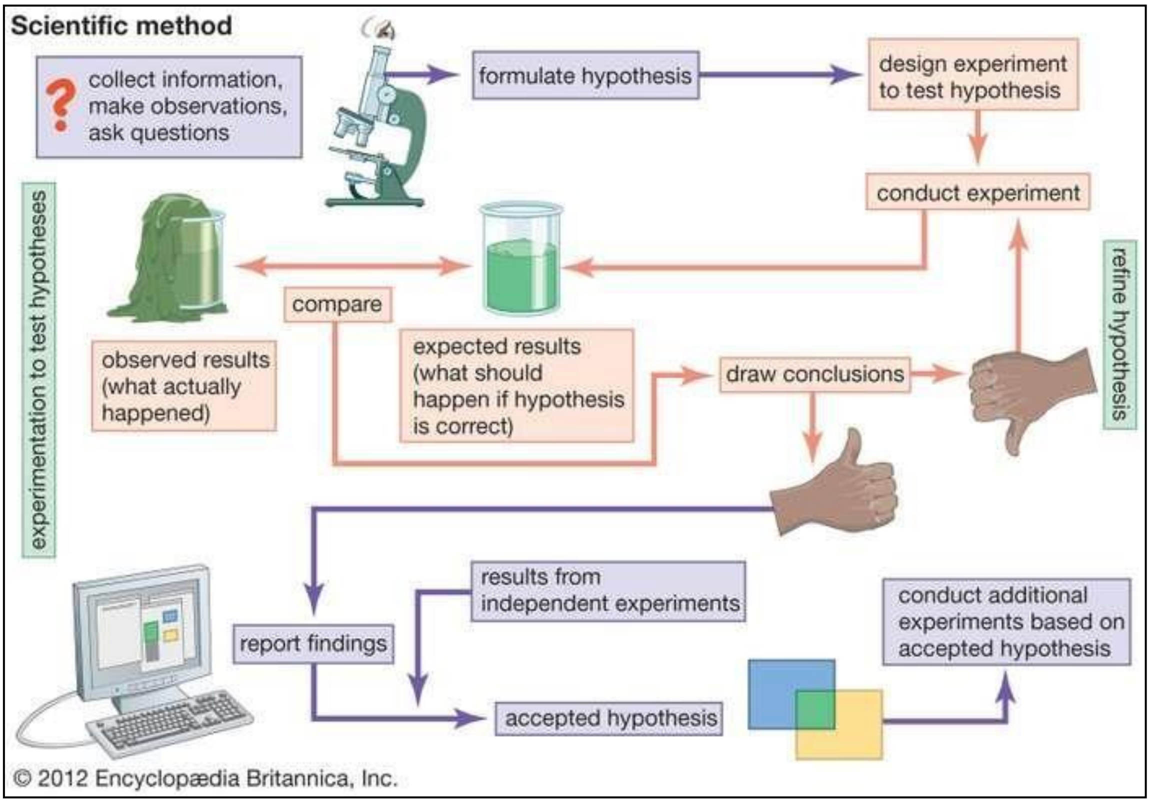


Note. Environmental science as an interdisciplinary field. From *Introduction to Environmental Science. Ch 1 Science & The Environment 1 Understanding Our Environment 2 The Environment and Society*, by A. Flowers, n.d. Copyright by The McGraw-Hill Companies, Inc.

As a ***science***, ES is a study of connections in nature. It makes use of the scientific method (Figure 2) in understanding the processes and systems in our environment. ES utilizes the other scientific fields mentioned above to study environmental problems and the impacts of human activities on the environment. Another definition is, that environmental science is the study of interactions between humans and the environment. ES is a relatively new field of science which came out of the environmental movement in the 1960's as environmental issues such as oil spills, release of environmental toxins and chemicals, and deforestation surfaced. Among the major influences to the growing environmental awareness during those decades were the books of Rachel Carson ("Silent Spring", 1968) and Paul R. Ehrlich ("The Population Bomb", 1968).

Figure 2

The Scientific Method



Note. The Editors of Encyclopaedia Britannica. (2020). Scientific method. In Encyclopedia Britannica. Encyclopædia Britannica, Inc. https://www.britannica.com/science/scientific-method

Why do we need to study environmental science, not just the separate fields of the sciences? Well, environmental problems such as air and water pollution cannot be analyzed and solved solely by using one field of science. For example, you need to know the nature of the pollutant (its composition and characteristics) – that's chemistry! How fast does the pollutant flow? – that's physics! What organisms are affected by the pollution? –that's biology! And so on and so forth.

Pause and ponder:

What environmental problems are you aware of? Give some examples.

____

____

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____

____

Environmental science is an applied science that gives attention to understanding and solving environmental challenges that our world is facing. Since almost all of our activities interact with our environment, we need to know and understand how we affect our environment in our day-to-day activities. Can you list some examples below?

Classwork: Smile! Take a photo of yourself holding your answers below. Write legibly using dark ink. Upload your photo in Google Classroom (see "Classwork" in Google Classroom)

Name: ____

Course / Year / Section: ______________________________________

Environmental component	What activities in your day-to-day life interact with these environmental components?
AIR	
WATER	
LAND	
BIOTA (PLANTS & ANIMALS)	

Environmental science is related, but different, from the fields of environmental engineering, environmental management, and environmental studies. ES is a scientific inquiry into understanding the environment and environmental problems. ***Environmental engineering*** is an applied field to design and use technology to improve environmental quality, while ***environmental management*** is focused on planning and making policies to manage our environment. In contrast, ***environmental studies*** is more social-science oriented and deals with how humans interact with the environment. For example, ***environmental engineers*** would want to develop technologies that will help solve water pollution; ***environmental managers*** might be involved in making policies that would lessen discharge of pollutants to a river. ***Environmental studies*** practitioners would be interested on how citizens view pollution in their community, while ***environmental scientists*** would be quantifying the pollutants in river and simulating their movement in the environment through environmental modeling (Figure 3).

Figure 3

Occupations related to environmental science

Note. Top left: an environmental scientist obtaining a water sample from a stream; right: environmental engineers looking at a plan related to clean energy with windmill on the background. From *The Newest Gold Mining Tool: Bacteria*, by C. Calam, 2018, https://www.thermofisher.com/blog/mining/the-newest-gold-mining-tool-bacteria/ and *20. Environmental Engineer*, by CNN Money, 2012, https://money.cnn.com/pf/best-jobs/2012/snapshots/20.html

B. Environmental Science Principles (excerpts from Boersema & Reijnders (2009)

1. The Principle of Sustainable Development

This principle states that "we humans must move towards the adoption of a lifestyle that can continue indefinitely." Simply, we must stop destroying the very necessities of our own existence. Our present lifestyle cannot continue indefinitely (is not sustainable).

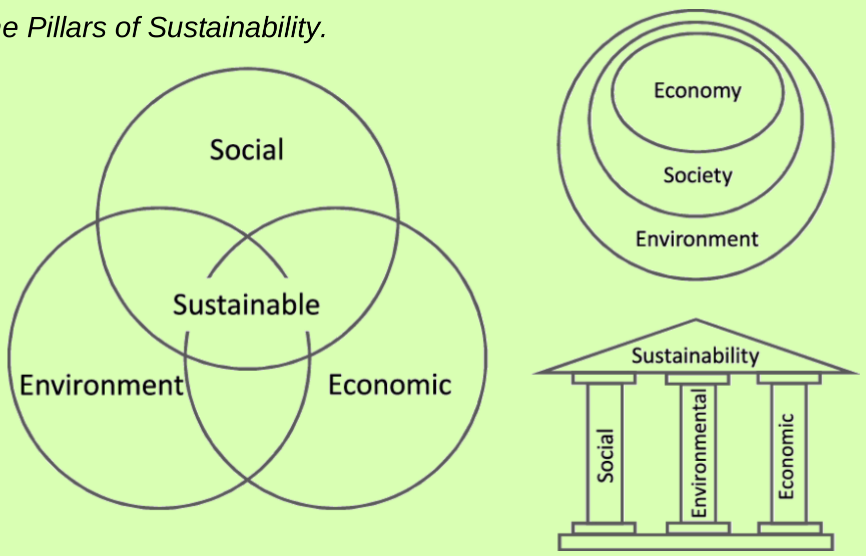
Perhaps the most popular definition of sustainable development is the one contained in the report "Our Common Future" (a.k.a. Brundtland Report) released by the United Nations World Commission on Environment and Development in 1987:

"Sustainable development
is development that meets the needs of the present
without compromising the ability of future generations
to meet their own needs."

Sustainable development is a goal composed of three pillars: economy, society, and environment. These three interdependent pillars must be balanced as shown in Figure 4:

Figure 4

The Pillars of Sustainability.



Note. From Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: In search of conceptual origins. Sustainability Science, 14(3), 681–695. https://doi.org/10.1007/s11625-018-0627-5

2. **The Principle of the Conservation of Energy (First Law of Thermodynamics)**

   Quantity of energy is constant: energy can be neither created nor destroyed, but only *transformed*.

3. **The Principle E=MC^2 (energy equals mass times the speed of light squared)**

   The aspect of this principle that is important for environmental science is that *matter is a form of energy*.

4. **The Principle of the Conservation of Matter**

   Quantity of matter is constant: energy cannot be transformed from a material form to a non-material form or vice versa. Matter can change from being in a state of high potential energy to being in one of low potential energy, but the total amount of matter in both states is the same.

5. **The Entropy Principle (Second Law of Thermodynamics)**

   This may be expressed in terms of systems (see box on the following page): *systems tend towards disorder (the amount of entropy in a system tends to increase)*; or the degree of 'organization' of matter in a system will tend to decrease. In environmental science, this means that whatever concentrations of energy or chemical elements presently existing on earth will tend to lessen over time. There will be a day when humans cannot use fossil fuels, uranium or metals, when the amount of usable energy needed to extract them exceeds the amount of usable energy they provide.

6. **The Principle of Evolution through natural selection**

   "Life forms on earth have evolved from a common source, each surviving as a species as a result of its being genetically adapted to its biological and physical environment." The principle of sustainable development aims to lead us to a stable relationship with our environment as a prerequisite for our continued existence.

   The following must hold true if there is to be evolution by a variational mechanism:

- ***variation***. Individual variety in morphology, physiology, and behavior within populations.
- ***heredity***. Similarities among offspring with their parents more than non-relatives.
- ***selection***. Chances of survival and reproduction in certain environments varies with different forms.

The Notion of a System

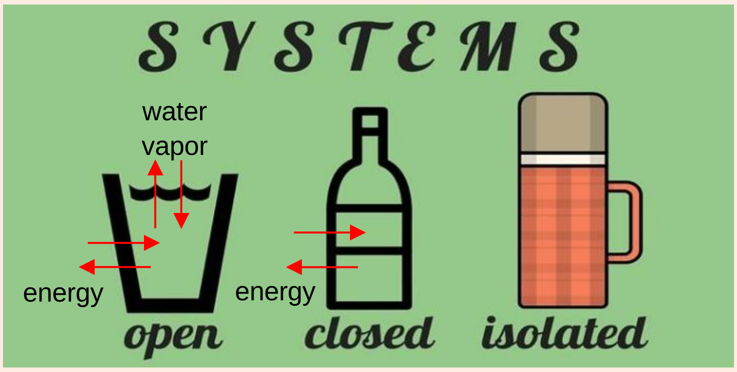
A system is any group of entities with an ongoing cause-and-effect relationship which gives the system its structure and determines how it is organized. If the processes in a system do not lead to organizational change, the system is in a state of equilibrium. When there is structural change, the equilibrium is dynamic; when there is none, it is static. A system is out of equilibrium when it has earlier experienced static equilibrium and is in the process of failing to exhibit dynamic equilibrium, before there is a change in its organization (after which it is no longer the same system).

Loss of dynamic equilibrium in individuals as systems results in death; in species, this results in their extinction. In ecosystems, however, the distinction is not so clear. If a tropical forest becomes a semi-arid desert, the dynamic equilibrium of the original system has been lost – and so there has been system change – even if some of the original species remain. In ecosystems, the loss of a system can be avoided despite loss of equilibrium due to their ability to regenerate. Unlike physical systems, ecosystems tend to decrease in entropy, thanks to solar energy.

Other important systems notions are those of open, closed, and isolated systems. The solar system is an open system, taking in matter and energy from outside, as well as giving off solar energy to the outside. In a closed system, matter neither enters nor leaves; and in an isolated system, energy neither enters nor leaves.

Figure 5

Illustration of an Open, Closed and Isolated System.



Note. Modified from Baker's Environmental Systems & Societies Class. (2015, September 21). Environmental Systems & Societies: Open, Closed and Isolated Systems. Environmental Systems & Societies. http://srhsess.blogspot.com/2015/09/open-closed-and-isolated-systems.html

7. The Principle of Ecology

"Various groupings of living beings constitute systems, each of which may or may not be in equilibrium with the other systems constituting its environment."

The systems with which the human species interacts are physical and biological. Examples of biological systems in living beings are DNA strands, cells, and organs. Individual living beings such as plants and animals are also biological systems. And populations of living beings constitute systems, which are subsystems of even larger systems, namely ecosystems. Eventually we get to the largest ecosystem, the biosphere, which has all other biological systems as subsystems.

The existence of each species, like the existence of the biosphere as a whole, is dependent on solar energy (Figure 6). In terms of systems, the maintenance of the population of each species as a system requires an influx of solar energy to (temporarily) counteract the effects of the entropy principle. In the case of plants this input is at least partly direct, via photosynthesis. For humans and other animals, it consists in taking usable energy from other material (biological and physical) systems, thereby increasing their entropy – in accordance with the entropy principle.

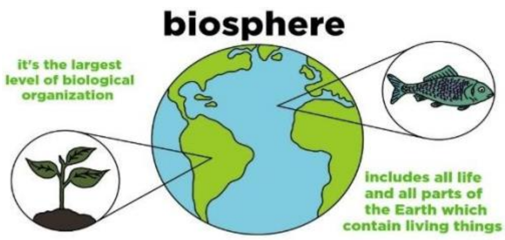
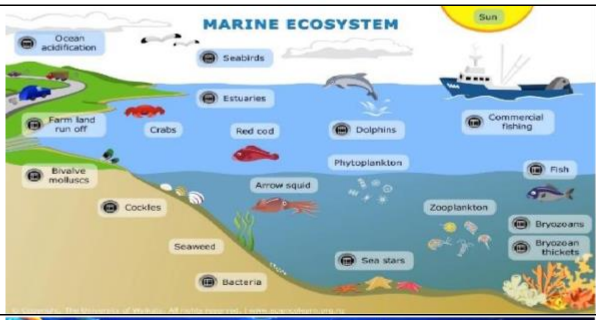
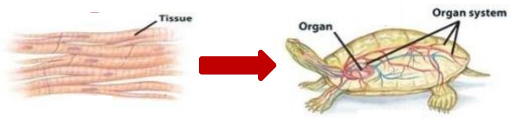
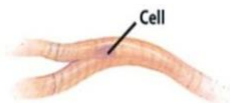
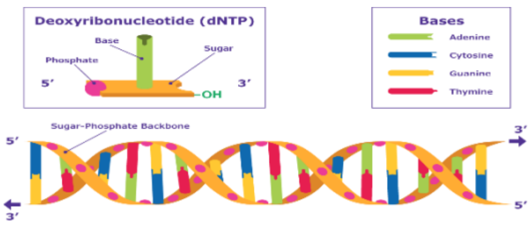
Figure 6

The Earth receiving energy from the sun.

Note. Solar energy is needed to maintain plant and animal populations. From "*Is the Distance from the Earth to the Sun Always the Same?"*, K. Bryant, 2019, https://www.rd.com/article/distance-from-earth-to-sun/

Figure 7

Levels of Ecological Organization.

Biosphere	The part of the Earth that contains all ecosystems	
Ecosystem	Community and its nonliving surroundings	
Community	Populations that live together in a defined area	
Population	Group of organisms that live in the same area	
Organism	Individual living thing	
Groups of cells	Tissues, organs, and organ systems	
Cells	Smallest functional unit of life	
Molecules	Groups of atoms; smallest unit of most chemical compounds	

Note. Adapted from *C4: Ecosystems & Communities*, by B. Allison, https://slideplayer.com/slide/14361195/

As compared with physical systems, systems involving living beings are exceedingly complex. Nevertheless, limits can be set on what behavior is possible, thanks to the principles being presented here. For example, the entropy principle makes it impossible for a sustainable society to continue using a finite resource indefinitely. Another difference between populations of living systems and purely physical systems, as taken up in the previous section, is that each living system tends to increase, not decrease, in its degree of organization.

Living systems could be physically defined as open systems in which entropy tends to decrease. Against the background of the entropy law, this means that living systems must exist in larger physical systems in which the total entropy is increasing. This energy-accumulating aspect of life lies behind the principle of population.

8. The Principle of Population

a. "There is a tendency for the human population (and that of any species) to be as large as its environment will allow."
b. If there were no checks to population size, that of the human (or any) population would tend to increase indefinitely.

Nonhuman populations tend to increase and decrease in cycles. The greater the numbers of a species, the greater the food consumption, ultimately leading to the population's experiencing scarcity. This in turn requires reduced consumption, which leads to a reduction in population size, allowing the resource to recover.

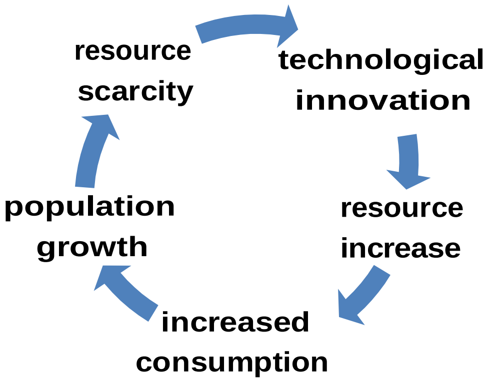
9. The Vicious Circle Principle

"Human development consists in an accelerating movement from situations of resource scarcity, to technological innovation, to resource increase, to increased consumption, to population growth, and back to resource scarcity."

Figure 8

Vicious circle

of human development



The human species is unique in sometimes reacting to resource shortage, or threat of resource shortage, with innovative technology. But where other species have settled down to roughly stable population sizes within certain limits (until losing equilibrium and becoming extinct), we humans have not yet come to the point where our population has stopped growing for the first time. We have not only been pushing against the limits of our environment, we have constantly been stretching those limits. In other words, the human species, as a system, has yet to attain the static equilibrium necessary for its dynamic equilibrium even to be tested.

Latest Developments. *Match the following technological innovations to the environmental problems they address (answers on page 12)*

1. Air pollution and depletion of fossil fuels in transportation	a. smart home technology
2. Climate change	b. “Direct Air Capture” (DAC) of CO_2 from the atmosphere
3. Energy wastage from appliances	c. coco bio-diesel

Supplemental learning:

- Watch a three-minute video “What is Sustainability?” at https://www.youtube.com/watch?v=gTamnIXbgqc
- Watch a four-minute video “Sustainability explained” at https://www.youtube.com/watch?v=_5r4loXPyx8
- Boersema, J., & Reijnders, L. (Eds.). (2009). Chapter 7—General Principles. In Principles of Environmental Sciences. Springer Science + Business Media B.V. https://doctoradocienciasambientales.files.wordpress.com/2012/09/principles-of-environmental-sciences1.pdf

Self-evaluation

- What is environmental science? Explain in your own words.
- Explain each of the environmental principles in your own words.

Review of Concepts

- **Environmental science** – a systematic study of our environment and their inter-relationships. ES integrates the various fields of the biological and physical sciences in understanding how our environment works and in analyzing environmental problems.

- Principles of environmental science:
  - **Sustainable development** – we must pursue lifestyles that can support the needs of both the present and future generations. It has 3 pillars: society, environment and economy.
  - **Conservation of Energy (First Law of Thermodynamics)** - Quantity of energy is constant: energy can be neither created nor destroyed, but only transformed.
  - **$E=MC^2$ (energy equals mass times the speed of light squared)** - matter is a form of energy
  - **Conservation of Matter** - Quantity of matter is constant
  - **Entropy Principle (Second Law of Thermodynamics)** - systems tend towards disorder; or, the amount of entropy in a system tends to increase. In other words, the quality of the energy in a system tends to decline.
  - **Evolution** - Adaptation to biological and physical environment is necessary for continued existence of species
  - **Ecology** - The environment is composed of various levels of systems such as individuals, populations, communities, ecosystems, and the biosphere.
  - **Population** - Populations tend to increase as its environment will allow and would tend to increase indefinitely if there were no checks to population size.
  - **Vicious circle** - human development consists in an accelerating movement from situations of resource scarcity, to technological innovation, to resource increase, to increased consumption, to population growth, and back to resource scarcity

Post-test

1. Quiz and oral recitation during face-to-face meeting

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Answers to „Latest Developments" on page 10:

1. c
2. b
3. a