##### **Chapter 1 Outline**

* 1. Living More Sustainably
  2. Environmental science studies how the earth works, our interaction with the earth, and the methods/procedures we use to deal with environmental problems.
     1. The biosphere is the natural world: plants, animals, soils, air, and water.
     2. The culturesphere is defined by technological, economic, cultural, and political aspects of our world.
  3. Environment considers everything that affects a living organism.
  4. Ecology studies relationships between living organisms and their environment.
  5. Environmentalism is a social movement dedicated to protecting life support systems for all species.
  6. Life and economies depend on solar capital (energy from the sun) and natural capital (Earth’s resources and ecological services).
     1. Capital is wealth; solar capital/energy creates renewable energy such as wind power, hydropower from flowing water, and biomass that is solar energy that has been changed to chemical energy and stored, in a biological form, such as wood.
     2. Natural capital includes natural resources such as air, water, soil, wildlife, minerals, etc. and ecological services.

a. Biological income from fish, grasslands, and underground water can be sustained, IF we don’t deplete it.

b. Man, as a newcomer species, is endangering quality of life for us and other species.

F. Man must protect our solar and natural capital and live off the resources they provide.

1. For an environmentally sustainable society we must not compromise the needs of future generations.

2. One view is that man must live sustainably by eliminating waste and discontinuing the depletion and degradation of resources.

3. A different view is that man can overcome these problems with ingenuity, economic growth, and technology.

1-2 Population Growth, Economic Growth, Economic Development, and Globalization

A. Human population growth continues to be more rapid than the earth can support—about 211,000 people per day.

B. Economic growth provides people with the goods and services needed.

1. Gross domestic product (GDP), also called gross national income (GNI), is the market value for goods and services produced within a country.

2. Standard of living is the GDP divided by the total population at midyear.

C. Economic development is improving living standards through growth. Most developed countries have high industrialization and high per capita income. Developing countries have moderate to low income; they represent about 97% of the projected increase in world population.

1. Economic developments reflect good and bad economic news.

a. Poverty produces harmful environmental effects.

b. Soil, water, and forests are depleted.

c. Pollution levels are high.

d. Infant mortality rate is 8 times higher than in developed countries.

e. Wages are very low with poor working conditions as the norm.

2. Developed countries enjoy a higher standard of living, including:

a. a longer life expectancy.

b. a decrease in infant mortality.

1. greater food production than food needs.
2. decreased air and water pollution.
3. a decrease in poverty overall.

D. Globalization leads to a world socially, economically, and environmentally more interconnected.

1. Technology, international trade, and human mobility allow people to interact with others.

2. Environmentally sustainable development rewards sustainable activities and discourages harmful activities.

1-3 Resources

A resource is anything obtained from the environment to meet our needs.

A. Natural capital/natural resources are those in the environment or those obtained from the environment: food, water, air, shelter, petroleum, etc.

1. Natural resources are classified as perpetual, renewable, or nonrenewable.
   1. A perpetual resource is renewed continuously, like solar energy.
   2. Renewable resources must not be used up faster than they are able to be replaced, like grasslands, fresh water and air, fertile soil, etc.
   3. Sustainable yield is the highest rate of use on an indefinite scale without degradation or depletion.
   4. Environmental degradation occurs when the use of resources exceeds the rate of replacement.

C. The Tragedy of the Commons describes the overuse or degradation of freely available resources such as ocean pollution, abuse of national parks, air pollution, etc. No one individual owns these free-access resources.

1. Limiting access to these resources is one possible way to protect them.
2. Reducing the population might also allow these resources to be used below estimated sustainable yields.

3. Converting free-access resources to private ownership is another possible means to protect them.

a. Private owners may not actually protect the resources.

b. Global resources such as oceans, air, and migratory birds cannot be divided up and made private property.

c. Access to the resources is eliminated/reduced for many people.

4. Governments have laws and treaties that regulate access to commonly owned resources.

D. What is our ecological footprint, our impact on the environment?

1. The per capita ecological footprint is the biologically productive land and water needed to supply renewable resources and absorb waste for each individual.

2. Currently, each person’s ecological footprint is 20% greater than can be sustained indefinitely. As a result, we have polluted air and water, waste overload, poorer health, less biodiversity, etc.

1. We need four more planet Earths to meet the consumption levels of the U.S.

E. What are nonrenewable resources?

1. Nonrenewable resources are those that exist in fixed quantity or stock in the earth’s crust. The resource is economically depleted when it costs too much to obtain what is left.

2. These include energy resources (oil, coal, natural gas, etc.), metallic mineral resources (copper, iron, aluminum, etc.), and nonmetallic minerals (salt, clay, sand, phosphates, etc.).

3. There are solutions for an economically depleted resource, which include:

a. trying to find more of the resource.

b. recycling the resource and buying products made from recycled material, or reusing the resource in the same form.

c. wasting less.

d. using less.

e. trying to develop a substitute for the resource.

f. waiting millions of years for more to be produced.

1-4 Pollution

Pollutants are chemicals at high enough levels in the environment to harm people or other living organisms.

A. Where do pollutants come from, and what are their harmful effects?

1. Pollutants may enter the environment naturally (for example, volcanic eruptions) or through human activities such as burning coal; pollution tends to occur in or near urban and industrial areas.

2. Point sources of pollutants are single, identifiable sources, such as automobiles or industrial plants. They are easier to identify and control than non-point sources.

3. Non-point sources are dispersed, such as pesticides in the air and water runoff. They are difficult to identify.

* 1. Pesticides sprayed into the air may be carried from their source.
  2. Fertilizer runoff enters streams away from the source.

4. Three unwanted effects of pollutants:

a. They can disrupt or degrade life-support systems of any organism.

b. They damage human health, wildlife, and property.

c. They can produce nuisances in noise, smells, tastes, and sights.

B. Solutions: What can we do about pollution?

1. We use two basic approaches to deal with pollution.

a. Pollution prevention/input pollution control reduces or eliminates the production of pollutants.

b. Pollution cleanup/output pollution control cleans up or dilutes pollutants after they have been produced.

c. Problems with pollution clean up:

1) It is a temporary bandage without long-term pollution control technology (like the catalytic converter).

2) The pollutant is removed but may cause pollution in another place (for example, burning garbage/burying it).

3) It is expensive to reduce pollution to an acceptable level. Prevention is less expensive in the long run.

1-5 Environmental and Resource Problems: Causes and Connections

A. Six major causes of environmental problems:

1. Population growth

2. Wasteful resource use

3. Poverty

* 1. The focus is on survival at the expense of forests, soil, grasslands, and wildlife.
  2. People live in areas with a greater risk of natural disasters.
  3. People generally work in unsafe and unhealthy conditions for low wages.
  4. Life expectancy is reduced.
  5. There are no government-sponsored health plans or retirement plans.
  6. People die from preventable causes (malnutrition, normally nonfatal infectious diseases, lack of clean drinking water, and respiratory problems).

4. Bad environmental accounting

5. Ecological ignorance

6. An inadequate understanding of how the earth works

B. Affluence is the addiction to over-consumption of material goods.

1. Symptoms include high debt level, declining health, increased stress, and more bankruptcies.
2. Solutions include admitting the problem, shopping less, and avoiding malls and other shopping addicts.
3. Toynbee’s law of progressive simplification: transfer energy and attention to the nonmaterial side of life.
4. Affluence of developed countries can lead to environmental improvements.

1. Money is available for technological improvements.

2. Compared to 1970, air and water are cleaner.

3. Money was spent on environmental improvements.

1. Environmental quality is affected by interactions between population size, resource consumption, and technology.

1. Environmental impact (I) depends on the number of people (P), average resource use/person (Affluence), and the beneficial and harmful effects of technologies (T) used to provide/consume each unit of resource.

2. Developing countries have large populations that result in degradation of renewable resources.

3. Developed countries have high per capita consumption (U.S. use 35–100 times more than other countries).

1. Some forms of technology are environmentally harmful, others are environmentally beneficial.

1-6 Is Our Present Course Sustainable?

A. Environmental news centers on improvements in the quality of life and protecting the environment. But, there are many serious problems not addressed and/or ignored.

B. If degradation of the environment is not halted, sustainable development is not possible.

1. The technological optimists tell us not to worry.

2. Environmental pessimists see the problem as hopeless.

C. Present and future environmental problems:

1. Poverty and malnutrition—biggest threats

2. Smoking and air pollution

3. AIDS

4. Climate change and water shortages

5. Decrease in biodiversity

6. Earth’s natural capital will be degraded so that living organisms are at even greater risks.

D. Most serious environmental risks in terms of people:

1. Biodiversity loss and climate change

2. Same as in C above

E. To live more sustainably, we must:

1. identify how the earth has sustained itself.

2. apply this information to our lifestyles and economies.

1. use economic rewards to encourage more sustainable forms of economic growth.
2. use economic penalties to discourage unsustainable forms of economic growth.

F. Change comes from dedicated, committed people; 5–10% of a population can bring major social change.

G. Guidelines for working with the earth:

1. Never leave the earth worse than you found it.

2. Take only what you need.

3. Do no harm.

4. Sustain diverse living organisms.

5. Maintain earth’s capacity for self-repair and adaptation.

6. Do not waste; do not pollute.

7. Decrease population; reduce poverty.

## Chapter 3 Outline

3-1 The Nature of Science

A. Science assumes that events in the natural world follow orderly patterns and that, through observation and experimentation, these patterns can be understood. Scientists collect data, form hypotheses, and develop theories, models, and laws to explain how nature works.

1. Scientists collect facts or scientific data.

2. Based on observations of phenomenon, scientists form a scientific hypothesis—an unconfirmed explanation of an observed phenomenon to be tested.

3. Parts of the scientific process are skepticism, reproducibility, and peer review.

B. A scientific theory is a verified, believable, widely accepted scientific hypothesis or a related group of scientific hypotheses.

1. Theories are explanations that are likely true, supported by evidence.

2. Theories are the most reliable knowledge we have about how nature works.

C. A scientific/natural law describes events/actions of nature that reoccur in the same way, over and over again.

D. There are many types of scientific methods used to gather data, formulate hypotheses, state theories and laws and, then, text them. Observation leads to a hypothesis, then to an experiment that produces results that lead to a conclusion. Variables/factors influence the gathering of data. In a controlled experiment, the scientist attempts to isolate and study the effect of one variable.

1. In an experimental group, one chosen variable is changed.

2. In a control group, the chosen variable is not changed.

3. Multivariable analysis uses mathematical models to analyze interactions of many variables.

1. Scientists try to establish that a particular theory/law has a high probability of being true. They always include a degree of uncertainty.

1. Scientists use both inductive reasoning and deductive reasoning to arrive at a general conclusion or hypothesis.

a. Inductive reasoning uses specific observations and measurements to arrive at a general conclusion or hypothesis.

b. Deductive reasoning uses logic to arrive at a specific conclusion based on a generalization or premise.

F. Frontier science includes scientific results that have not been confirmed; sound science or consensus science includes scientific results that have been well tested and are widely accepted. Frontier science represents tentative results in the process of being validated.

G. Junk science includes scientific results/hypotheses that have not been reviewed by peer scientists, that is scientists with competencies and skills comparable to the researcher describing his/her findings.

1. Junk science is sometimes used as a label if it does not uphold/support a particular person’s view.

2. Media people mislead us by providing support from one who is not an expert in the field being discussed or who does not accept the consensus science.

3. Consider the reliability of the individuals presenting the data, any particular point that they may be promoting, their scientific credentials, and their funding sources. Determine if their conclusions are valid, if there has been impartial peer review, and the consensus view of experts in the field has been presented.

3-2 Models and Behavior of Systems

1. Scientists project the behavior of complex systems by developing a model of its inputs, throughputs (flows), and outputs of matter, energy, and information.
2. Mathematical models consist of one or a series of equations to describe the likely behavior of a system.
3. They are useful when there are many interacting variables, a long time from and when controlled experiments are not feasible.
4. They are used to answer a series of “if-then” questions.
5. Feedback loops can cause a system to do more of what it was doing (positive feedback) or less (negative feedback).
6. Prolonged time delays in a complex system may cause a weakening or failure of the feedback mechanisms.
7. A synergistic interaction results in the combined effects of a process being greater than the sum of the separate effects. Social science research suggests that 5–10% of a population working together influence other people.
8. Any action in a complex system has multiple effects that may be unintended and often have unpredictable effects. Crossing an environmental threshold can lead to a sudden shift in balance.

3-3 Matter

A. Matter is anything that has mass and takes up space, living or not. It comes in chemical forms as an element or a compound.

1. An element is the distinctive building block that makes up every substance; chemically, elements are represented by a one- or two-letter symbol.

2. Chemists classify elements by their chemical behavior, arranging them in a periodic table of elements.

B. The building blocks of matter are atoms, ions, and molecules.

1. An atom is the smallest unit of matter that exhibits the characteristics of an element.

2. An ion is an electrically charged atom or combinations of atoms.

3. A molecule is a combination of two or more atoms/ions of elements held together by chemical bonds.

1. Each atom has a nucleus containing protons and neutrons. One or more electrons whiz around the nucleus of an atom.
2. A proton (p) is positively charged, a neutron (n) is uncharged, and the electron (e) is negatively charged.
3. Each atom has an equal number of positively charged protons in the nucleus and negatively charged electrons outside the nucleus, so the atom has no net electrical charge.
4. Each element has a specific atomic number that is equal to the number of protons in the nucleus.
5. Most of the mass of an atom is concentrated in the nucleus. The mass number of an atom equals the total number of neutrons and protons in its nucleus.
6. Isotopes of an element are various forms of an element that have the same atomic number, but different mass number.
7. Atoms of some elements can lose or gain one or more electrons to form ions with positive or negative electrical charges.

1. Elements known as metals tend to lose one or more electrons; they are electron givers.

2. Elements known as nonmetals tend to gain more electrons; they are known as electron receivers.

3. Positive or negative ions are shown as a superscript after the symbol.

4. The amount of a substance in a unit volume of air, water, or other medium is its concentration.

5. Hydrogen ions (H+) in a solution are a measure of how acidic or basic a solution is. Neutral pH is 7; acid solutions are below 7; and basic solutions are above 7.

1. Chemical formulas are a type of shorthand to show the type and number of atoms/ions in a compound.

1. Each element in the compound is represented by a symbol: H = hydrogen, N = nitrogen.

2. Subscripts show the number of atoms/ions in the compound.

3. Ionic compounds are made up of oppositely charged ions, (Na+ and Cl-).

4. Compounds made of uncharged atoms are called covalent compounds (CH4).

1. Organic compounds contain carbon atoms combined with one another and with various other atoms. Only methane (CH4) has one carbon atom.

1. Hydrocarbons: compounds of carbon and hydrogen atoms

2. Chlorinated hydrocarbons: compounds of carbon, hydrogen, and chlorine atoms

3. Simple carbohydrates: specific types of compounds of carbon, hydrogen, and oxygen atoms

1. Polymers are larger and more complex organic compounds which have molecular units, linked by chemical bonds; three major types are complex carbohydrates, proteins, and nucleic acids.
2. Complex carbohydrates contain two or more monomers of simple sugars linked together.
3. Proteins are formed by linking monomers of amino acids together.
4. Nucleic acids are made of sequences of nucleotides linked together.
5. Genes: specific sequences of nucleotides in a DNA molecule
6. Chromosomes: combinations of genes that make a single DNA molecule, plus some proteins
7. Genome: the complete sequence of DNA base pairs that combine to make up the chromosomes in a typical member of each species
8. All compounds without the combination of carbon atoms and other elements’ atoms are inorganic compounds.
9. Matter exists in four states: solid, liquid, and gaseous physical states and a fourth state known as plasma.
10. Water exists as ice, liquid, or water vapor depending on its temperature.
11. Plasma is a high-energy mixture of positively charged ions and negatively charged electrons. It is the most abundant form of matter in the universe, but very little is found on Earth.
12. Scientists make artificial plasmas in fluorescent light, arc lamps, neon signs, gas discharge lasers, and TV and computer screens.
13. According to the usefulness of matter as a resource, it is classified as having high or low quality.

1. High-quality matter is concentrated with great potential for usefulness and is usually found near the Earth’s surface.

2. Low-quality matter is dilute and found deep underground and/or dispersed in air or water.

3. Material efficiency/resource productivity describes the total amount of material needed to produce a unit of goods/service.

3-4 Energy

A. Energy is the capacity to do work and transfer heat; it moves matter.

1. Kinetic energy has mass and speed; wind and electricity are examples.

1. Potential energy is stored energy, ready to be used: an unlit match, for example.
2. Potential energy can be changed to kinetic energy: drop an object, for example.

B. Electromagnetic radiation is energy that travels as a wave, a result of changing electric and magnetic fields.

1. Each form of electromagnetic radiation has a different wavelength and energy content.

2. The electromagnetic spectrum describes the range of electromagnetic waves that have different wavelengths and energy content.

1. Heat is the total kinetic energy of all moving atoms, ions, or molecules in a substance.
2. It can be transferred from one place to another by convection, conduction, and radiation.
3. Temperature is the average speed of motion of atoms, ions, or molecules in a sample of matter.

3. Energy quality is measured by its usefulness. High energy is concentrated and has high usefulness. Low energy is dispersed and can do little work.

3-5 The Law of Conservation of Matter: A Rule We Cannot Break

1. When matter has a physical change, its chemical composition is not changed; the molecules are organized in different patterns.
2. In a chemical change, the chemical composition of the elements/compounds change. Shorthand chemical equations represent what happens in the reaction.
3. The Law of Conservation of Matter states that no atoms are created/destroyed during a physical or chemical change. The same is true for energy.

1. Atoms are rearranged into different patterns/combinations.

2. Atoms can have physical or chemical changes, but they are never created nor destroyed.

1. Chemical equations are used to verify that no atoms are created or destroyed in a chemical reaction. The number of atoms on one side of the equation must equal the number of atoms on the other side of the equation.
2. We will always have some pollutants, but we can produce less and clean up some that we do produce.

1. Three factors determine the severity of a pollutant’s harmful effects: chemical nature, concentration, and persistence.

2. Dilution of concentration of a pollutant is only a partial answer.

3. Pollutants are classified into four categories based on persistence: degradable, biodegradable, slowly degradable, and non-degradable.

3-6 Nuclear Changes

1. Matter can undergo a change known as a nuclear change. Three types of nuclear change are radioactive decay, nuclear fission, and nuclear fusion.
2. Radioactive isotopes emit high-energy radiation at a fixed rate until the original unstable isotope is changed into a stable isotope.

1. Alpha particles are fast-moving and positively charged; they consist of two protons and two neutrons.

2. Beta particles are high-speed electrons.

3. Rate of decay into a stable isotope is expressed in terms of half-life: the time needed for one-half of the nuclei of a given quantity to form a different isotope.

4. Half-life time is used to estimate storage time needed in a safe container to reach a safe level.

5. Exposure to ionizing radiation from alpha particles, beta particles or gamma rays damages cells in two possible ways: genetic damage (mutation of DNA molecules) and somatic damage to tissues that harm the quality of life.

1. Nuclei of certain isotopes with large mass numbers (uranium-235) are split apart into lighter nuclei when struck by neutrons. This is nuclear fission

1. A critical mass of fissionable nuclei must be present.

2. Multiple fissions within the critical mass result in a chain reaction with release of enormous amounts of energy.

3. Nuclear fission is used to produce high-pressure steam to generate electricity.

1. Nuclear fusion occurs at extremely high temperatures and involves the fusion of two isotopes of light elements (H). It is difficult to initiate, but once started, releases more energy per unit than fission. This technology is still in the laboratory stage after 50 years of research.

3-7 Energy Laws: Two Rules We Cannot Break

1. The First Law of Thermodynamics states that energy can neither be created nor destroyed, but can be converted from one form to another.
2. The Second Law of Thermodynamics states that when energy is changed from one form to another, there is always less usable energy. Energy quality is depleted.

1. In changing forms of energy, there is a loss in energy quality; heat is often produced and lost.

2. Changing forms of energy produces a small percentage of useful energy; much is lost in the process, energy not used by the application.

3. In living systems, solar energy is changed to chemical energy, then to mechanical energy. High quality energy degrades to low quality heat.

4. High-quality energy cannot be recycled/reused.

5. Energy efficiency/productivity measures the amount of useful work by a specific input of energy. Overall, energy efficiency is very poor—about 16% of energy produces useful work.

6. Forty-one percent is unavoidable waste energy, and forty-three percent is unnecessarily wasted energy. A change in habits can further reduce this waste.

3-8 Matter and Energy Laws and Environmental Problems

A. Resource use automatically adds some waste heat/waste matter to the environment.

B. Advanced industrialized countries have high-throughput (high waste) economies.

1. Resources flow into planetary sinks (air, water, soil, organisms) with accumulation to harmful levels.

* 1. Eventually consumption will exceed capacity of the environment to dilute/degrade wastes.

1. Recycling/reusing more of Earth’s matter resources slows depletion of nonrenewable resources and reduces environmental impact.
2. Waste heat is added to the environment even with recycling/reuse, but does slow the process and buys some time.
3. Shifting to a more sustainable, low-throughput (low-waste) economy is the best long-term solution to environmental/resource problems. Waste less matter; live more simply; and slow population growth.