Lifelong Learning Programme

TÜRKİYE CUMHURİYETİ
AVRUPA BİRLİĞİ BAKANLIĞI
REPUBLIC OF TURKEY
MINISTRY FOR EU AFFAIRS

AB EĞİTİM VE GENÇLİK PROGRAMLARI MERKEZİ BAŞKANLIĞI

Leonardo da Vinci Transfer of Innovation Project
2011-1-TR1-LEO05-27987

ECO-MATRIX

I want to be an Ecologist!

Chemistry, Engineering, Biology and Architecture in the context of Ecology

www.Eco-Matrix.com

This Publication was created and edited within the project ECO MATRIX (LdV TOI 2011-1-TR1-LEO05-27987) that has been founded with support from the European Commission under the Lifelong Learning Program. This publication reflects only the views of the authors and the European Commission cannot be held responsible for any use which may be made for the information contained therein.

Imprint

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European Commission within the Lifelong Learning Program

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1 INTRODUCTION

Ecology is the scientific study of the way that living organisms interact with their environment.

Origin of the word “ECOLOGY”:

- Greek origin
- OIKOS = household
- LOGOS = study of…
- Study of the “house/environment” in which we live

We can define the work of an “ecologist” and an “environmentalist,” as follows:

- Environmentalists seek to preserve natural systems.
- Ecologists, while they may share the ideals of environmentalists, are mainly involved with gathering information about the communities of animals and plants, as well as the physical elements (such as rocks and soil) present in a given geographical area.

Various aspects of ecology is presented in ECO-MATRIX Leonardo da Vinci Transfer of Innovation Project, which is funded by the European Commission, through the following partners from four different countries, Turkey, Bulgaria, Austria and Greece:

- Cem Acikkol Architecture Co. Ltd. (TR)
- Erbil Project Consulting Engineering Incorporated Company (TR)
- Research and Development Center “Biointech” Ltd. (BG)

- Institut fuer Bildungsforschung der Wirtschaft (AT)
- Natural Balance Society (TR)
- Aristotle University of Thessaloniki (EL)
- Pamukkale University (TR)
- Piramit Construction Tourism Industry and Trade Ltd. Co. (TR)

In ECO-MATRIX Project and its book “I Want to Be an Ecologist,” we aim to discuss ecology in terms of the following subjects:

- ARCHITECTURE
- BIOLOGY
- CHEMISTRY
- ENGINEERING

It is intended that this book will provide people with a greater understanding of ecology and environment, the principles associated with the protection of the environment and provide an opportunity for the increase in understanding of ecology through architecture, biology, chemistry and engineering concepts.

Ecology is a multidisciplinary science that is closely related to biology, climatology, chemistry, biophysics, engineering, mechanics, architecture, geology, physics and mathematics.

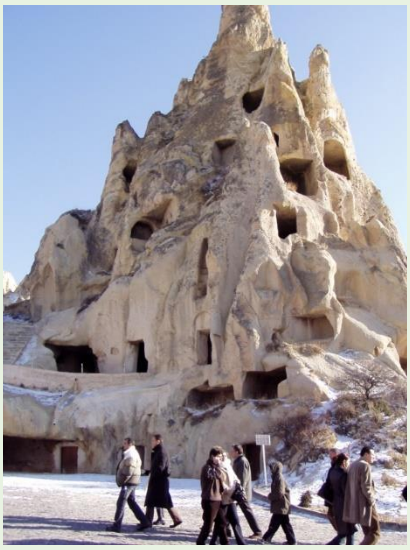
Ecology includes the study of environmental problems and the science of ecology mainly focuses on research of the natural world from many perspectives and employing many techniques. Modern ecology relies heavily on experiments, both in the laboratory and onsite field settings. These techniques provide practical results in testing ecological theories, and help in arriving at concrete decisions concerning the management of natural resources.

An understanding of ecology is important fact that must be taken into consideration in order to ensure the survival of the world and human beings. All around the world, populations are increasing rapidly and we are in danger of losing the resources that we need for our long-term survival. An understanding of ecological principles can help us understand the global and regional consequences of competition among humans for the limited natural resources that support us.

The purpose of ecology is to provide knowledge about the way the world works and provide evidence on the interdependence between the natural world and people. A better understanding of ecological systems will allow society to predict the consequences of human activity on the environment.

The word “ecology” (“Ökologie”) was coined in 1866 by the German scientist Ernst Haeckel (1834–1919). Ancient Greek philosophers such as Hippocrates and Aristotle laid the foundations of ecology in their studies on natural history. Modern ecology transformed into a more precise science in the late 19th century. Evolutionary concepts on adaptation and natural selection became the cornerstones of modern ecological theory. Ecologists seek to explain:

- Life processes and adaptations
- Distribution and abundance of organisms
- The interchange of materials and energy through living communities
- The successive development of ecosystems
- The abundance and distribution of biodiversity in the context of the environment



Ecology is a human science as well. There are many practical applications of ecology in conservation biology, wetland management, natural resource management (agro-ecology, agriculture, forestry, agro-forestry, and fisheries), city planning (urban ecology), community health, economics, basic and applied science, and human social interaction (human ecology). Ecosystems maintain biophysical feedback mechanisms that modulate metabolic rates and evolutionary dynamics between living (biotic) and non-living (abiotic) components of the planet. Ecosystems sustain life-supporting functions and produce natural resources through the regulation of continental climates, global biogeochemical cycles, water filtration, soils, food, fibers, medicines, erosion control, and many other natural features of scientific, historical, economic, or intrinsic value.

Modern ecology is a young science that first attracted substantial scientific attention towards the end of the 19th century (around the same time that evolutionary studies were gaining scientific interest). In the early 20th century, ecology transitioned from a more descriptive form of natural history to a more analytical form of scientific natural history. Frederic Clements published the first American ecology book in 1905, presenting the idea of plant communities as a super organism. This publication launched a debate between ecological holism and individualism that lasted until the 1970s.

Ecology entails physics because every biotic process implies the transfer and storing of energy. Producer organisms, like plants, take advantage of light energy to produce organic compounds. Other organisms, like bacteria and fungi, obtain energy by the disintegration of the molecular structures of other organisms.

Ecology applies chemistry because metabolic processes and physiology of bio-systems involve chemical reactions.

Ecology is related to geology because the distribution of the biomass depends on the geological structure and composition of the Earth's surface.

Geography is important to ecology because living beings are distributed across the Earth and follow specific patterns. The ecologist (i.e., a professional dedicated to the study of ecology) must know where to locate a particular ecosystem or biome to research and investigate it.

Mathematics is a central science to ecology in order to make calculations, statistics, projections and extrapolations concerning the number and distribution of species, amount of biomass, population growth, extension of communities, biodiversity, incoming energy, outgoing energy, etc. Additionally, ecologists use mathematics to quantify the environmental conditions that have a direct or indirect influence on the living beings inhabiting a given biome.

Climatology and meteorology are disciplines that help ecologists understand how the variations of climatic conditions affect regional biodiversity. In addition, climatology and meteorology assist ecologists in identifying the effects of regional and global climate changes on the survival of individuals, populations and communities inhabiting a certain geographic location, and how the regional climate relates with the distribution of living beings on Earth.

Levels of Organization in Ecology

The main five levels of organization in discipline of ecology consist of:

1. **Individual:** Individual is any living being. Individuals act reciprocally with the environmental abiotic factors, which limit their distribution.

2. **Population**: A group of individuals of a given species that live in a specific geographic area.

3. **Community**: All the living beings distributed into a specific geographical area. A community includes organisms of different species.

4. **Ecosystem:** The term refers to all the abiotic factors (physical and chemical constituents) and all the communities that are established in a specific area.

5. **Biosphere:** It is the whole portion of Earth colonized by living beings. Biosphere is the sum of all the ecosystems established on Earth.

The Four Laws of Ecology

Formulated by physicist and ecologist, Barry Commoner:

1) Everything is connected to everything else - humans and other species are connected/dependent on a number of other species.

2) Everything must go somewhere - no matter what you do, and no matter what you use, it has to go somewhere. For example, when you burn wood, it doesn't disappear, it turns into smoke which rises into the air, and ash, which falls back down to the earth.

3) Nature knows best - Like it says, nature knows best. As much as you think it might help a place by repainting it, you are submitting the fumes into the air and into your lungs. Why not put siding on it?

4) There is no such thing as a free lunch - Everything you do, must have a reason behind it. For example, a class pizza party. In order to win the party, you have to fill out a survey, and submit it back to your teacher. This law basically means you have to do something in order to get something in return.

2 CHEMISTRY

Zoi Georgiou, Vassilis Mougios

Introduction

Chemistry can be defined as the science dealing with the composition, properties, and structure of matter and with the ways in which substances interact (react) to produce new substances. Chemists are unique among other scientists in that they understand and explain scientific matters and subjects of importance to people in everyday life in terms of the properties of the around one hundred elements constituting all matter and the dazzling variety of molecules that are created by forming and breaking bonds between atoms of these elements. Thus, chemistry is defined by its approach rather than its subject matter. Chemistry understands and explains any subject in terms of the properties of atoms and molecules.

If chemistry has led to great improvements in human life style, it has also at the same time led to a number of hazardous effects on the environment. The emission of dangerous waste materials from chemical industries, almost all of which are not biodegradable, has led to an increase in environmental pollution through ways like the release of chlorofluorocarbons into the atmosphere, which leads to the thinning of the ozone layer.

Another well-known example is the excessive consumption of fossil fuels in the industry and transportation sectors, which leads to the emission of large amounts of greenhouse gases like carbon dioxide. This puts the burden on the shoulders of modern chemists to work, alone or with other scientists, for the remediation of the consequences of human activity on the environment. Hence comes the development of ecological chemistry.

2.1 What is ecology in chemistry? Ecology and Chemistry

Chemistry is vital to ecology. Chemical knowledge and chemical skills, possessed by qualified professionals, are valuable tools in environmental protection. This emanates from the fact that chemical form, state and reactivity determine how materials influence biological systems. Understanding the routes, dynamics and effects of the transfer of materials through atmospheric, terrestrial and aquatic systems and then putting this knowledge into practice to improve the quality of air, water, soil and food is part of chemistry's contribution to ecology.

Key areas of ecological chemistry include:

- Environmental pollution: distribution, fate and ecological implications of pollutants in the air, soil and water; transfer of pollutants to living organisms and the food chain.
- Ecotoxicology: responses to toxic agents at community, species, tissue, cellular and sub-cellular level; uptake, metabolism and excretion of toxicants; impact of environmental pollution on food and human health.
- Environmental bioremediation and biotechnology: laboratory and field activities to identify, evaluate and use biological/biotechnological means to restore contaminated air, soil and water.

2.2 Ecology related professions in chemistry

The main profession serving ecology from the side of chemistry is, naturally, that of the chemist. A chemist in the European Union can be a graduate of a University or technical University, but also of a VET college or VET school. He or she may be specialized in chemical analysis, inorganic chemistry, organic chemistry, industrial chemistry etc.

Additional professions that have a place in ecology and chemistry include the chemical technician, environmental analyst and environmental manager. Again, these specialties can be acquired from various levels of education, from VET school to University. Finally, certain countries offer apprenticeship training in waste reprocessing and recycling.

2.3 Green abilities

The following is a general outline of abilities that we consider desirable in the field of ecological chemistry. For a detailed listing visit http://www.eco-matrix.com.

- Monitor, meter and analyze pollutants in air, soil and water
- Collect and analyze organic or inorganic compounds of environmental origin to determine chemical properties, composition, structure, relationships and reactivity
- Identify and characterize chemical causes/sources of environmental pollution
- Monitor and analyze waste production by the chemical industry
- Meter and screen to determine exposure to environmental pollutants
- Know and apply chemical methods to limit air, soil and water pollution and improve environmental conditions
- Manage chemical waste (collect, transport, store, process, dispose of)
- Plan and run water purification plants
- Treat biogenic waste
- Recycle/extract raw materials and energy out of waste
- Protect groundwater from pollution
- Know national and international standards and legislation on ecologic and environmental protection
- Conduct quality control regarding the chemical composition of environmental specimens to ensure compliance with environmental specifications
- Plan, develop and implement programs/policies regarding chemical approaches to improve environmental habitats
- Prepare technical and research reports on the environmental impact of chemicals and communicate the results to the industry, business, government and general public

- Offer consultation on environmental protection, waste avoidance, waste segregation and the effective use of energy and environmental technology
- Evaluate the environmental situation for private construction or industrial projects
- Perform ecological auditing of enterprises
- Perform phytoremediation
- Know how waste can be degraded through processes such as photolysis, hydrolysis and fermentation
- Conduct applied research on the use of chemical products, such as polymers, for the protection, restoration and remediation of environmental habitats
- Promote the use of environmental management systems to reduce waste and minimize environmental damage from industrial production
- Compile and analyze information to determine the efficiency of industrial processes and equipment in meeting environmental standards and diagnose malfunction during manufacture
- Provide and maintain a safe work environment in production facilities

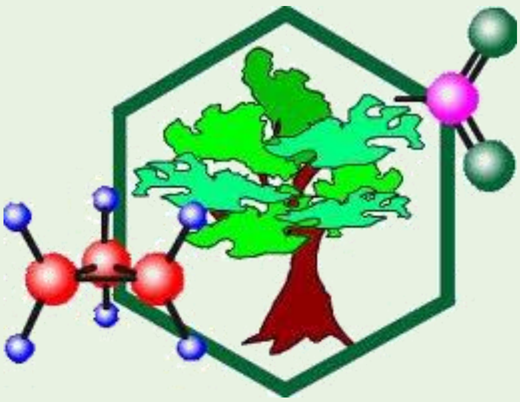
2.4 What can a chemist learn from ecological systems?

By studying and working on ecological systems, a chemist may gain a better understanding of the chemistry and biochemistry of living organisms, as well as their interactions with each other and the environment. This will result in a deeper appreciation of the delicate balance of most ecosystems and how easily human activities can disturb it. It will also result in a deeper appreciation of the value of chemistry in understanding environmental change and protecting the environment.

In this context, when chemists design new chemicals it is vital that they recognize and consider the potential harm to the environment. Many tests can be used to this end, including the estimation of damage on aquatic organisms by defining the minimum concentration at which a certain chemical can destroy certain fish species. The method is also applied for the estimation of possible harm caused by the disposal of chemical wastes to the environment. By this way, the balance of an ecosystem is used as a sensitive marker of possible environmental harm.

2.5 How can an ecological understanding of systems contribute to chemistry?

The natural environment represents an immense source of information and challenge for chemistry. This became very clear by observing reactions taking place in ecosystems. By this way, scientists realized that various ecosystems in nature are closely connected to each other and that actions taken within one ecosystem may affect the living organisms of another ecosystem. It also became clear that there are no borders preventing pollution from being transferred from one place to another in nature and that permanent harm to the environment eventually affects human beings. In practice, destroying components of various ecosystems can compromise the quality of human life and lead to disease and death.



Therefore, it became very important to design chemicals that are safer to use and possess certain environmentally friendly characteristics.

This led to the introduction of the Green Chemistry Concept and the design of chemicals that are less hazardous to human health and the environment. Such chemicals should be;

- less toxic to organisms and ecosystems,
- not persistent or bio accumulative in organisms or the environment, and
- Inherently safer with respect to handling and use.

Green chemistry consists of chemicals and chemical processes designed to reduce or eliminate negative environmental impact. The use and production of such chemicals may involve reduced waste products, non-toxic components, and improved efficiency. Green chemistry is a highly effective approach to pollution prevention because it applies innovative scientific solutions to real-world environmental situations.

2.6 How can a chemist contribute to a sustainable world?

The chemical industry has had (and still has) its share in environmental relegation through practices that harm the atmospheric, terrestrial and aquatic systems. From this emanates a key contribution of chemists to a sustainable world, that is, to help minimize ecological harm from the chemical industry by designing, implementing and monitoring measures against pollution.

In this context, green chemistry offers environmentally friendly, sustainable chemicals and processes whose use results in reduced waste, safer outputs, and reduced or eliminated pollution and environmental damage. Green chemistry encourages innovation and promotes the creation of products that are both environmentally and economically sustainable. Hence, the term Sustainable Chemistry has been coined. This includes the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle of a chemical product, including its design, manufacture, and use. Thus, the benefits that green chemistry technology provides can be summarized as

- reduced waste,
- safer products,
- reduced use of energy and resources, and
- Improved competitiveness of chemical manufacturers and their customers.

In order for a chemist to contribute to a sustainable word, chemical products and processes should be designed according to the Sustainable Chemistry Hierarchy and be cost-competitive in the market, as follows (taken from www.epa.gov/greenchemistry/pubs/about_gc.html).

1. Green chemistry: source reduction/prevention of chemical hazards
    - Design chemical products to be less hazardous to human health and the environment
    - Use feed stocks and reagents that are less hazardous to human health and the environment
    - Design syntheses and other processes to be less energy and materials intensive (high atom economy, low E-factor)
    - Use feed stocks derived from annually renewable resources or from abundant waste
    - Design chemical products for increased, more facile reuse or recycling

2. Reuse or recycle chemicals

3. Treat chemicals to render them less hazardous

4. Dispose of chemicals properly

2.7 What worked in the past, what is working now, what might work in the future in terms of ecology and chemistry?

2.7.1 Milestones

The US Pollution Prevention Act of 1990 set the stage for green chemistry: Its focus is the prevention of pollution at the source rather than the treatment of pollutants after they are formed. This goal became a formal objective of the Environmental Protection Agency (EPA) in 1991. Anastas coined the term green chemistry the same year. Two of the most prominent and early advocates of green chemistry were Kenneth Hancock of the National Science Foundation (NSF) and Joe Breen, who, after twenty years of service at the EPA, became the first director of the Green Chemistry Institute (GCI) during the late 1990s.

Anastas and Warner formulated the twelve principles of green chemistry in 1998. These serve as guidelines for chemists seeking to lower the ecological footprint of the chemicals they produce and the processes by which such chemicals are made.

The twelve principles of green chemistry

1. It is better to prevent waste than to treat or clean up waste after it is formed.
2. Synthetic methods should be designed to maximize the incorporation of all materials used in the process in the final product.
3. Wherever practical, synthetic methods should be designed to use and generate substances that pose little or no toxicity to human health and the environment.
4. Chemical products should be designed to preserve efficacy of function while reducing toxicity.
5. The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary whenever possible and innocuous when used.
6. Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
7. A raw material feedstock should be renewable rather than depleting whenever technically and economically practical.
8. Unnecessary derivatization (blocking group, protection/deprotection, and temporary modification of physical/chemical processes) should be avoided whenever possible.
9. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.
11. Analytical methods need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.
12. Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including release, explosion, and fire.

2.8 Best practices, case studies

Starting in 1996, outstanding examples of green chemistry have been recognized in the United States each year by the Presidential Green Chemistry Challenge (PGCC) awards. These are the only awards in chemistry that are bestowed at the presidential level.

The EPA and the American Chemical Society (ACS) have played a major role in promoting research and development, as well as education, in green chemistry. In 2000 the GCI became a partner of the ACS. Chemical societies around the globe have recognized the importance of green chemistry and promote it through journals, conferences, educational activities, and the formation of GCI chapters. There are GCI chapter affiliates all over the world.

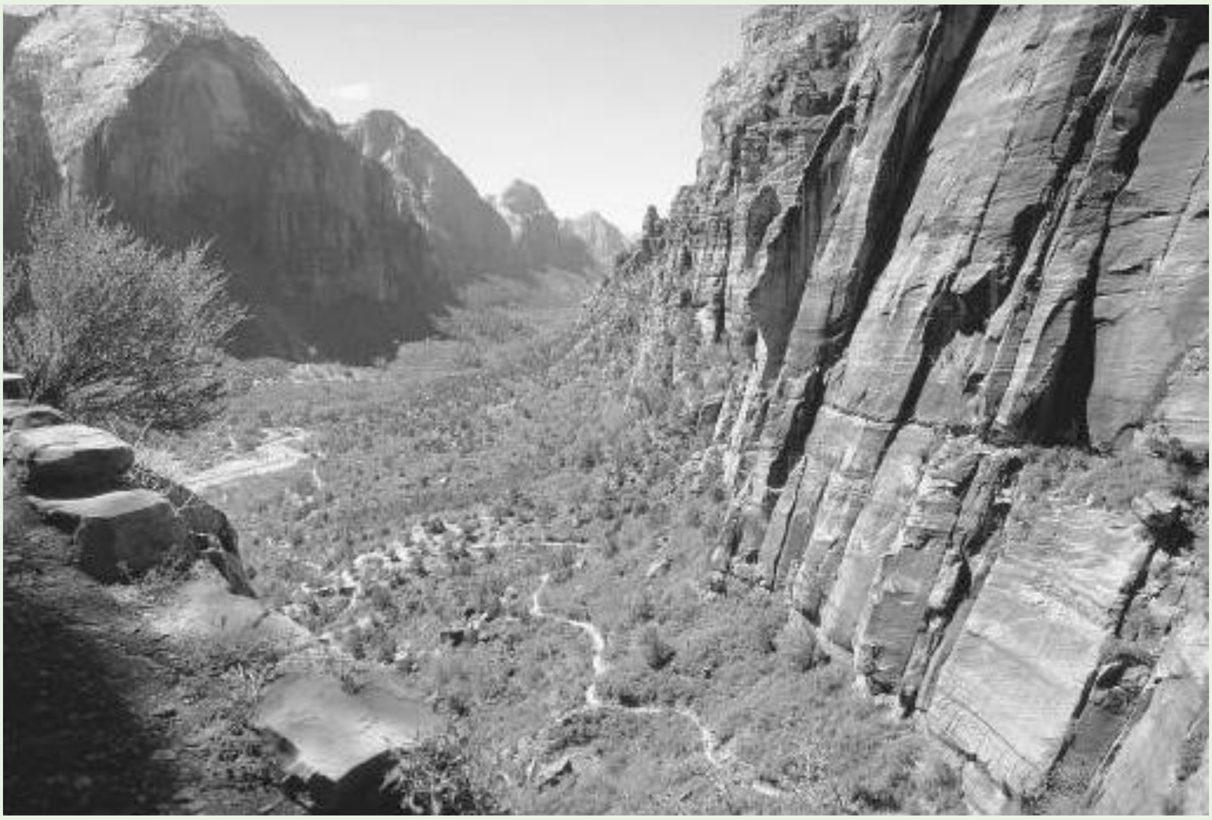
2.8.1 Importance to industry: the triple bottom line

During the 1990s many industries began to earnestly adopt green chemistry and other sustainable practices. Forward-looking companies realized that the practice of green chemistry not only leads to environmental benefits, but also economic and social benefits. The combination of these three benefits is known as the “triple bottom line” and provides strong encouragement for businesses to develop sustainable products and processes.

The following real-world examples of green chemistry represent the accomplishments of several winners of the PGCC awards. They illustrate how green chemistry impacts a wide array of fields including pharmaceuticals, pesticides, polymers, and many others.

2.8.2 The concept of atom economy

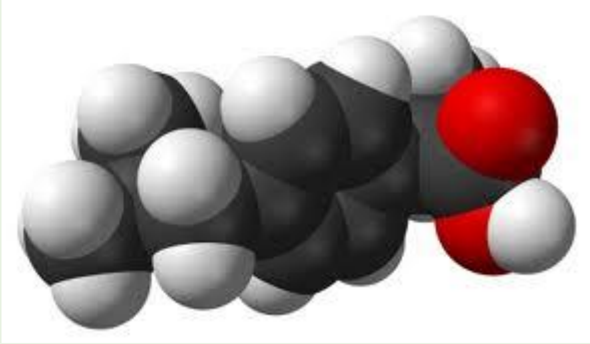
When chemists are considering a compound, they are concerned with the chemical, biological, and physical properties of this compound, and the method by which the compound is prepared. In order to focus greater attention on waste by-products that are formed during a synthesis, Barry Trost of Stanford University developed the concept of atom economy. This concept deals with the question: How many of the atoms of the reactants are incorporated into the final desired product and how many are wasted by incorporation into by-products? An example of the application of this concept is discussed in the following synthesis of ibuprofen.



Concerns over the pollution of natural resources such as this valley in Zion National Park, Utah, prompted the development of green chemistry in the 1990s.

2.8.3 Pharmaceuticals

Ibuprofen is the active ingredient in many analgesic and inflammatory drugs such as Advil, Motrin, and Medipren. Beginning in the 1960s, ibuprofen was produced by a six-step synthesis with an atom economy of only 40%. This meant that less than half of the weights of all the atoms of the reactants were incorporated in the ibuprofen molecule, whereas 60% were wasted in the formation of unwanted by-products. The annual production of approximately 15 million kilograms of ibuprofen by this method resulted in over 20 million kilograms of waste. But during the 1990s, the BHC Company developed a new synthesis of ibuprofen with an atom economy of 77-99%.



This synthesis not only produces much less waste, it is also only a three-step process. A pharmaceutical company can thus produce more ibuprofen in less time and with less energy, which results in increased profits.

2.8.4 Pesticides

Dichlorodiphenyl trichloroethane (DDT) is one of the most known insecticides. During World War II it saved thousands of lives of the Allied Forces by killing disease-carrying insects, but during the 1960s the serious environmental damage caused by DDT was brought to the public's attention by Rachel Carson in Silent Spring (1962). As a result of the controversy generated by this book and other media coverage, the substance's use was banned in the United States in 1973.

During the 1960s and 1970s organophosphates largely replaced organo-chlorine pesticides such as DDT. These pesticides rapidly degrade in the environment, but they are much more toxic to mammals. They are deadly to a wide array of insects and kill not only the target organism but also beneficial insects, such as bees and predatory beetles, and can also be harmful to humans.

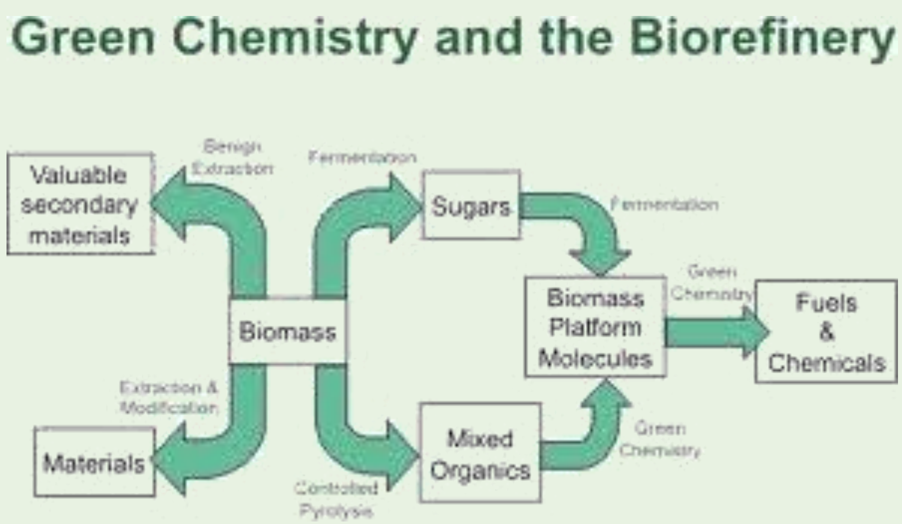
One approach to producing less environmentally harmful pesticides is to use compounds that destroy only the target organisms. One manufacturer, Rohm & Haas, has developed insecticides that mimic a hormone used only by molting insects. Insects that do not molt are not affected, which leaves many beneficial insects unharmed.

A more recent strategy for protecting plants from pests and disease involves the use of genetically altered plants. This method is controversial. Concerns include cross-pollination with unaltered plants and the entry of altered plants into the food supply.

Another approach to protecting plants from pests and diseases is to activate their natural defense mechanism against pests or diseases. EDEN Bioscience Corporation has developed what is known as harpin technology. Harpin is a naturally occurring protein that is isolated from genetically altered bacteria. When applied to the leaves and stems of plants, this protein elicits their natural defense systems. The EPA has classified harpin as Category IV, which is reserved for materials with the lowest hazard potential. As an added benefit, harpin also stimulates plant growth.

2.8.5 Polymers

Synthetic polymers or plastics are everywhere. They are used in cars, computers, planes, houses, eyeglasses, paints, bags, appliances, medical devices, carpets, tools, clothing, boats, batteries, and pipes. More than 30 million kilograms of polymers are produced in the United States each year. The feedstock that are used to produce these polymers are virtually all made from petroleum, a non-renewable resource. Approximately 2.7% of all crude oil is used to generate chemical feedstock.



In order to decrease human consumption of petroleum, chemists have investigated methods for producing polymers from renewable resources such as biomass. NatureWorks polylactic acid (PLA) is a polymer of naturally occurring lactic acid, and lactic acid can be produced from the fermentation of corn. The goal is to eventually manufacture this polymer from waste biomass. Another advantage of PLA is that, unlike most synthetic polymers which litter the landscape and pack landfills, it is biodegradable. PLA can also be easily recycled by conversion back into lactic acid. It can replace many petroleum-based polymers in products such as carpets, bags, cups, and textile fibers.

2.8.6 Computer chips

The manufacture of computer chips requires excessive amounts of chemicals, water, and energy. Estimates indicate that the weight of chemicals and fossil fuels required to make a computer chip is 630 times the weight of the chip, as compared to the 2:1 ratio for the manufacture of an automobile. Scientists at the Los Alamos National Laboratory have developed a process that uses supercritical carbon dioxide in one of the steps in chip preparation. This reduces the quantities of chemicals, energy, and water needed to produce chips considerably.

2.8.7 Dry cleaning

Condensed-phase carbon dioxide is used as a solvent for the dry cleaning of clothes. Although carbon dioxide alone is not a good solvent for oils, waxes, and greases, the use of carbon dioxide in combination with a surfactant allows for the replacement of perchloroethylene (which is the solvent used most often to dry clean clothes, although it poses hazards to the environment and is a suspected human carcinogen).

2.8.8 Other examples

Some other examples of green chemistry include the following:

- taking chromium and arsenic, which are toxic, out of pressure-treated wood
- using new, less toxic chemicals for bleaching paper
- substituting yttrium for lead in auto paint
- using enzymes instead of a strong base for the treatment of cotton fibers

Green chemistry reduces toxicity, minimizes waste, saves energy, and cuts down on the depletion of natural resources. It allows for advances in chemistry to occur in a much more environmentally benign way. In the future, when green chemistry is practiced by all chemists and all chemical-related companies, the term ‘green chemistry’ will ideally disappear as all chemistry becomes green.

2.9 Questions and answers

1. **Which are the key areas of ecological chemistry?**

- Environmental pollution: distribution, fate and ecological implications of pollutants in the air, soil and water; transfer of pollutants to living organisms and the food chain.
- Ecotoxicology: responses to toxic agents at community, species, tissue, cellular and sub-cellular level; uptake, metabolism and excretion of toxicants; impact of environmental pollution on food and human health.
- Environmental bioremediation and biotechnology: laboratory and field activities to identify, evaluate and use biological/biotechnological means to restore contaminated air, soil and water.

2. **Which are the main green abilities that a chemist should possess?**

- Monitor, meter and analyze pollutants in air, soil and water
- Collect and analyze organic or inorganic compounds of environmental origin to determine chemical properties, composition, structure, relationships and reactivity
- Identify and characterize chemical causes/sources of environmental pollution
- Monitor and analyze waste production by the chemical industry
- Meter and screen to determine exposure to environmental pollutants
- Know and apply chemical methods to limit air, soil and water pollution and improve environmental conditions
- Manage chemical waste (collect, transport, store, process, dispose of)
- Plan and run water purification plants
- Treat biogenic waste
- Recycle/extract raw materials and energy out of waste
- Protect groundwater from pollution
- Know national and international standards and legislation on ecologic and environmental protection
- Conduct quality control regarding the chemical composition of environmental specimens to ensure compliance with environmental specifications
- Plan, develop and implement programs/policies regarding chemical approaches to improve environmental habitats
- Prepare technical and research reports on the environmental impact of chemicals and communicate the results to the industry, business, government and general public
- Offer consultation on environmental protection, waste avoidance, waste segregation and the effective use of energy and environmental technology

- Evaluate the environmental situation for private construction or industrial projects
- Perform ecological auditing of enterprises
- Perform phytoremediation
- Know how waste can be degraded through processes such as photolysis, hydrolysis and fermentation
- Conduct applied research on the use of chemical products, such as polymers, for the protection, restoration and remediation of environmental habitats
- Promote the use of environmental management systems to reduce waste and minimize environmental damage from industrial production
- Compile and analyze information to determine the efficiency of industrial processes and equipment in meeting environmental standards and diagnose malfunction during manufacture
- Provide and maintain a safe work environment in production facilities

3. **What is the Green Chemistry Concept?**

- Design chemicals that are less hazardous to human health and the environment.

4. **Which are the main characteristics of green chemicals?**

- Less toxic to organisms and ecosystems
- Not persistent or bio accumulative in organisms or the environment
- Inherently safer with respect to handling and use

5. **Which are the main benefits that green chemistry technology provides?**

- Reduced waste
- Safer products
- Reduced use of energy and resources
- Improved competitiveness of chemical manufacturers and their customers

6. **Which are the principles of Sustainable Chemistry Hierarchy?**

- Green chemistry: source reduction/prevention of chemical hazards
- Design chemical products to be less hazardous to human health and the environment
- Use feedstock and reagents that are less hazardous to human health and the environment
- Design syntheses and other processes to be less energy and materials intensive (high atom economy, low E-factor)
- Use feedstock derived from annually renewable resources or from abundant waste

- Design chemical products for increased, more facile reuse or recycling
- Reuse or recycle chemicals
- Treat chemicals to render them less hazardous
- Dispose of chemicals properly

7. **Which are principles of green chemistry?**

- It is better to prevent waste than to treat or clean up waste after it is formed.
- Synthetic methods should be designed to maximize the incorporation of all materials used in the process in the final product.
- Wherever practical, synthetic methods should be designed to use and generate substances that pose little or no toxicity to human health and the environment.
- Chemical products should be designed to preserve efficacy of function while reducing toxicity.
- The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary whenever possible and innocuous when used.
- Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
- A raw material feedstock should be renewable rather than depleting whenever technically and economically practical.
- Unnecessary derivatization (blocking group, protection/deprotection, and temporary modification of physical/chemical processes) should be avoided whenever possible.
- Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
- Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.
- Analytical methods need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.
- Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including release, explosion, and fire.

8. **What is the concept of atom economy?**

When synthesizing a compound, try to maximize the number of atoms of the reactants that are incorporated into the final desired product and minimize the number of atoms of the reactants that are wasted by incorporation into by-products.

9. **How has green chemistry affected the production of pesticides?**

Several approached are being employed to produce pesticides that are less environmentally harmful than the ones used in previous decades (such as DDT and the organophosphates). One such approach is to use compounds that destroy only the target organisms. For example, there are insecticides that mimic a hormone used only by molting insects. Insects that do not molt are not affected, which leaves many beneficial insects unharmed. Another approach is to activate the natural defense of plants against pests or diseases. In the so called harpin technology, a naturally occurring protein that is isolated from genetically altered bacteria elicits the natural defense systems of plants. The EPA has classified harpin as Category IV, which is reserved for materials with the lowest hazard potential. As an added benefit, harpin also stimulates plant growth.

10. **Give three examples of green chemistry implementation in everyday life.**

Polymers. Synthetic polymers or plastics are used by the tons in everyday life. The feedstock that are used to produce these polymers are virtually all made from petroleum, a nonrenewable resource. In order to decrease human consumption of petroleum, chemists have investigated methods for producing polymers from renewable resources such as biomass. Polylactic acid (PLA) is a polymer of naturally occurring lactic acid, and lactic acid can be produced from the fermentation of corn. The goal is to eventually manufacture this polymer from waste biomass. Another advantage of PLA is that, unlike most synthetic polymers which litter the landscape and pack landfills, it is biodegradable. PLA can also be easily recycled by conversion back into lactic acid. It can replace many petroleum-based polymers in products such as carpets, bags, cups, and textile fibers.

Computer chips. The manufacture of computer chips requires excessive amounts of chemicals, water, and energy. Estimates indicate that the weight of chemicals and fossil fuels required to make a computer chip is 630 times the weight of the chip, as compared to the 2:1 ratio for the manufacture of an automobile. Using supercritical carbon dioxide in one of the steps in chip preparation reduces the quantities of chemicals, energy, and water needed to produce chips considerably.

Dry cleaning. Condensed-phase carbon dioxide is used as a solvent for the dry cleaning of clothes. Although carbon dioxide alone is not a good solvent for oils, waxes, and greases, the use of carbon dioxide in combination with a surfactant allows for the replacement of perchloroethylene (which is the solvent used most often to dry clean clothes, although it poses hazards to the environment and is a suspected human carcinogen).

3 ENGINEERING

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3.1 What is ecology in engineering? Ecology and Engineering

Destruction of nature by anthropogenic activities, especially by industrialization and urbanization are loading heavy burden on the earth itself. Carrying capacity of the nature is being exceeded. Decrease in biodiversity, depletion in ozone layer, floods, storms, shortly, climate change are the indicators of reactions of nature towards exceeding our limits as human beings. Therefore it is evident that, there should be a challenge towards a new life styles, new consumption and production patterns which is more nature-friendly. Changing paradigm -in engineering aspects- would require that, engineering training programs and thus applications should be and are being modified as including ecological aspects. Adaptation of ecological way of thinking into technical and analytical thinking must be a prerequisite for graduation and authorization of engineers.

In 1828, Tredgold defined engineering as “the art of directing the great sources of power in nature for the use and convenience of man” (Meijers, 2009). When we examine this definition in depth, his approach is directly anthropocentric (see section 3.4.1.1.) which is very normal in that period. The harmful impacts of environmental problems have not faced yet; people are in the period of just enjoying their success in some technological advancement, feeling themselves as the conqueror of the universe. Successive industrial evolutions have since increased man’s capacity to dominate over nature. So it is thought that, human beings have the power of directing natural resources and nature itself with their intelligence. Unfortunately, the story did not progress as it is expected and desired. Water and coal-powered mechanization of industry at the beginning of 18th century cause to increasing consumption of chemicals which led to the poisoning of European rivers, climaxing in the 1971 pollution scandal in the Rhine which finally led to massive efforts to clean up the river. While industries did not use coal as a key factor during early period, energy supply was still dominated by coal and coal consumption for steel production increased steeply in the most dynamic industrial regions such as the Ruhr and Pittsburgh. Here, the use of coal for steelworks produced serious smog problems. In addition, the smog problems characterizing Britain in the 19th century were not sufficiently ameliorated. Extension of electricity networks lagged behind here, and coal burnt in ineffective open hearths was still common. The adequate regulation of smoke only emerged after the smog disaster of 1952, when 4 000 people died within a few days in London (Kasa, 2009).

Along this line as it is mentioned in the introduction, now many engineers understand their brief to include directing the powers of humanity for the benefit of nature, the flipside of the Tredgold's definition (Bell, 2011). This awakening lead to a new thinking -a paradigm shift- SUSTAINABILITY. Sustainability could be achieved by taking better consideration of the environment within the process of industrialization and development. That is; engineers are indispensable actors/factors of sustainability. They should become intimately associated with ecology and sustainability.

The question of "How can engineering practice and technology help to move the products, processes, and systems developed by society toward sustainability?" could be answered as; by greening of engineering. This term accepts that humanity is inseparable from and dependent on natural systems and that the growing worldwide population and consumption have damaged, and will increasingly stress global ecosystems. Green engineering is the design of sustainable systems, consistent with ecological principles (see section 3.5.1) which integrate human society with its natural environment for the benefit of both. It recognizes the relationship of organisms (including humans) with their environment and the constraints on design imposed by the complexity, variability and uncertainty inherent to natural systems (Bergen et al., 2001).

According to this understanding of greening, engineers should:

- Understand the interdependence of human beings and natural resources
- Understand how resources, consumption, population, and worldviews define sustainability
- Understand how contemporary value systems determine our human interactions with nature.

Green Engineering can be defined as environmentally conscious attitudes, values, and principles, combined with science, technology, and engineering practice, all directed toward improving local and global environmental quality (Virginia Tech. 2012).

Green engineering is the design, commercialization, and use of processes and products, which are feasible and economical while minimizing 1) generation of pollution at the source and 2) risk to human health and the environment. Green engineering embraces the concept that decisions to protect human health and the environment can have the greatest impact and cost effectiveness when applied early to the design and development phase of a process or product.

Principles of Green Engineering are listed below which was developed by more than 65 engineers and scientists at the Green Engineering: Defining the Principles Conference, held in Sandestin, Florida in May of 2003. The preliminary principles forged at this multidisciplinary conference are intended for engineers to use as guidance in the design or redesign of products and processes within the constraints dictated by business, government and society such as cost, safety, performance and environmental impact.

1. Engineer processes and products holistically, use systems analysis, and integrate environmental impact assessment tools.
2. Conserve and improve natural ecosystems while protecting human health and well-being.
3. Use life-cycle thinking in all engineering activities.
4. Ensure that all material and energy inputs and outputs are as inherently safe and benign as possible.
5. Minimize depletion of natural resources.
6. Strive to prevent waste.
7. Develop and apply engineering solutions, while being cognizant of local geography, aspirations, and cultures.
8. Create engineering solutions beyond current or dominant technologies; improve, innovate, and invent (technologies) to achieve sustainability.
9. Actively engage communities and stakeholders in development of engineering solutions.

As a summary; this new paradigm has developed to improve engineers' understanding of ecological processes and understand holistic approach. Engineers should harmonize technology with ecological way of thinking.

3.2 Ecology related professions in engineering

All professions in the engineering area affect the nature directly or indirectly and they should be evaluated as ecology related professions. But some of the engineering professions are more related to the ecology compared to the others. According to the study performed in the Austria, Bulgaria, Greece and Turkey as a part of the ECO-MATRIX Leonardo da Vinci project, ecology related professions in engineering professional area and their diploma degrees are listed in the Table 1.

Table 1 Ecology related professions in engineering professional area

Country	Profession	Degree
Greece	Antisoilling technologist	Higher education
Turkey	Chemical engineer	University
Austria	Chemical process engineer	Apprenticeship training
Turkey	Civil engineer	University
Greece	Ecology and environmental technologist	Higher education
Bulgaria	Domes and towers construction engineer, Bridge construction engineer, Construction engineer, Port construction engineer, Railroad construction engineer, Road construction engineer, Water construction engineer, Industrial and civil construction engineer	University
Bulgaria	Manufacture and distribution of natural gas engineer, Development and exploitation of oil and natural gas engineer, Steam and water boilers engineer	University
Bulgaria	Chimneys engineer, Drilling machines engineer, Gas turbines engineer, Hydraulic and pneumatic machinery engineer, Hydropower construction engineer, Machines and apparatus for producing nuclear energy engineer, Power engineer, Nuclear power engineer, Power generation engineer, Thermal power engineer, Water turbines engineer	University
Bulgaria	Enrichment and briquetting of coal engineer, Enrichment of minerals engineer, Mining machinery engineer, Chemical processes engineer, Chemical engineer, Mining engineer	University
Bulgaria	Forest engineer, Hydrology engineer, Irrigation engineer, Irrigation construction engineer, Water purification engineer, Water supply and sewerage engineer	University
Turkey, Greece	Environmental engineer	University
Turkey	Environmental protection and control technician	VET college
Austria	Installations technology	Apprenticeship training
Austria	Plastics engineer	Apprenticeship training
Greece	Pollution monitoring and counter-pollution facility technician	Higher education
Greece	Regional planning and regional development engineer	University
Austria	Solar engineer	VET college, University of applied sciences

Source: Summary of National Reports within the project ECO MATRIX

3.3 Green Abilities

Knowledge, skills, and abilities (KSA) is a concise essay about one's talent and expertise and related experiences and accomplishments. Knowledge is a body of information applied directly to the performance of a function, skill is an observable competence to perform a learned psychomotor act and ability is competence to perform an observable behavior or a behavior that results in an observable product (http://en.wikipedia.org/wiki/Knowledge,_Skills,_and_Abilities).

According to the study mentioned in the Section 3.2, green knowledge, green skills and green abilities are listed below which are essential for the engineering professional area.

Green Knowledge:

- Counseling and information about waste avoidance and waste segregation
- Counseling and information of private households and enterprises concerning efficient use of energy
- Develop or evaluate environmental impact studies
- Energy accounting – knowledge to capture data of energy expenditure and energy revenues
- Fuel techniques – extraction and transformation of fuels
- Know-how and knowledge of methods about the physical-chemical processing and storage of waste
- Knowledge about running of power plants
- Knowledge about waste management
- Knowledge in energy storage
- Knowledge in energy supply
- Knowledge in not-renewable energy sources
- Knowledge in photovoltaic
- Knowledge in planning power plants
- Knowledge in power plant techniques
- Knowledge in professional collection of waste
- Knowledge in running clarification plants
- Knowledge in sealing of disposal sites to avoid that polluted water soak into the groundwater
- Knowledge in separation, storage and processing of waste paper
- Knowledge in storage of waste

- Knowledge of alternative energy sources
- Knowledge of gas supply
- Knowledge of gas technique
- Knowledge of measurements to protect waters
- Knowledge of techniques to store thermal energy
- Knowledge of waste analyzing methods to breakdown the inherent materials of a waste sample
- Permanent repository – knowledge in development, construction and run of permanent repositories for radioactive waste materials
- Pollution prevention of groundwater
- Recycling – knowledge in extraction of row materials, products and energy out of waste
- Sewage management – knowledge of collection, discharge and preparation of polluted water
- Specify technical characteristics for the installation of systems based on mild forms of energy (such as solar and wind energy)
- Waste water draw-off – Transportation of wastewater through channels
- Determination of characteristics of emission
- Direct environmental compliance activities (operational instructions, environmental impact statements, reports, presentations) associated with nuclear plant operations or maintenance
- For safe, economical, and environmentally sound extraction of minerals, ores and petroleum products
- Knowledge about biotechnical techniques
- Knowledge about physical, chemical, biological and advanced treatment processes
- Knowledge about recycling
- Knowledge in collection and storage of waste
- Knowledge in disposal of municipal and hazardous waste
- Knowledge in professional collection of municipal waste and hazardous waste
- Knowledge of collection, discharge and preparation of polluted water
- Sewage management, knowledge of collection and discharge
- Wastewater collection and disposal
- Wastewater collection and transportation using channels
- Water (surface and groundwater) quality control and management
- Water pollution control and water preparation
- Water supply and distribution

Green Skills:

- Install and maintain instruments, apparatus and systems in anti-pollution facilities
- Measure soil, air, water, wastewater and waste quality
- Monitor the good operation of counter-pollution facilities according to current standards and regulations
- Monitor water and waste treatment facilities
- Sample air, water, and soil for pollutant analysis
- Assemble or test energy providing materials and systems including new green technologies
- Create or modify electrical components to be used in renewable energy generation
- Inspect or monitor energy systems to identify energy savings opportunities and make recommendations to achieve more energy efficient operation
- Metering of smoke, gas, dust and heat and rays
- Test air to detect toxic gases and recommend measures to remove them

Green Abilities:

- Analyzing of wastewater
- Assess and monitor environmental, ground water and air quality
- Assess the environmental impact of technical projects or other activities according to current legislation
- Assess, test, and prevent pollution (Integrated Pollution Prevention Control, IPPC)
- Certify enterprises according to environmental standards
- Cleaning of wastewater
- Collect environmental data, develop studies and present them to stakeholders
- Design and implement programs to prevent and address the consequences of human activities on the environment
- Design antisoiling systems
- Determine polluting sources
- Develop methods for river basin planning, management of irrigation systems, quality management of surface and underground water, and processing of liquid and solid waste
- Develop, apply and improve methods, systems and facilities of pollutant monitoring and management
- Formulate policies in relation to the environment
- Identify environmental cost

- Implement environmental management systems ISO 14000, 14001.
- Implement environmental testing methods (Eco-Management and Audit Scheme, EMAS)
- Implement new technology in environmental protection
- Inform and raise awareness of responsible bodies on environmental issues
- Interpret pollutant analysis data
- Market and handle equipment, instruments, materials and accessories used in antipollution installations and systems
- Optimize pollution control methods, processes and facilities
- Organize, supervise, conduct, process and evaluate measurements and experiments on all categories of pollutants
- Participate in projects of applied research on pollutant management
- Perform maintenance and calibration of pollutant analysis equipment
- Perform pollutant analysis in the aforementioned matrices
- Plan, implement and monitor programs for the protection and management of the environment
- Prepare environmental impact studies
- Prepare environmental management projects
- Provide assessments and consultancy services relating to anti-pollution equipment, systems and installations
- Study, plan and oversee the operation of antipollution systems and facilities
- Analyze information related to constructing and transportation, their environmental impact and long-range planning needs for development sustainable strategies at the local, regional, or national levels
- Analyze manufacturing processes or byproducts to identify engineering solutions to minimize the output of carbon or other pollutants
- Analyze the environmental systems such as integrated with their reasons and results
- Apply integrated design and operation of water resource systems
- Conduct environmental impact studies for water and wastewater collection and treatment
- Conduct environmental studies related to conventional and alternative energy sources, their waste disposal, environmental remediation and restore, and promote social awareness
- Conduct research to develop new and improved existing ecological chemical manufacturing process

- Conduct research, consulting, organization and control of chemical-technological processes in production and processing of crude oil, petroleum products and alternative fuels
- Conduct water quality studies to identify water pollutant sources
- Design / engineer systems to efficiently dispose of chemical, biological, or other toxic wastes
- Design and implement environmental controls on oil and gas operations
- Design chemical plant equipment for manufacturing environmental friendly chemicals and products
- Design energy efficient and environmentally sound constructions
- Design measurement and control systems for chemical plants based on data collected in laboratory experiments and in pilot plant operations
- Design water or wastewater treatment plants
- Develop / implement engineering solutions to clean up industrial accidents or other contaminated sites
- Develop methods for river basin planning management of irrigation systems
- Develop new techniques for reforestation forest renewal and controlled cutting with minimum waste and environmental damage
- Develop, implement and consult of mineral extraction, mining, and drilling, other environmental friendly methods and ensure their optimal use
- Develop methods for river basin planning
- Devise solutions to problems of land reclamation and water / air pollution, such as methods of storing excavated soil and returning exhausted mine sites to natural states
- Environmental monitoring and assessment
- Establish and implement short- and long-term projects for management of forest lands, forest resources and forest-cleared lands for conservation of wildlife habitats as well as soil and water quality
- Evaluate chemical equipment and processes to identify ways to optimize performance or to ensure compliance with safety and environmental regulations
- Identify environmental risks or quantify environmental hazards and develop risk management strategies
- Implement environmental management systems
- Implement national / international standards in wastewater treatment
- Monitor and evaluate construction activities and facilities or installations to determine their environmental impact and ensure adherence to environmental regulations
- Analyze the concepts of optimum resource utilization and sustainability

- Organize and plan engineering projects, carry out quality controls and set up indicators for evaluation the viability of plans
- Oversee design or construction aspects related to energy engineering, management, and sustainable design
- Oversee the construction of wastewater treatment systems
- Plan and direct forest surveys and related studies and prepare reports and recommendations
- Quality management of surface and ground water
- Recommend chemical, biological, or other wastewater treatment methods Recommend sludge treatment or disposal methods
- Review architectural, mechanical, or electrical plans and specifications to evaluate energy efficiency
- Select locations and plan mining activities
- Specify and supervise modification and stimulation programs to maximize oil and gas recovery
- Perform and manage forest protection activities
- Perform hydrological analyses to model the dispersion of chemical pollutants in the water supply

3.4 Environmental Ethics

Integration of environmental ethics into engineering ethics should be explained and their importance be able to have eco-engineers should be emphasized in this section. Therefore, first of all, two different subjects, namely, environmental ethics and engineering ethics should be explained and distinguished.

3.4.1 Environmental ethical approaches

Environmental ethics emerged as a new sub-category to philosophy in early 1970s as people came face to face and began to felt destructive impacts of environmental problems. Environmental ethics refers to the moral relations between human beings and their natural environment. By definition, environmental ethic consists of the study of normative issues and principles relating to human interactions with the natural environment and to their context and consequences. It is the code of behavior and actions to bring human beings to terms with each other and with the environment.

People and nature are mutually interrelated and integrated. We depend on nature in many ways: directly dependent on resources like water, oxygen, minerals, etc. and indirectly dependent for recreational activities, wetlands for water filtering, etc. Earth has 4.5 billion years history and life has existed for about 3.8 billion years. However, the appearance of first human forms was about 800,000 years ago. That is in a very short period of time (800,000 year in total of 4.5 billion years), negative impacts of human beings have begun to felt heavily. As explained in International Panel on Climate Change (2007) Report, unfortunately, human species is the most significant factor for environmental problems, especially for climate change. Therefore, environmental ethics becoming more and more important which refers to the value that mankind places on protecting, conserving, and efficiently using resources that the earth provides. It is a standard that we use to view issues pertaining to the environment. Some people may have varying degrees of consciousness in this area, but everyone has an environmental ethic that they hold to. The key is to balance an awareness and motivation for environmental issues while not neglecting the needs of people (http://nathan-reed.blogspot.com/2012/01/definition-on-environmental-ethics.html, accessed 25 November 2012). Each of us has her/his own worldview that is a commonly shared perspective based on a collection of our basic values that helps us make sense of the world, understand our place and purpose in it, and determine right and wrong behaviors. These worldviews lead to behaviors and lifestyles that may or may not be compatible with environmental sustainability (Raven and Berg, 2006). So, depending on moral care for nature and moral care for sustainability; these worldviews (approaches) might be anthropocentric or non-anthropocentric. The distinction between those two main approaches could be made by asking “who or what belongs to the moral universe?”

3.4.1.1 Anthropocentric approaches

In anthropocentric view, the answer to the above question is, human beings take place at the center and only humans are moral agents. Other living and non-living things; animals, plants, ecosystems, in short all nature have a “value” since they are necessary for human survival. There is no other reason for estimating nature, no value of nature for itself; it is only valuable in respect to human interests. This is called as functional or instrumental value: Something has value -is good- because one sees it as an instrument, a tool to realize one’s goals or ends. When something is valued instrumentally, that means we only value it as a means to achieve some other end which is, in turn, more important. Thus, if a tree is of instrumental value, that means that I only value it insofar as it generates oxygen, serves wood, gives fruits, etc. In anthropocentric ethics, values are all human focused and for the welfare of human, not even the future generations. Anthropocentric worldview created during the seventeenth century, perceive the world as a machine made up of interchangeable atomic parts that are manipulated by human This approach use of nature as a commodity and instrumental good served for the welfare of human beings. In time it is realized that, mechanical thinking and industrial capitalism lie at the root of many environmental problems. So, at the end of 18th century, as the people faced with the destructive results of environmental problems (death of 4000 person in London in 1952, oil spills, Chernobyl), a new worldview that is holistic and emphasizes the importance of wholesomeness over the parts and does not separate humans from the environment, as the world begin to experience environmental problems. This ecological paradigm entails a new ethic in which all parts of the ecosystem, including humans, are of equal value and recognizing the intrinsic value of all beings. It pushes social and ecological systems toward new patterns of production, reproduction, and consciousness that will improve the quality of human life and nature.

3.4.1.2 Non-anthropocentric approaches

A defining feature of almost all recent non-anthropocentrism is some appeal to “intrinsic values” in nature (DesJardins 1998). Intrinsic value as opposed to instrumental values is a value regardless of any direct usefulness to human beings. Something which has intrinsic value is valued purely for itself. So, response to question “who or what belongs to the moral universe”, moral community is extended to include non-humans.

To understand and internalize environmental ethics, the term “value” and its derivatives (inherent value, intrinsic value, instrumental value, etc.) should be digested well.

There exist several approaches to classify non-anthropocentric world-view. For example, Merchant (1992) divided environmental ethical theories into three; egocentric, homocentric and ecocentric. She placed egocentrism and ecocentrism to the opposite sides of the ethical approach scale. Then put the homocentrism in which holistic, organic view is dominant between these two extremes. Vromans et al., (2012) classified non-anthropocentric theories into four:

1. Pathocentrism;
2. Biocentrism;
3. Ecocentrism
4. Holism.

Each kind of theory deals with the question, which element(s) of nature and environment is (are) candidate(s) to have a moral status and what is the argumentation to have moral status? The essence of the four can be found by looking at the meaning of the Greek roots:

Pathocentrism is derived from the Greek pathos, meaning feeling. Pathocentrism gives moral status to all beings that can have pleasure and pain, can suffer and a re-sentient and says that making sentient beings suffer is wrong.

Biocentrism is derived from bios, meaning life. Biocentrism gives moral status to all living beings.

Ecocentrism and holism: ‘Eco’ means ‘house’ and is mostly used for ‘environment’. Ecocentrism deals with the moral status of larger entities like species and ecosystems. The difference with holism (Greek ‘holos’ means ‘whole’ or ‘all’) is not always clear, but holism has to do with the moral status of the ‘whole’. That can mean ‘Gaia’, mother Earth, nature. Holism puts also forward the question to the moral status of rocks, rivers, landscape (Vromans et al., 2012).

In the light of brief explanations given above on environmental ethics, in recent years it is recognized that, environmental issues must be viewed in their entirety. A common environmental world view reached today is “sustainable development” in which social, economic and ecological aspects of the development should be in balance.

Nowadays, the cradle to cradle principle is receiving more acceptances. That is integration of environmental requirements in all stages of the product development process, within the aim of reducing the impact of all life cycle steps and maximizing sustainability.

We, as engineers are the major actors of integrating environmental ethical values into new approach of cradle to cradle principle. Because, each engineer has a capacity to change his/her relationship with nature as soon as he/she notices or is faced with the adverse impacts of existing interaction, in a way towards rehabilitated, cleaner environment. He/she should reorganize relations with nature as well as his/her capacity to destroy the nature. In one aspect, human beings have a tendency to overuse natural resources assuming they are limitless, however in another aspect they have the capacity to prevent pollution and destruction via technology and ethical values owned at the same time (Tekeli, 2000).

In this chapter, it is aimed to remind, as engineers we have to understand the wholesomeness of the ecosystems, their fragility and how they function. If it is understood well and internalized, an engineer can recognize his position within the whole ecosystem, and then reaches the situation of consciousness. Scientific knowledge and experiences about nature increase sensitivity and may lead to facilitated consciousness that leads to the sense of responsibility. As engineers, we have responsibilities towards nature, (such as to guarantee the sustainability of natural resources or try to re-establish damaged balances or rehabilitate ecosystems, etc.) towards to society (we are living in the society and we have to consider the common interests, however, those interests should not be only human-centered) and towards future generations (Karakoç, 2005).

3.4.2 Engineering Ethics

Engineering Ethics is the study of moral issues that are discussed in environmental ethics section and engage these values into engineering applications. It is the study of related questions about moral ideals, character, policies and relationship of people and corporations involved in technological activity.

Engineering ethics is as much a part of what engineers in particular know as factors of safety, testing procedures, or ways to design for reliability, durability, or economy. Engineering ethics is part of thinking like an engineer (Harris, 1996). However for sustainable development, green engineering, cleaner production are very important and almost obligation. To achieve environmental friendly production patterns, to achieve environmental management; all engineers should understand and internalize environmental ethical values in addition to engineering ethics.

The fundamental principles are given by Accreditation Board for Engineering and Technology (ABET) as; Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

I. Using their knowledge and skill for the enhancement of human welfare;
II. Being honest and impartial, and servicing with fidelity the public, their employers and clients;
III. Striving to increase the competence and prestige of the engineering profession; and
IV. Supporting the professional and technical societies of their disciplines.

As it can be noticed, environmental issues and responsibilities are not emphasized in those principles. Therefore it is strongly recommended to integrate environmental ethics into engineering ethics. Please try to evaluate items given below and think……

- Why care about nature "for itself" when only people "matter"? If you deny that "only people matter," on what grounds can you defend that denial? (After all, if no people are around to regret it, what difference does it make if a species, a canyon, or even a planet is destroyed? If people who are around prefer to destroy natural objects and landscapes, then so what? Why not?
- When species or landscapes or wilderness areas are destroyed, what, of value, is lost to mankind?
- Will future generations "miss" what we have "taken from them"? (How could they if they never will know what they have "lost"?)
- Do human beings have a need for nature that implies an obligation to preserve it? What is the evidence for this?
- What are the ultimate grounds of an affirmation to protect the environment? Are they rational? Irrational? Non- rational? Mystical?
- What, basically, is wrong with the developer's anthropocentric and utilitarian land ethic? Why not treat land as a "commodity" rather than a "community"?
- Do future generations (who, after all, do not exist now) have a "right" now to a clean and natural environment when their time comes?
- Can man "improve" upon nature? How? What constitutes "improvement"?
- Do the facts of environmental science have moral implications?
- Are human beings psychologically capable of caring for nature and for future generations? If they have this capacity, are we morally obligated to nurture it (Partridge, 1997)?

3.5 What can an engineer learn from ecological systems?

The current environmental problems have been created by the development of industrial society since the industrial revolution. Successive industrial revolutions have since increased man’s capacity to transform nature (Kasa, 2009). However, instead of transforming nature, we should UNDERSTAND nature. When the ecosystems are not understood, or even recognized or appreciated as a system; biodiversity will continue to decrease, environmental pollution will increase, and the impacts of climate change will be felt heavily in the world.

As discussed in Section 3.4.1.2 each engineer has a capacity to change his/her relationship with nature. In one aspect; engineer may have a tendency for overconsumption, overproduction, misuse of natural resources, and misuse of technology for the benefit of himself or entrepreneurs. However in another aspect they have the capacity to prevent pollution via technology. At that point, to know how ecosystems function and how they are sensitive, fragile systems lead engineers to choose in which direction they move; destroy or protect.

3.5.1 How ecosystems work?

We tend to associate life with individual organisms since they are alive. But sustaining life on earth requires more than individuals or even single populations or species. Life is sustained by the interactions of many organisms functioning together in ecosystems interacting through their physical and chemical environments (Botkin and Keller, 2005)

An ecosystem works when all members of the ecological community live in relative balance with each other to create a sustainable place to live. From the simplest microorganism to the tallest trees to the largest mammal, all parts of the ecosystem remain interdependent upon each other for long term survival. Affecting one part of the ecosystem changes other members in the system and may damage the system beyond what is necessary to maintain a livable environment.

Environmental problems are generally complex, and so our understanding of them is often less complete than we would like it to be (Raven, 2006). To understand environmental issues and their impacts in engineering applications, basic principles of ecosystems should be understood:

Structure: An ecosystem is made up of two major parts; living and non-living things. The non-living part is the physical-chemical environment, including atmosphere, soil or other substrate in water. The living part called the ecological community is the set of species interacting within the ecosystem.

Processes: Two basic kinds of processes occur in an ecosystem: a cycling of chemical elements and a flow of energy (Botkin and Keller, 2005). These processes are very important for engineers. If their function and mechanisms are understood well, this might be helpful in the design of many engineering works and processes. It is evident that, natural processes could be models for man-made processes. How they operate, how they affected by different internal and external factors will obviously guide engineers.

Change: An ecosystem changes over time and can undergo development through a process called succession. This dynamic structure of the ecosystem towards better position may lead engineers too. This characteristic of ecosystems may create new horizons for engineers.

Engineers adapt designs for housing, cities and many types of buildings to specific environments and ecosystems. They use their environment, knowledge of the biosphere and the concept of ecosystems to inform their designs and shape the human-built environment. Engineers and scientists use bio domes to study ecosystems and model how living and nonliving things interact in those natural environments (http://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_bio/cub_bio_lesson02_activity1.xml).

Along this line, changing paradigms would require that engineers be educated to question the sustainability of current patterns of production and consumption and to consider which practices need to be changed in accordance with ecosystem approach. Taking a systems approach may stimulate new patterns of acting and thinking among engineers. Such engineers will be able to:

- Understand the interdependence of human beings and natural resources
- Understand how resources, consumption, population, and worldviews define sustainability
- Understand how contemporary value systems determine our human interactions with nature
- See the impact of a consuming lifestyle on natural resource supplies
- Understand what value systems and survival modes preceded ones presently dominant—and what modes modernization displaced and how the change to the present values and survival modes came about
- Comprehend the sequence of events that led up to present conditions
- Develop a general knowledge of the countries where major industrial and scientific changes took place, what the motivations, means, and methods were for those changes, and what values those changes fostered
- Understand how those industrial and scientific changes affected social and environmental systems and who the key players were in those changes

- Major criteria determining which human activities—development, production, consumption—are unsustainable
- Describe ecological sustainability
- Explain why we need a vision for a sustainable future and how we might achieve one
- Describe measures for determining Quality of Life for everyone (Wiedenhoeft, 1999).

3.6 How an ecological understanding of systems contribute to engineering design?

The fundamental concepts of ecological engineering that make it different from other engineering fields are as follows: (1) self-design (self-organization); (2) the field involves biological systems; (3) sustainable ecosystems.

3.6.1 Self-design

Self-design is the property of ecosystem development in which the chance presence of species is analogous to the occasional mutation necessary for evolution to proceed. The application of self-design in ecological engineering is that if an ecosystem is open to allow seeding, through human or natural means, of enough species' propagates, the system itself will optimize its design by selecting for that assemblage of plants, microbes and animals best adapted for existing conditions. It contrasts with traditional engineering 'design', where rigid control over system properties is sought. In a typical engineering project, the engineer tries to anticipate every perturbation to make a predictable and reliable system that will perform a given function for a given life-time of the system, be it an airplane, a building, a dam, or an electronic circuit. The ecological engineer, in contrast, relies more on nature's ability to self-design a resilient, difficult-to-perturb system than on his or her foresight and expertise to design a flawless system. This design philosophy, in essence, takes advantage of the wealth of information available from nature's library—its biodiversity. Nature contributes to the final design of the system and this should be celebrated; human engineers simply provide the initial conditions for that self-design to happen (Mitsch, 1998).

3.6.2 Biological components

Ecological engineering has been extrapolated to include many systems including waste separation systems, green engineering and so on. One of the defining characteristics of ecological engineering should be that it deals with biological systems; self-design cannot be anticipated in a purely physical system (Mitsch, 1998).

3.6.3 Sustainability

Ecological engineering should result in a sustainable or nearly sustainable system, running primarily on natural energies such as solar radiation, wind, rainfall, stream flow and other sustainable forcing functions (Mitsch, 1998).

3.7 How can an Engineer contribute to a sustainable world? What worked in the past, what is working now, what might work in the future?

Sustainable development is one of the key challenges of the twenty-first century. The engineering profession is central to achieving sustainable development. To date, engineering contributions to sustainability have focused on reducing the environmental impacts of development and improving the efficiency of resource use (Bell, 2011). Definitions of the term "sustainability" are usually traceable to the definition in The Brundtland Report of the United Nations World Commission on Environment and Development: **"… a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs"** (Prins et al., 2008).

3.7.1 Environmental sustainability

Assessment of environmental sustainability of technology traditionally focuses on immediate impact of technology on the environment through quantifying resource extraction and generated emissions. However, technology does not only exchange materials with the environment but also with the industrial society as a whole, the so-called industrial metabolism. A higher compatibility of a specific technology with the industrial system, as studied in industrial ecology, can result in lower resource extraction and reduced waste emission, indirectly contributing to a better environmental sustainability. Starting from the considerations above and based on the second law of thermodynamics, as Dewulf and Langenhove (2005) stated a set of five environmental sustainability indicators for the assessment of products and production pathways, integrating industrial ecology principles. The indicators all scaled between 0 and 1, take into account: (1) renewability of resources; (2) toxicity of emissions; (3) input of used materials; (4) recoverability of products at the end of their use; (5) process efficiency.

There is no doubt that sustainable development is a topic in engineering and technology. Companies, institutions and authorities aim at the development and implementation of more sustainable technologies. The effect of technology on the environment is a complex phenomenon. The immediate origin of its effects are the physical chemical interactions, i.e. exchange of mass and energy (e.g. resource extraction, gaseous emissions, etc.). Due to these exchanges, a number of mechanisms start up in the environment, for example climate change, vegetation degradation due to acidification, etc., leading to deterioration of the natural system. However, the effects of a specific technology on the environment do not only depend on the immediate interface between the considered technology and the environment, but also on the degree of integration within the overall industrial metabolism (Dewulf and Langenhove, 2005).

There are several concepts today providing guidelines to organize the environmental component of technology in a sustainable way: Clean Technology, Green Chemistry, and Industrial Ecology. All principles covered in these concepts are implicitly based on the consideration of exchanges, conversions and effects of mass and energy that are related to the life cycle of a product or a process chain (Dewulf and Langenhove, 2005).

3.7.2 The chronology of sustainable development

A number of important conference, conventions and commissions on sustainable development were held by United Nations (UN). Some of them are (Bell, 2011):

- The UN Conference on the Human Environment held in Stockholm in 1972 was the first in series of international meetings which addressed the need to protect the environment whilst maintaining essential processes of the development.

- The 1987 our Common Future report by the World Commission on Environmental and Development, also known as the Brundtland Report, Comprehensively addressed the problem of sustainable development.
- The first international conference on ecological engineering was held in Trosa, Sweden in 1991.
- The Journal of Ecological Engineering began publication in 1992.
- The UN Conference on Environment and Development was held in Rio de Janeiro in 1992. This conference was the largest ever gathering of international heads of state and represented a watershed in international efforts to address sustainable development and the need for international cooperation on environmental protection. The conference resulted in important UN conventions relating to biodiversity, climate change and desertification. The Rio meeting also gave rise to Agenda 21 which outlined how sustainable development should be pursued and implemented into the twenty-first century.
- SCOPE project in ecological engineering and ecosystem restoration established in Paris (1994 - 2002)
- The 2002 World Summit on Sustainable Development was held in Johannesburg, with a much lower political profile than the meeting in Rio. The private sector and business groups were more visible in Johannesburg than at previous conferences, highlighting growing awareness of sustainable development amongst corporations.

3.7.3 Common environmental problems in the world

The cultural revolutions have given us much more energy and new technologies to alter and control increasingly larger parts of the earth to meet our basic needs and a rapidly expanding list of wants. By expanding food supplies, increasing average life spans, and improving average living standards, each of these shifts have also led to sharp increase in the size of the human population. But these cultural shifts have also led to the exponentially increasing resource use, pollution, and environmental degradation we are experiencing today (Miller, 1991).

The world faces a number of major environmental issues, which threaten to have dire consequences for the future of the planet and its life-forms unless tackled. Many of these environmental problems are man-made, the result of pressures the human race has placed on the planet through activities such as land clearance, globalization and industrialization. Environmental problems contribute to global warming and to the destruction of ecosystems (http://www.ehow.com/list_7537583_common-environmental-problems-world.html, 2012). The global environmental problems are as follows (Hawken, 2010):

- Climate change and global warming
- The Oceans and Coral reefs
- Fresh water
- Forests
- Biodiversity
- Waste, pollution and toxics
- Energy

3.7.4 The contributions of the engineer

The contributions of the engineer to the global environmental problems should be as follows (Hawken, 2010):

When the amount of GHGs exceeds the capacity of the ocean, forests, and soil to absorb it (these are our “carbon sinks”), more heat is retained in the atmosphere; then air, ocean, and land temperatures rise and global warming is said to occur. Climate change is a result. Increasing awareness of the greenhouse gas consequences of our energy use, travel, food, and other choices is the first step toward reducing our own emissions. Therefore, the following precautions should be taken as:

- Act now to limit potential damage from climate change rather than waiting and having to take more costly, reactive measures in the future. Timely action could ease the coming impacts of hotter weather, rising sea levels, and bigger storms.
- Harness the power of markets to drive innovation and protect the climate. Subsidize renewable energy investments.
- Don’t make carbon-intensive investments in developing countries.
- Financiers must devise new ways of investing in the needed global transition to a low-carbon “re-industrialization
- Use a lot less fossil fuel-based energy. Use as little plastic as possible. Don’t eat endangered or threatened species.

All life on Earth is connected to the oceans. They are our life support systems, from the food chain to the water cycle. Therefore, the following precautions should be taken as:

- We are pushing up against limits by overfishing, as well as by polluting and dumping waste into waterways and seas, including non-biodegradable plastic.
- Use a lot less fossil fuel-based energy. Use as little plastic as possible. Don't eat endangered or threatened species. Limit your consumption of seafood in general, and learn which species concentrate toxins and thus toxify you.

Coral reefs are among Earth's most diverse, exquisite, and fragile ecosystems, essential to the web of life. They have been vanishing at alarming rates for the last 40 years, mainly from run-off of agricultural (including lawn) chemicals and waste. Coral reefs appear particularly vulnerable to even the most modest climate-change scenarios, as they are unable to adjust to rapid changes in temperature and ocean acidity, and we may be approaching a tipping point that will wipe out entire bio regions. Therefore, the following precautions should be taken as:

- The area of coral reefs under protection needs to be increased globally from the current level of 15% to 30%.
- Don't buy coral jewelry, and inform those selling it about the threats to coral.

We all know that most life on Earth is impossible without water, so why would we pollute and waste this priceless substance? Water bodies are assumed to have endless capacity to "disappear" toxins, trash, and wastes (industrial, sewage, agricultural, to name a few). But Earth's rivers, lakes, and oceans have suffered so much dumping that their ability to support life is lost, compromised, or disappearing fast. There isn't enough anymore, with our increasing population, to waste another drop. Climate change will exacerbate water shortages. Water security in a warming world will require major improvements in water use efficiency (especially in the agricultural and industrial sectors) and in techniques such as rainwater harvesting and groundwater management and use. Therefore, the following precautions should be taken as:

- Rainwater harvesting can take place anywhere there is a roof by gathering rainwater in do-it-yourself systems (such as plastic barrels) or commercial systems (for irrigation and livestock).
- Techniques for water retention and improved technology allow simple practices such as solar water heating, rainwater harvest and storage, storm water management (bio swales, sediment traps, Rolling dips), micro-hydro electricity generation, and bio filtration ("living machines")— all of which help replenish groundwater resources, conserve water, and use it wisely.

Scientists agree that the world's rainforests are the best natural defense against climate change because they are carbon sinks. Forests were not considered as carbon sinks in the Kyoto Protocol, but later realization that deforestation accounts for roughly 20% of global greenhouse gas emissions has led to their reevaluation. Meanwhile, the buyer of the offset can keep polluting. Therefore, the following precautions should be taken as:

- Don't destroy pristine ecosystems to make way for plantation farming.
- Instead of cutting and burning forests to make way for palm plantations, farmers should be encouraged to grow the crop on already cleared land.
- Wood and paper buyers should endeavor to understand the origin of the products they buy.

Extinction is accelerating all around us, in myriad large and small ways. Although extinction is a natural phenomenon, its "background" rate is about one to five species per year. If present trends of human consumption continue, half of all species of life on Earth could be extinct in less than a century "as a result of habitat destruction, pollution, invasive species, and climate change. Habitat alteration and loss is the main force driving species extinction. As human populations increase exponentially, more land is deforested or otherwise altered for housing, farming, livestock, fuel, roads, and other uses. Species previously living on that land either move and adapt or die. Therefore, the following precautions should be taken as:

- Support conservation groups locally and worldwide.
- Demand elimination of subsidies that promote destruction of habitats (forests, wetlands, oceans, etc.).
- Write to companies that have an obvious negative impact on species, e.g., those that promote operations that cut down rainforests or pollute.
- Eat lower on the food chain: a plant-based diet respects the lives of animals as well as the sustainability of the planet.
- Grow a wildlife garden, not a lawn.

As a species we've created a lot of pollution on Earth, far more than anyone wants to really know. That fact is not news if you have read about or even experienced poisoned produce, toxic tuna, birth defects, or asthma induced from particulates in the dirty air. Yet the work of reducing waste and pollution at its source remains to be tackled with resolve. Excess consumption, wasteful practices, and the ongoing manufacture of deadly toxins are at the core of many of our environmental problems. They need to be comprehensively addressed at the industrial level as well as the personal. Therefore, the following precautions should be taken as:

- Raise the price of what harms the environment. This will help reduce consumption of unnecessary items as well as trigger efficiency improvements in businesses.
- Agencies at all levels of government need to mandate and enforce emissions reduction targets and pollution limits for cars and trucks, industry and agriculture.
- Eliminate subsidies that go to polluting businesses.
- Products must be easy to recycle, the least toxic, and the most cradle-to-cradle in terms of raw materials. Our calculus must take into account the life cycle of the product and its true value; we must reject cheap products that don't last.
- Adopt the 3Rs of solid waste management: reduce, reuse and recycle. Inorganic materials such as metals, glass and plastic; also organic materials like paper, can be reclaimed and recycled. This takes into account that the proven solution to the problem of proper waste management (especially in third world countries) is proper disposal (in waste bins for collection and not in the street where it could fall into drains), waste segregation and collection, and recycling.
- Use eco-friendly or biodegradable materials instead of plastic which are made up of highly toxic substances injurious to your health.
- Industries should monitor their air emissions regularly and take measures to ensure compliance with the prescribed emission standards.
- Never throw, run or drain or dispose into the water, air, or land any substance in solid, liquid or gaseous form that shall cause pollution.

Energy is critical foundation for economic growth and social progress. Modern society, as we see it today, would have not been possible without energy (Chaudry et al., 2009). As economy advances and human society requires more energy, the lack of fossil energy and its pollution on the environment has given rise to a serious contradiction among energy providing, environment protection and economic development. Since the energy crises in the 1970's, public and private decision makers are considering how to achieve a sustainable transition from fossil fuel based energy to sustainable and clean energies-namely renewable energy- that can overcome the problems of the gradual depletion of fossil fuels as well as the global warming caused by the greenhouse gas emission. Therefore the development of renewable energy has received great attention and its application has been accelerated in the past few years (Ching et al., 2011). Renewable energy is defined as any energy resource that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). Renewable energy does not include energy resources derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources. Fossil fuels are both finite and climate polluting, necessitating a large scale switch to renewable energy sources in a short time frame. Therefore, the following precautions should be taken as (Hawken, 2010):

- Insist on and be part of the shift to clean, renewable energy. Laws as well as individual activities must aim to rein in global warming pollution and transition to a clean energy economy. Shift to renewable and energy efficiency in all possible aspects of your life.
- Climate, energy, and transportation policies must complement one another and aim for similar goals.
- Make your home energy-efficient. This yields dramatic savings in heating and cooling.
- Buy energy-efficient electronics and appliances. Look for the Energy Star label on new appliances or visit www.energystar.gov to find the most energy-efficient products.
- Low-carbon transportation fuels, such as biofuels made from crop waste and switch grass, can replace imported oil.
- Coal-fired power plants can possibly be part of our energy future if they are equipped with technology to carry out carbon capture and storage of CO2 emissions deep in the Earth, where it is gradually absorbed.
- Reduce subsidies to food-based biofuels (mainly corn) and increase them for fuels with a low-carbon footprint, such as waste and cellulose-derived biofuels. Biofuels made from waste biomass or from biomass grown on abandoned agricultural lands planted with perennials incur little or no carbon debt and offer immediate and sustained GHG advantages.
- Insist on and be part of the shift to clean, renewable energy. Laws as well as individual activities must aim to rein in global warming pollution and transition to a clean energy economy.

3.8 Best Practices, Case Studies

3.8.1 Little Enough or Too Much - A Case Study for Environmental Ethics

Bryan was recently hired by a large chemical company to oversee the construction of production facilities to produce a new product. X Chemical developed a new industrial lubricant which it felt it could produce at a price close to those of its competitors. The plant to manufacture the lubricant was built on land adjacent to the East River. X Chemical had already applied for and received the necessary permit to dump waste materials from the process in the river. Several other chemical plants in the near vicinity are also releasing waste materials into the river. Bryan is concerned because the government agency which oversees the permit process has granted X Chemical a permit to release more waste in the river than previously anticipated. An additional stage in the production process which would have reduced the waste and recycled some materials became unnecessary due to the regulatory agency's decision. Because the additional process would have added capital and production costs, it was not built as part of the existing plant. Yet, X Chemical has always stated publicly that it would do all that it could to protect the environment from harmful materials.

The company has had mediocre performance for several quarters, and everyone is anxious to see the new product do well. Tests have shown it to be a top-quality industrial lubricant which can now be produced at a cost significantly below these of their competitors. Orders have been flowing in, and the plant is selling everything it can produce. Morale in the company has increased significantly because of the success of the new product. Due to the success of the new product, all employees are looking forward to sizable bonuses from the company's profit sharing plan.

Bryan is upset that the company failed to build the additional stage on the plant and fears that the excess waste released today will cause problems for the company tomorrow. Bryan approaches Bill, the Plant Supervisor, with his concerns. Bill replies, "It's up to the government agency to protect the river from excess waste, and the company only had to meet the agency's standards. The amount of waste being released poses no threat to the environment, according to the agency. The engineers and chemists who originally designed the production process must have been too conservative in their rtes. Even if the agency made a mistake, the additional recycling and waste reduction process can be added later when it becomes necessary. At this point, building the additional process would require costly interruptions in the production process and might cause customers to switch to our competitors. Heck, environmental groups might become suspicious if production was stopped to add the additional process-they might see it as an admission of wrongdoing.

No one in the company wants to attract any unwarranted attention from the environmental groups. They give us enough trouble as it is. The best thing we can do is make money while the company can and deals with issues as they come up. Don't go trying to cause trouble without any proof. The company doesn't like troublemakers, so watch your step. You're new here, and you wouldn't want to have to find a new job."

Bryan is frustrated and upset. He can see all the benefits of the new product, but inside he is sure the company is making a short-sighted decision which will hurt them in the long run. The Vice President of Operations will tour the plant next week, and Bryan is considering approaching the officer with his corm. It might also be possible to contact the government agency and request that the permit be reviewed. Bryan is unsure what to do, but he feels he should do something.

Author: Originally developed by Eric Heist, graduate student at Washington University, as a class project in “Ethical Decision Making.” Edited and submitted by Dr. Raymond L. Hilgert, Professor of Management and Industrial Relations, Washington University.

3.8.2 LEED - A Best Practice for Engineering and Ecology

LEED (Leadership in Energy and Environmental Design) is a voluntary, consensus-based, market-driven program that provides third-party verification of green buildings. From individual buildings and homes, to entire neighborhoods and communities, LEED is transforming the way built environments are designed, constructed, and operated. Comprehensive and flexible, LEED addresses the entire lifecycle of a building.

Participation in the voluntary LEED process demonstrates leadership, innovation, environmental stewardship and social responsibility. LEED provides building owners and operators the tools they need to immediately impact their building’s performance and bottom line, while providing healthy indoor spaces for a building’s occupants.

LEED projects have been successfully established in 135 countries. International projects, those outside the United States, make up more than 50% of the total LEED registered square footage. LEED unites us in a single global community and provides regional solutions, while recognizing local realities (https://new.usgbc.org/leed).

For commercial buildings and neighborhoods, to earn LEED certification, a project must satisfy all LEED prerequisites and earn a minimum 40 points on a 110-point LEED rating system scale. Homes must earn a minimum of 45 points on a 136-point scale.

The LEED International Roundtable is a green building powerhouse that is fueled by the collective knowledge of green building councils or organizations representing 21 countries (Argentina, India, Romania, Brazil, Italia, Russia, Canada, Jordan, Spain, Chile, Mexico, Sweden, Columbia, Norway, Turkey, Finland, Poland, United Arab Emirates, South Korea, United States of America, France) across the globe. The International Roundtable represents the impact and application of LEED worldwide. These 21 countries serve as an advisory group to United States Green Building Council (USGBC) in advancing the relevancy and application of the LEED rating systems internationally. Get to know the work of each of these great organizations and you will best understand the impact they collectively make in advancing LEED worldwide (https://new.usgbc.org/about/committees/international).

3.8.2.1 LEED Green Building Rating Systems

Rating systems are groups of requirements for projects that want to achieve LEED certification. Each group is geared towards the unique needs of a project or building type. LEED is flexible enough to apply to all project types including healthcare facilities, schools, homes and even entire neighborhoods. Projects earn points to satisfy green building requirements. Within each of the LEED credit categories, projects must satisfy prerequisites and earn points. The number of points the project earns determines its level of LEED certification.

Main credit categories:

- Sustainable sites credits encourage strategies that minimize the impact on ecosystems and water resources.
- Water efficiency credits promote smarter use of water, inside and out, to reduce potable water consumption.
- Energy & atmosphere credits promote better building energy performance through innovative strategies.
- Materials & resources credits encourage using sustainable building materials and reducing waste.
- Indoor environmental quality credits promote better indoor air quality and access to daylight and views.

Additional LEED for Neighborhood Development credit categories:

- Smart location & linkage credits promote walkable neighborhoods with efficient transportation options and open space.
- Neighborhood pattern & design credits emphasize compact, walkable, vibrant, mixed-use neighborhoods with good connections to nearby communities.
- Green infrastructure & buildings credits reduce the environmental consequences of the construction and operation of buildings and infrastructure.

Additional LEED for Homes credit categories:

- Location & linkage credits encourage construction on previously developed or infill sites and promotes walkable neighborhoods with access to efficient transportation options and open space.
- Awareness & education credits encourage home builders and real estate professionals to provide homeowners, tenants and building managers with the education and tools they need to understand and make the most of the green building features of their home.

Two bonus credit categories:

- Innovation in design or innovation in operations credits address sustainable building expertise as well as design measures not covered under the five LEED credit categories. Six bonus points are available in this category.
- Regional priority credits address regional environmental priorities for buildings in different geographic regions. Four bonus points are available in this category.

3.8.2.2 LEED certification steps

LEED certification involves five primary steps:

1. Determine which rating system you will use and prepare your certification application. Applications differ depending on your building type and the LEED credits you decide to pursue.
2. Register your project. The registration fee for a project is $900 for USGBC members and $1200 for non-members.
3. Submit your certification application and pay a certification review fee. Fees differ with building type and square footage.
4. Await the application review. Review processes differ slightly for each building type.

5. Receive the certification decision, which you can either accept or appeal. An affirmative decision signifies that your building is now LEED certified.

In LEED there are 100 possible base points distributed across five major credit categories: Sustainable Sites (21), Water Efficiency (11), Energy and Atmosphere (37), Materials and Resources (14), Indoor Environmental Quality (17), plus an additional 6 points for Innovation in Design and an additional 4 points for Regional Priority. Buildings can qualify for four levels of certification:

- Certified: 40–49 points
- Silver: 50–59 points
- Gold: 60–79 points
- Platinum: 80 points and above

3.9 Questions & Answers

Please select the best answer for the Questions 1-3.

1. What do you understand from “holistic thinking”?
   a) emphasizing the importance of the whole
   b) the independence of all parts
   c) analysis or separation into parts
   d) wholes can be reduced to separate parts
   e) exclusive approach

   Answer: (a)

2. What one of the following refers to “ecosystems’ fragility”?
   f) ecological robustness
   g) ecological vulnerability

   Answer: (b)

3. Do you think that an engineer will benefit from ecological thinking to in case of crisis?
   h) Yes b) No

   Answer: (a)

Please fill in the blanks in Question 4 with the suitable terms.

4. ________________is defined as a production and consumption strategy that aims at taking into account all of the impacts (environmental, economic and social) that a product or service will have throughout its life cycle, "from cradle to __________". However, nowadays, the cradle to _________ principle is receiving more acceptances.

   Answer: Life cycle thinking, grave, cradle

Please select the best answer for the Questions 1-4.

1. Do you believe in 'sustainable capitalism' for environmental ethics?

   a)Yes b) No

   Answer: (b)

2. What is your own world view about human-nature relationship?

   a) anthropocentric
   b) ecocentric
   c) homocentric
   d) egocentric
   e) none of the above
   f) all of the above

   Answer: (c)

3. Value regardless of any direct usefulness to human beings is;

   i) Instrumental value
   j) intrinsic value

   Answer: (b)

4. Which one is more close to technological developments, engineering ethics or environmental ethics in case of green engineering?

   a) engineering ethics
   b) environmental ethics

   Answer: (b)

5. What are the long term and short term consequences of your particular worldview?

Please specify the sentence given in the Question 4 True or False.

6. All that is lacking is a moral and social commitment to an ethic of stewardship, a commitment to rightness and goodness in our relationships with each other and with the earth.

   Answer: True

Please fill in the blanks in Questions 7 and 8 with the suitable terms.

7. ______________ gives moral status to all beings that can have pleasure and pain, can suffer and a re-sentient and says that making sentient beings suffer is wrong.

Answer: Pathocentrism

8. Human beings take place at the center and only humans are moral agents in __________________ approaches.

Answer: Anthropocentric

Please select the best answer for the Questions 1-3.

1. Could you adapt “flow of energy in the ecosystems” into engineering applications?

a)Yes b) No

Answer: (a)

2. Is the establishment of a balance of nature ever possible by using technology?

a)Yes b) No

Answer: (b)

3. What do you know about ‘carrying capacity’ of nature?
   a) maximum population size of the species that the environment can sustain indefinitely
   b) carrying capacity is defined as the environment's maximal load
   c) a measure of sustainability
   d) all of the above

   Answer: (d)

Please fill in the blanks in Questions 1 and 2 with the suitable terms.

1. ____________ is a special problem which is associated with fossil fuels?

   Answer: global warming

2. _____________ aims to establish a system of resource consumption that both meets the needs of human life and leaves the environment healthy enough to continue to produce the resources future generations will need.

Answer: Sustainable development

4 BIOLOGY

Maya Kitanova, Emiliya Pisareva and Anna Kujumdzieva

4.1 What is ecology in biology? Ecology and Biology

Ecology is a branch of Biology that studies the interactions between living organisms and their environment and is also called bionomics. All the interactions vice versa influence the distribution and abundance of living organisms. The specialists in Ecology study tremendous variety of organisms and environments: from microorganisms in the soil or puddle of water to plants and animals in the forest or oceans. As the human activity very often has a determinable influence on the natural world, ecologists are the specialists involved in the process of presentation of natural habitats by solving environmental problems.

Ecology is a broad science encompassing many fields. The following sub-disciplines can be listed:

- Behavioral ecology
- Community ecology (synecology)
- Ecophysiology
- Ecosystem ecology
- Evolutionary ecology
- Global ecology
- Human ecology
- Population ecology

The science of ecology includes several important structural and integrative levels: individuals, populations, communities, and ecosystems.

1. Population

A population is a group of organisms, of a same species, which occupies the same geographical area at the same time. Individual members of the same population can interact with each other as well as with a similar environment conditions.

Populations are identified by a number of characteristics. These are: population size; population density; patterns of dispersion; age structure; natality; mortality; population growth and dispersal; biotic potential.

Population size

Population size is the number of individual organisms in a population. Population's size depends on the environmental conditions and relationships with other organisms.

Population density

Population density is the number of individual organisms per unit area or unit volume, or population mass per unit area. Different species exist at different densities in their environments, and the same species may be able to achieve one density in one environment and another in a different environment.

Patterns of dispersion

Individual members of populations may be distributed over a geographical area in a number of different ways:

- Clumped distribution (attraction)
- Regular (uniform) distribution (repulsion)
- Random distribution (minimal interaction/influence)

Population growth and dispersal

Population growth can be defined as the change in the number of individuals in a population using "per unit time" for measurement.

Population dispersal is the process, by which groups of living organisms expand the space or range within which they live.

Age structure

Age structure refers to the size of cohorts within a population. A cohort is a group of individuals all of the same age. In a typical population, the size of cohorts varies with the age of individuals.

Natality (Birth rate)

Natality is the scientific term for birth rate. Natality can increase or decrease in a population according to environmental conditions and certain regulating factors. In times of hardship for a population, such as a lack of food, natality has been expected to decrease. Natality typically varies with the age of individuals.

Generation time

Generation time is the average time between the birth of individuals and the birth of their offspring. Generation time usually expresses the average age of breeding females within a population. A shorter generation time will result in faster population growth.

Mortality (Death rate)

Mortality or death rate is the rate at which individuals of a certain age die. Mortality rate is a measure of the number of deaths in a population, scaled to the size of that population, per unit of time. Mortality rates often vary with age. Population growth occurs when overall birth rates exceed overall death rates.

Sex ratio

Sex ratio is the ratio of males to females in a population. The rate, at which a population may grow is dependent on the sex ratio in the population.

Biotic potential

Biotic potential is the maximum reproductive capacity of an organism under optimum environmental conditions. Full expression of the biotic potential of a population is restricted by environmental resistance, any condition that inhibits the increase in number of the members.

2. Community

A community is a group of two or more populations of different species that occur together the same geographical area (for example – plant community or bacterial community). An ecological community is a group of actually or potentially interacting species living in the same location. Communities are bound together by a shared environment and a network of influence each species has on the other.

Every community comprises a group of different species and their number and identities are difficult to study. Most communities are so large that it is not possible to enumerate all species - microorganisms and small invertebrates are especially difficult to investigate.

3. Ecosystem

An ecosystem is a community of living (biotic) and nonliving (abiotic) elements considered as a unit. Biotic and abiotic factors combine to create a system or more precisely, an ecosystem (biogeocoenosis).

Good examples of ecosystems are a lake, an island and a forest. The sides of the lake, island and forest define the boundaries of the ecosystem. Within these boundaries organisms live and carry out their activities, modifying the characteristics of the lake, island and forest as well as each other.

4.2 Ecology related professions in Biology

Increasingly scientists are choosing careers, in which they can help create a more sustainable world, where all people can live healthy, fulfilling lives. From developing new vaccines and delivery mechanisms for tropical diseases, to finding ideal conservation corridors for endangered species, to creating plastics that don't require petroleum products, there are countless ways that one can use his/her scientific skills to create a sustainable future.

While this handout aims to provide some of the more interesting sustainability opportunities available for scientists, we have to keep in mind that one don't have to work on renewable energy or conservation biology to make a difference. Creating a sustainable world will take lots of creativity and cooperation, with scientists in all fields working together and working with the community to help solve the complex problems our world is facing. How will they put their scientific skills to use to create a sustainable world?

There is a growing need to understand the natural world and to manage human impact on it. This need has resulted in increasing demand and job opportunities for people with ecological / environmental background. The opportunities for employment are expected to grow considerably in the near future. Numerous job opportunities have recently appeared in research, resource management and education. The graduates in Ecology can successfully find employment within state and federal agencies, non-profit organizations, private consulting firms and schools. Potential careers for people with interest in Ecology and the Environment Protection include: research technicians, park naturalists, outdoor educators, wildlife biologists, foresters, environmental consultants, college professors, entomologists, water quality control technicians, environmental planners, natural resources managers, field ecologists, researchers, environmental impact analysts, toxicologists, museum or zoo curators, conservation biologists, fisheries biologists, etc.

Ecology professions:

Whether they investigate urban, suburban, rural, forest, desert, farm, fresh water, estuarine, or marine environments, ecologists help the society to understand the connections between organisms and their environment. Environmental Consultants assess the ecological impacts of conservation, development, and industry projects and recommend solutions to environmental problems. Natural Resource Managers manage ecological resources for public and private organizations. Park Naturalists develop and deliver education programs to students of all ages. Restoration Ecologists plan, organize, and carry out programs to reestablish natural ecosystems.

Biology professions:

Biologists, as well as medical professionals, play important roles in helping to keep people healthy throughout the world. From developing new pharmaceuticals to finding ways to increase agricultural yields, biologists are at the forefront of fighting illness and malnutrition. Biologists also work in management and conservation careers to solve environmental problems and preserve the natural world for future generations. The Park Rangers protect state and national parks, help preserve their natural resources, and educate the general public. Zoo Biologists carry out endangered species recovery programs. In addition, Management and Conservation Biologists often work with members of a community such as landowners and special interest groups to develop and implement management plans. Science Advisors work with lawmakers to create new legislation on environmental protection, ensuring that decisions are based upon solid science. Trained professionals work with the government and other organizations to study and address the economic impacts of biological issues, such as species extinctions, forest protection, and environmental pollution

(http://www.aaas.org/programs/centers/sd/careers.pdf).

4.3 Green Abilities: a substantial part of professional career

Competencies are the personal attributes, skills and knowledge that are critical to being an effective and successful performer in a given job. They identify those requirements, which are essential to perform the work. The competency development process recognizes one may acquire competencies in many different ways.

Assessment, outcomes, and accountability are words that may strike terror (or at least annoyance) into the hearts of professionals. However, most professions have accepted the importance of measuring outcomes, and environmental protection and ecology cannot be an exception. The practice of environmental protection is extremely diverse, and it requires a large variety of knowledge and skills.

Green abilities are dedicated to providing effective environmental management and creating solutions designed to reduce and limit the negative impact that their operations have on the environment.

Around the world, the interest in green jobs for sustaining the ecological balance and protecting the environment is now the faster growing market for employment. As new type of jobs, namely “green” ones are created now, people that can satisfy these requirements are needed. If somebody needs to enroll in a class that enables adaptation of green skills, it should be done as soon as possible. This kind of jobs will fill fast once the next generation of workers enters the job force. In order to receive such effect there is a need of retooling old skills for the newest equipment, processes and methods of operation. No industry exempt from green jobs today. Every major corporation is designing eco-jobs in nearly every department of operation.

Development of new materials and energy sources to replace non-renewable and polluting substances is itself a part of chemistry and materials science. However, industrial ecology plays a role in evaluating the broader systems implications of proposed solutions like bio-fuels or genetically engineered organisms. Can we devote a significantly larger proportion of farm land to crops for ethanol or for new biomaterials and still preserve basic ecological functions and meet growing demand for food? It is a modern study for innovation in this field.

For example if the environment managers receive a request for locating a steel plant, they will be able to decide whether they can meet the water requirement of the steel plant over the next few decades. They can also easily calculate the likely secondary demand on water resources as an outcome of locating the steel plant (for instance, the increase in population). Based on this analysis, the environment planners may choose to either refuse permission or insist that the industry finds its own sources of water (set up desalination plants and use desalinated sea water, for example). Promoting recycling of wasted resources would also assist an environment planner to set up waste exchange programs.

4.4 What can a biologist learn from ecological systems?

"I bequeathed myself to the dirt, to grow from the grass I love; if you want me again, look for me under your boot-soles."

Walt Whitman

The ecosystem is a core concept in Biology and Ecology, serving as the level above that of the ecological community (organisms of different species interacting with each other) but at a level below, or equal to, the biomes and the biosphere. Essentially, biomes are regional ecosystems and the biosphere is the largest of all possible ecosystems. An ecosystem consists of the biological community that occurs in some place, and the physical and chemical factors that make up its non-living or abiotic environment. Ecosystems are dynamic interactions between plants, animals, and microorganisms and their environment working together as a functional unit. Ecosystems will fail if they do not remain in balance. No community can carry more organisms than its food, water, and shelter can accommodate. Food and territory are often balanced by natural phenomena such as fire, disease, and the number of predators. Each organism has its own niche or role to play. The boundaries are not fixed in any objective way, although sometimes they seem obvious, as with the shoreline of a small pond. Usually the boundaries of an ecosystem are chosen for practical reasons having to do with the goals of the particular study.

An ecosystem can be as large as the Sahara Desert or as small as a puddle or vernal pool.

The study of ecosystems mainly consists of the study of certain processes that link the living, or biotic, components to the non-living, or abiotic, components.

In ecosystem ecology we put all of this together and, insofar as we can, we try to understand how the system operates as a whole. This means that, rather than worrying mainly about particular species, we try to focus on major functional aspects of the system. These functional aspects include such elements as the amount of energy that is produced by photosynthesis, how energy or materials flow along the many steps in a food chain, or what controls the rate of decomposition of materials or the rate at which nutrients are recycled in the system (http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/ecosystem/ecosystem.html).

Structure of the Ecosystem

Abiotic Factors

Abiotic (means not alive) are nonliving factors that affect living organisms. Environmental non-living factors called biotope or habitat. Biotope is synonymous to the term habitat, which is more commonly used in English-speaking countries. Biotope is an area of uniform environmental conditions providing a living place for a biocoenosis or the environment in which species normally live. Biotope can be a pond, lake, ocean, desert, and mountain. Weather (temperature, cloud cover, rain, snow, hurricanes, etc.), air, water or mineral soils are abiotic factors. Atmosphere affects ecosystem by wind speed, humidity, light intensity, temperature. Temperature depends on solar radiation, wind speed, time of year, time of day, altitude, exposition. Temperature affects water loss, respiration, photosynthesis. Changes in temperature affect relative humidity and evaporation from soils and water surfaces. Water affects ecosystem by pH, salinity, dissolved nutrients, and dissolved oxygen. Soil affects ecosystem by available nutrients, pH, temperature, moisture, structure.

Biotic Factors

Biotic are living factors. Plants, animals, fungi, protists and bacteria are all biotic or living factors. Together, the biotic factors are called biocoenosis.

So, ecosystem (biogeocoenosis) is total communities of organisms (biocoenosis) together with the nonliving components (biotope) of their environment. Thus, the ecosystem can be understand as a superorganism.

Within an ecosystem biocoenosis can be defined as a community of living beings belonging to different species.

The components of each biocoenosis in an ecosystem are:

- Zoocoenosis for the faunal community;
- Phytocoenosis for the floral community;
- Microbiocoenosis (microbocoenosis) for the microbial community.

Zoocenosis

Zoocoenosis includes the fauna - all the animal life of any ecosystem. Zoocenoses are formed on the interrelationships of animals not only with each other but also with other organisms, such as higher plants and microorganisms, and with the inorganic environment (biotope).

Phytocoenosis

Phytocoenosis (also plant community) includes the flora - the plant life of any ecosystem. The plants of a phytocoenosis display complex interrelations with other plants, with animals, microorganisms and with the environment. Each phytocoenosis is a system with a definite composition (consisting as a rule of many different species) and a definite structure. The composition and structure of phytocoenoses evolve as a result of the natural selection of plant species capable of coexisting with each other and with animals in certain environmental conditions, and in many instances as a result of the influence of man.

Microbocoenosis

Microorganisms, also called, microbes are microscopic organisms which exist mainly as a single cell (unicellular) organisms. Microorganisms include bacteria, fungi, algae, and protozoa. Microorganisms live in all parts of the biosphere including soil, hot springs, on the ocean floor, high in the atmosphere and deep inside rocks within the Earth's crust.

Flora, fauna and microbes are collectively referred to as biota.

Pedogenesis is the process that leads to the formation of soil. The soil is formed over time as a consequence of climatic, mineral and biological processes from soil forming rocks.

Nutrient cycle is the movement and exchange of organic and inorganic matter back into the production of living matter. The process is regulated by food web pathways that decompose organic matter into mineral nutrients. Nutrient cycles occur within ecosystems.

Ecological niche. Niche is a term describing the way of life of a species. Each species have a separate, unique niche. An organism’s ecological niche depends not only on where it lives but on what it does. The ecological niche can be understood as the ecological role and space that an organism fills in an ecosystem. For example, the ecological niche of a sunflower includes absorbing light, water and nutrients (for photosynthesis), providing food for other organisms (e.g. bees, ants, etc.), and giving off oxygen into the atmosphere.

Energy transformations and **biogeochemical cycling** are the main processes that comprise the field of ecosystem ecology. As it was mentioned earlier, ecology generally is defined as the interactions of organisms with one another and with the environment, in which they occur. We can study ecology at the level of the individual, the population, the community, and the ecosystem.

The transformations of energy in an ecosystem begin first with the input of energy from the sun. Energy from the sun is captured by the process of photosynthesis. Carbon dioxide is combined with hydrogen (derived from the splitting of water molecules) to produce carbohydrates (CHO). Energy is stored in the high energy bonds of adenosine triphosphate (ATP).

The prophet Isaah said "all flesh is grass", earning him the title of first ecologist, because virtually all energy available to organisms originates in plants. Because it is the first step in the production of energy for living beings, it is called **primary production**. **Herbivores** obtain their energy by consuming plants or plant products, **carnivores** eat herbivores, and **detritivores** consume the droppings and carcasses of us all.

Function of the Ecosystems

Biotic components (living organisms) in each ecosystem include:

- Producers or Autotrophs - plants and specialized microbes. These organisms manufacture their own food from simple inorganic substances (from sunlight, water, and carbon dioxide).
- Consumers or Heterotrophs - animals and microbes. They feed from autotrophs or other heterotrophs to obtain energy (herbivores, carnivores, omnivores).
- Decomposers or Detritivores - microorganisms like fungi and bacteria. They break down chemicals from producers and consumers (dead organic matter) into simpler substances which can be reused.

These tree groups of organisms realize ecosystem processes, such as primary production, pedogenesis, nutrient cycling, and various niche construction activities and regulate the flux of energy and matter through an environment.

An ecological science dealing with the flow of energy and matter through the biotic and abiotic components of ecosystems is an **Ecosystem ecology**. The ecosystem is the principal unit of study in ecosystem ecology. Ecosystem ecology approaches organisms and abiotic pools of energy and nutrients as an integrated system. Ecosystem ecology is the integrated study of biotic and abiotic components of ecosystems and their interactions within an ecosystem framework. This science examines how ecosystems work and how this work affects their components - chemicals, bedrock, soil, plants, microbes and animals.

A main focus of ecosystem ecology is on functional processes and mechanisms that maintain the structure and functions of the ecosystems - primary production (production of biomass), decomposition, and trophic interactions.

Studies of ecosystem functions support human understanding of sustainable production of forage, fiber, fuel, and provision of water. Functional processes are mediated by regional-to-local level climate, disturbance, and management. Thus ecosystem ecology provides a framework for identifying ecological mechanisms that interact with global environmental problems, especially global warming and degradation of surface water.

These studies also introduce practical problems into natural resource management. Who will manage which ecosystem? Will timber cutting in the forest degrade recreational fishing in the stream? These questions are difficult for land managers to address while the boundary between ecosystems remains unclear; even though decisions in one ecosystem will affect the other. We need better understanding of the interactions and interdependencies of these ecosystems and the processes that maintain them before we can begin to address these questions.

Human ecology is a branch of Ecology sciences concerned with the relations of human beings with their physical, biological and social environment. More broadly, it is an interdisciplinary and Trans disciplinary study of the relationship between humans and their natural, social, and built environments. The scientific philosophy of human ecology has a diffuse history with advancements in geography, sociology, psychology, anthropology, zoology, and natural ecology.

Human ecology is sometimes seen as a field in environmental sociology; at other times it is regarded as a completely separate field.

4.5 How an ecological understanding of systems may contribute to biology?

Many ecologists believe that the 21st century will be the era of restoration in ecology. Ecological restoration aims to recreate, initiate, or accelerate the recovery of an ecosystem that has been disturbed. Disturbances are environmental changes that alter ecosystem structure and function. Common disturbances include logging, damming rivers, intense grazing, hurricanes, floods, and fires. Restoration activities may be designed to replicate a pre-disturbance ecosystem or to create a new ecosystem where it had not previously occurred. Many restoration projects aim to establish ecosystems composed of a native species; other projects attempt to restore, improve, or create particular ecosystem functions, such as pollination or erosion control. Natural resource managers in forestry, for example, employ ecologists to develop, adapt, and implement ecosystem based methods into the planning, operation, and restoration phases of land-use.

Restoration projects differ in their objectives and their methods of achieving different goals. Some examples of different kinds of restoration include the following:

- Revegetation - establishment of vegetation on sites where it has been previously lost. For example, vegetated buffers are strips of vegetation that protect water quality in riparian ecosystems from urban or agricultural run-off.
- Habitat enhancement- the process of increasing the suitability of a site as habitat for some desired species.
- Remediation - improving an existing ecosystem or creating a new one with the aim of replacing another that has deteriorated or been destroyed.
- Mitigation - remediation for loss of protected species or ecosystems.

And while the Industrial Revolution meant that more goods could be produced for human consumption, it also meant that more pollution would be emitted into the sky and more natural resources would have to be exploited in the production process.

Industrial Ecology explores the idea that industrial activities should not be considered in isolation from the natural world but rather as a part of the natural system. In fact industrial systems should be viewed as industrial ecosystems that function within the natural ecological system or biosphere. The industrial system, in a similar way to the natural ecosystem, essentially consists of flows of materials, energy and information, and furthermore relies on resources and services provided by the biosphere. Therefore, tourism, housing, medical services, transportation and agriculture are all part of the industrial system.

The development of industrial ecology is an attempt to provide a new conceptual framework for understanding the impacts of industrial systems on the environment. This new framework serves to identify and then implement strategies to reduce the environmental impacts of products and processes associated with industrial systems, with an ultimate goal of sustainable development (Garner and Keoleian, 1995).

The concept of “Industrial Symbiosis” describes the close relationship between industries – specifically those relationships where the waste of one industrial process feeds as the resource into another industrial process.

In today's society, resources are exploited, producing unusable waste streams and release of pollutants to soil, water, and air, leading to complex sustainability problems. For instance, plastics from ocean dumping of garbage are disintegrating to a molecular level and entering into food chains. The ocean waters in northern seas are becoming less saline due to ice melting as the result of a warming atmosphere. Therefore, there is a great need for Industrial Ecology trained persons that have a grasp of the complexities of the field of sustainable development. Decision-makers need knowledge and skills to deal with the complex interactions among such complex systems.

Industrial ecology may be able to help us perceive the whole system required to feed the planet, preserve and restore its farm lands, preserve ecosystems and biodiversity, and still provide water and land for a growing population.

Another strategy that is often talked about is that of a Design for Environment. In recent times the concept of the “3Rs” (Reduce, Reuse, Recycle) has entered common parlance. The concept of the 3Rs is the products and processes to be designed so that they perform the same function with lower resource consumption, and they have to be easy to reuse and have to be made of materials that can be recycled.

The understanding of industrial environmental impact helps companies become more competitive by improving their environmental performance and strategic planning as well as to develop and maintain an industrial base and infrastructure without sacrificing the quality of environments.

4.6 How can a biologist contribute to a Sustainable World?

"The Use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time"

Rudolph Diesel, 1912

A variety of environmental problems now affect our entire world. As globalization continues and the earth's natural processes transform local problems into international issues, few societies are being left untouched by major environmental problems.

As a species we are heating the World by flooding the atmosphere with our pollutants and catastrophically changing the climate. We are erasing the Rain Forests (the "carbon reservoirs" of our Planet) at an alarming rate. We are using up the Planet's mineral resources faster and faster - and when they've gone …… they've gone forever. We are reducing the glorious biodiversity of our Planet by wiping out more and more species. We fill our precious land and just-as-precious oceans, rivers and lakes with toxic pollutants and untreated sewage. We over-fish, over-farm, and over-eat (well, those in the privileged position of being able to, while many don't get to eat at all). We threaten each other with more and more destructive technologies. We show selfish disregard for the World which our children will inherit (http://sustainableworld.org.uk/).

To bring our world toward sustainability -- or any other goal -- we need to take different kinds of steps, which require different kinds of knowledge, talent, skill, and work. We need, for example, to make things happen -- pass laws, make budgets, find resources, hire people, establish and manage organizations, invent technologies, build, restore, protect, tax, subsidize, regulate, punish, reward, DO THINGS. Implementation is the active, visible phase of achieving a goal, and therefore it is the most discussed phase (Meadows, 1994).

Sustainable Living is a practical philosophy whereby we strive to use only renewable (sustainable) resources to safeguard the future for our children.

The most widely held definition of sustainable living is that of the Brundtland Commission Report of 1987 which stated that we must "meet the needs of the present without compromising the ability of future generations to meet their own needs". Another way of putting it is that when people make decisions about how to use the Earth's resources (water, forests, minerals, food, wildlife, etc.) they must take into account not only how much of these resources they are using, what processes they use to attain the resources and who has access to them, they must also consider whether enough resources are going to be left for our grandchildren to use? (http://sustainableworld.org.uk/)

The sustainable energy age has begun. It was recently announced that a company in Florida called Green Flight International (GFI) has plans to construct a $100-million, algae biofuel plant aimed at making fuel for the aviation industry as well as for ground-based transportation (http://solargreenenergy.blogspot.com/2008/11/algae-biofuel-revolution.html).

Microbes are the hidden powers on the planet world. Most types of microbes remain unknown. It is estimated that we know less than 1 % of the microbial species of the Earth. Microbes play an important role in biogeochemical cycles and are essential partners in biotechnological processes.

The potential of algae and microbes biofuel for both vehicles and air travel is so promising that it will play a large role in helping humankind finally become energy independent. Biofuel from algae completely eliminates the food vs. fuel concerns of other biofuels, and CO_2 will be significantly reduced. Algae and microorganisms are the fastest growing organisms in the world, and that fact translates into 20,000 gallons of biofuel per acre for cultivated algae. Soybean, corn, switchgrass and other biofuels cannot even compete (http://solargreenenergy.blogspot.com/2008/11/algae-biofuel-revolution.html).

The study of microbes connected with their environment and their interactions with each other is the main topic of Microbial ecology. Microbial ecology can show us our place in the cosmos – how life organized and how it evolved, and how are related to the great diversity of all other organisms.

This branch of science Ecology is a large field that has many applications related to the Environmental protection:

4.6.1 Bioremediation

Many environmental problems can be solvable by microbes. Microbes are used to clean up the polluted soil and water - oil spills, pesticides and industrial wastes.

4.6.2 Recycling and reuse

Microorganisms recycle most organic wastes:

- **Waste treatment:** Microbes are used in sewage treatment and methane production.
- **Animal waste treatment:** Microbes clean up waste produced by farm animals.
- **Yard composting**: Composting is now the modern practice of converting kitchen and yard wastes into a rich soil amendment.
- **Municipal composting**: Thousands of tons of leaves and grass clippings are composted in large municipal composting facilities.

4.6.3 Biodiversity

The large number of microbial species is unknown. Of the more than one million species of bacteria suspected to exist, only about 4200 species of bacteria are described. Studies of the biodiversity of microbial world will rich the rest of the sciences.

4.6.4 Food Microbiology

Food crops depend on healthy soils with its normal microbial life. Much of the protein that we eat is the result of bacterial fixation of nitrogen from the air by microbes such as Rhizobium. Many of foods are prepared with the aid of microbes, such as yeast in bread, and Lactobacillus in yogurt. Many of our food supplements, from vitamins, amino acids to flavor enhancers and preservatives, come from microbes. Microbes are also used as probiotics, a digestion supplement that colonizes the intestines, preventing the colonization of disease-causing microbes.

Biotechnology

Microbes are used as reagent in the production of many compounds: fuel, pharmaceuticals, and chemicals. They are also used in mining, insect and disease control, genetic engineering and some are even used to make computer biochips.

For example: Fuel production - ethanol production for automobile fuel; Mining – leaching of metals from ore bearing rocks by microbes (5 % of world's copper is produced by bio-leaching; uranium is mined with help of bacteria); **Biocontrol** - using microbes to destroy pests in soils is called biocontrol. One of the most popular forms of biocontrol is the use of Bacillus thuringiensis, a bacterium that produces a toxin that kills over 40 problem pests such as the Gypsy moth; **Computer biochips** - microorganisms may someday be used to produce protein-based microprocessors with more switches than conventional.

Biotechnology can be used alongside microbial ecology to solve a number of environmental problems. For example, molecular techniques such as community finger printing can be used to track changes in microbial communities over time or assess their biodiversity. Managing the carbon cycle to sequester carbon dioxide and prevent excess methanogenesis is important in mitigating global warming, and the prospects of bioenergy are being expanded by the development of microbial fuel cells.

Recreation ecology is the field of ecology that is concerned with the impact of recreation on the environment. Thus the Recreation ecology examines all the components of the ecosystems - soils, vegetation, water, wildlife and microbes, in the recreation sites. Relationships, environmental resistance and mobility and monitoring are some of the major themes in recreation ecology. Recent growth of ecotourism has activated also studies of recreation ecology for protecting the ecosystems.

Now Recreation ecology has to answer to many questions, some of which are:

- Why does the social carrying capacity of public lands change across space and time?
- What is an acceptable level of changes?
- What are the quality indicators of changes? Why do they vary within ecosystems in parks and protected areas?

Study results have been applied to make management decisions and to provide scientific input to management planning frameworks.

Conservation ecology is the study of the relationships of living organisms to the environment, how those relationships change though time, and how human activities correspond to those relationships. Conservation ecology can be understand as a scientific study of the nature and status of Earth's biodiversity with the aim of protecting species, their habitats, and ecosystems from erosion of biotic interactions.

Conservation ecology is tied closely to conservation biology in researching for better understand the restoration ecology of native plant and animal communities. Conservation ecology is concerned with phenomena that affect the maintenance, loss, and restoration of biodiversity and ecosystem. The concern stems from estimates suggesting that up to 50 % of all species on the planet will disappear within the next 50 years, which has contributed to poverty, starvation, and will reset the course of evolution on this planet. As human continue to alter biodiversity in the environment, the need grows for such investigations for preventing of environmental problems,

Our knowledge of ecological systems provides a solid foundation for creating balanced ecological designs and solutions that are sustainable, cost-effective and enduring.

4.7 What worked in the past, what is working now, what might work in the future? (In terms of ecology and biology)

The past …

Environmental history surely goes back to the origin of humanity. Action or the lack of appropriate action, taken by people over the millennia, throughout centuries and particularly during these past few decades has had an enormous impact on our environment and eco-systems. It is therefore vital to recall some of the main phases and turning points in our efforts to take action to reverse, on the one hand, negative damage caused, and on the other, to take preventive action to preserve our environment in support of sustainable development (Learner´s Guide No6, 2004).

A concern for environmental protection has recurred in diverse forms, in different parts of the world, throughout history. In England, the burning of sea-coal was banned by in 1272, after its smoke had become a problem. The fuel was so common in England that this earliest of names for it was acquired because it could be carted away from some shores by the wheelbarrow. Air pollution would continue to be a problem in England, especially later during the Industrial Revolution, and extending into the recent past with the Great Smog of 1952.

Later, the Industrial Revolution gave rise to modern environmental pollution as it is generally understood today. The first large-scale, modern environmental laws came in the form of the British Alkali Acts, passed in 1863, to regulate the deleterious air pollution.

Due to the pressures of population and technology, the biophysical environment is being degraded, sometimes permanently. This has been recognized, and governments have begun placing restraints on activities that cause environmental degradation. Since the 1960s, activity of environmental movements has created awareness of the various environmental issues. There is no agreement on the extent of the environmental impact of human activity, and protection measures are occasionally criticized.

… The present …

The application of ecology study to real-world problems is the topic of the applied ecology. It is an integrated science with the ecological, social, and biotechnological aspects. Applied ecology is also called ecological or environmental technology. Applied ecology is a framework for the application of knowledge and skills about ecosystems so that actions can be taken to create a better balance and harmony between people and nature in order to reduce human impact on other beings and their habitats.

Aspects of applied ecology include: agro-ecosystem management, biodiversity conservation, biotechnology, conservation biology, ecosystem restoration, habitat management, protected areas management, restoration ecology. Applied ecology typically focuses on geomorphology, soils, and plant communities as the basis for vegetation and wildlife management.

Studies in this field are connected with bringing the practical land-use decisions. The purpose of the study can be: the distribution and abundance of any nationally notable plant species; to solve problems associated with the intensive human use of the environment; protection of rare species and habitats; restoration of industrial wasteland; using wetland ecosystems for treating wastewater; environmental valuation in relation to the needs for conservation; integration of sustainable ecosystems with commercial enterprises, such as agriculture and nature tourism.

Environmental pollution and related human health concerns have now reached critical levels in many areas of the world. International programs for researching, monitoring and preventing the causes of these phenomena are ongoing in many countries. There is an imperative call for reliable and cost-effective information on the basal pollution levels both for areas already involved in intense industrial activities, and for sites with industrial development potential. Biomonitoring methods can be used as unfailing tools for the control of contaminated areas, as well as in environmental prevention studies. Human biomonitoring is now widely recognized as a tool for human exposure assessment, providing suitable and useful indications of the `internal dose' of chemical agents. Bioindicators, biomonitors, and biomarkers are all well-known terms among environmental scientists, although their meanings are sometimes misrepresented. Therefore, a better and full comprehension of the role of biological monitoring, and its procedures for evaluating polluting impacts on environment and health is needed. (Conti et al., 2008).

… And the future

Ecosystem science is evolving rapidly in both methodology and focus. Human alteration of ecosystems is now so pervasive globally, that ecologists are working to integrate humans into ecosystem science at many levels—including the study of urban ecology, agroecology and global ecology. New techniques for ecosystem modeling are being developed all the time, as are new methods for observing ecosystems from space by remote sensing and aerial platforms, and even by networks of sensors embedded in soils and plants across ecosystems and on towers that can make observations on ecosystem exchanges with the atmosphere on a continuous basis. Examples of cutting edge ecosystem research are the Carnegie Airborne Observatory - an aerial remote sensing system capably of precisely mapping ecosystem carbon and species diversity, and the development of the National Ecological Observatory Network (NEON), a continental-scale research platform for discovering and understanding the impacts of climate change, land-use change, and invasive species on ecosystems (http://www.eoearth.org/article/Ecosystem?topic=58074).

4.8 Best practices, case studies

Best Practices

The concept of best practice has been employed extensively in environmental management. For example, it has been employed in aquaculture such as recommending low-phosphorus feed ingredients, in forestry to manage riparian buffer zones, in livestock and pasture management to regulate stocking rates, and in particular, best management practices have been important to improving water quality relating to nonpoint source pollution of fertilizers in agriculture as well as the identification and adoption of best practice for controlling salinity. However, in the context of complex environmental problems such as dryland salinity, there are significant challenges in defining what is best in any given context. Best management practice for complex problems is context specific and often contested against a background of imperfect knowledge. In these contexts, it is more useful to think of best management practice as an adaptive learning process rather than a fixed set of rules or guidelines. This approach to best practice focuses on fostering improvements in quality and promoting continuous learning.

In accordance to the Energy Facility Contractors Group's database, some of the best environmental best practices for the last decade are:

- **Environmental Scorecards** (01.10.2012) are an organization-specific measure of environmental performance to assist managers and environmental support staff in identifying opportunities for improvement. Six factors, based on functional metrics, make up the overall rating which follows a familiar “stop light” color system, similar to the site-wide metrics. The scorecards clarify roles and responsibilities and increase ownership of environmental performance in the organizations. They provide feedback for continuous improvement and allow organization managers to consider environmental performance when setting priorities and goals. Posting the scorecards on an internal website fosters constructive competition with positive peer pressure.

- **Mortar-lining Aged Water Distribution Lines Protects Groundwater and Minimizes Waste** (12.08.2004) - The U.S. Department of Energy, Richland Operations Office (DOE-RL) pioneered the application of mortar-lining technology, an innovative, cost-effective, and environmentally friendly solution to restore water distribution lines. The implementation of the mortar-lining project allowed DOE to protect the groundwater, reduce energy use, maintain water quality, minimize waste and ensure the reliability of the fire protection system.

Case studies

1. **Himalayan Glaciers: Climate Change, Water Resources, and Water Security**

Scientific evidence shows that most glaciers in South Asia's Hindu Kush Himalayan region are retreating, but the consequences for the region's water supply are unclear. The Hindu Kush Himalayan region is the location of several of Asia's great river systems, which provide water for drinking, irrigation, and other uses for about 1.5 billion people. Recent studies show that at lower elevations, glacial retreat is unlikely to cause significant changes in water availability over the next several decades, but other factors, including groundwater depletion and increasing human water use, could have a greater impact. Higher elevation areas could experience altered water flow in some river basins if current rates of glacial retreat continue, but shifts in the location, intensity, and variability of rain and snow due to climate change will likely have a greater impact on regional water supplies (http://dels.nas.edu).

2. **Sustainable Water and Environmental Management in the California Bay-Delta**

Water management in the California Bay Delta is directed toward providing a more reliable water supply for California, and protecting and rehabilitating the Delta ecosystem, including five endangered and threatened populations and species of fish that live in or migrate through the Delta. However, water management in the Bay and Delta is distributed among many agencies and organizations, a structure that hinders the development and implementation of an integrated, comprehensive plan. As a result, recent Bay Delta planning efforts have not resolved the best plan for the environment or for satisfying anticipated water needs. Challenges include the fact that water scarcity has not been adequately addressed in planning for Delta water and environmental management; the interacting effects of the many environmental stressors that impact the Delta ecosystem, and the many biological and physical effects of climate change. This report discusses the issue of scarcity, factors affecting the listed species and the Delta ecosystem in general, future water-supply and delivery options, scientific uncertainties, the degree of restoration likely to be attainable, and the need for comprehensive planning (http://dels.nas.edu).

3. Shellfish Mariculture in Drakes Estero, Point Reyes National Seashore, California

Drakes Estero, 25 miles northwest of San Francisco, is a marine estuary home to harbor seals, waterfowl, fish, and other marine organisms. It was designated the estuary a Potential Wilderness in 1976, signifying the intention to incorporate the area into an existing Wilderness area in Point Reyes National Seashore. Drakes Estero is also the site of commercial oyster farming since the 1930s, and Drakes Bay Oyster Company continues to operate today under a permit. The permit is set to expire in 2012, which would effectively close the oyster farm unless it is extended by congressional action. As the expiration date approaches, the Park Service has issued a series of reports presenting scientific information that describes negative effects of the oyster farm on the Drakes Estero ecosystem (http://dels.nas.edu).

4. Ocean Noise and Marine Mammals

For the 119 species of marine mammals, as well as for some other aquatic animals, sound is the primary means of learning about their environment and of communicating, navigating, and foraging. Ambient noise and its potential impacts have been regulated since the passage of the Marine Mammal Protection Act of 1972; however, public awareness of the issue has escalated in the past decade when researchers began using high-intensity sound to measure ocean climate changes and stranding of beaked whales occurred in proximity to U.S. Navy sonar use. The well-understanding of sources of noise in the ocean environment, what is known of the responses of marine mammals to acoustic disturbance, and what models exist for describing ocean noise and marine mammal responses will help for future data gathering efforts, studies of marine mammal behavior and physiology, and modeling efforts necessary to determine what the long- and short-term impacts of ocean noise on marine mammals (http://dels.nas.edu).

5. The Kalundborg Example

A process of "Industrial Symbiosis", which has evolved during the last three decades in the small city of Kalundborg, in Denmark, offers the best evidence that such an approach can be very practical and economically viable. Kalundborg, located 130 km west of Copenhagen, can be seen as a successful example of an industrial complex minimizing pollution and optimizing the use of various resources. A few industries located there, including a power plant, a gypboard plant, a biotech unit, the fishing activity in the town and the town municipality developed a method of sharing each other's wastes to mutual advantage. Ever since the initial discovery of these interactions in 1989, the economic and environmental benefits along with specific details of resources being shared by industries in Kalundborg has been documented and advocated by the Kalundborg Centre for Industrial Symbiosis.

5 ARCHITECTURE

Bolkar Açıkkol, Cem Açıkkol

5.1 What is ecology in architecture? Ecology and architecture

German biologist Ernst Heinrich Haeckel introduced the term ecology in 1866. The term, derived from the Greek oikos, means “household,” which is the root word for economy as well. Charles Darwin developed his theory of evolution by making the connection between organisms and their environments.

Ecology is the study of the relationship of plants and animals to their environment. The flow of material and energy between things within their environment is their spatial context, their community. It is the study of that spatial connectivity between organism and environment that makes ecology an excellent model for sustainable design. Conceptually, sustainable design expands the role of the design program, moving the design goal from object to community, and then designs the connections, illustrating the relationship between available energy and the natural place. The flow of renewable energy, which powers all the essential processes needed for life, dwarfs the power and use of nonrenewable energy sources. These energies power functions at no cost and without pollution-loading the environment. The removal of natural systems not only increases costs, but it reduces the functioning of natural systems—as nature is reduced, the cost of life and to life increases. The physical environment includes the sun, water, wind, oxygen, carbon dioxide, soil, atmosphere, and many other elements and processes. The diversity and complexity of all the components in an ecological study require studying organisms within their environments. Ecological study connects many fields and areas of expertise, and in so doing illustrates holistic aspects of components and their relationships to one another within their spatial community. Planning and architecture must work together to be sustainable. Sustainable design challenges the designer to design connections to the site and to the site’s resident energy—to design holistically and connectedly and address the needs of the building and the environment and community of which it is a part. Sustainable design and planning make use of the regional climate and local resources. To design sustainably is to integrate the design into the ecology of the place—the flows of materials and energy residing in the community.

‘Ecology’ is the study of living systems and their relations to one another. A living system is an integrated whole whose properties emerge from the relations between its individual parts. Each part reflects the whole but the whole is always different from the mere sum of its parts. Through this basic definition of a living system we can begin to identify the main difference between living and non-living systems. In a non-living system (such as buildings) the components together form the whole through a hierarchical structure of construction – each part of the system has its own function and is built specifically to perform this function. The interaction between the components serves the whole but we cannot say that the whole emerges from the interactions between the parts.

The study of living systems has influenced architectural design in various ways, although, the results suggest that architects and designers do not truly comprehend how living systems function, but rather try to borrow new ideas from science and ecology and express them in architecture in a rather superficial way.

How can architecture reflect such complex living processes in a way which is not just based on formal considerations? The key distinction is to see how ecology may inform architecture not as object but as process. Ecological architecture could also be called green architecture or sustainable architecture. It would be defined as buildings that are built with the environment in mind, i.e. energy efficiency, earth friendly building materials, etc.

Buildings to every scale deserve greater efficiency. Forms that are exciting are now in need to perform to higher levels for their owners, inhabitants, users, visitors and the community they are part of. Through smart ecological design this can be achieved with considerable success.

5.2 Ecology related professions in Architecture

Ecological architecture recognizes the built/natural environment as a complex web of interacting parts constantly exchanging energy and resources. In keeping with this perspective, professionals are interested in developing architecture and urban design that is as dynamic as the context from which it arises.

Architecture, along with its allied professions of urban design, landscape architecture, and planning, must be in the forefront of creative thinking about the post-industrial era. Because they make and unmake the world daily through building, they are responsible for a large percentage of resource extraction, depletion, energy use, carbon emissions, waste and transportation costs. It is projected that buildings consume as much as 60% of the world's energy divided between our industrial production and buildings for other uses.

The Ecological Professions in architecture offers an intense exploration of the role that the discipline plays in the making of the next world. This focus requires collaborative association with allied professionals and disciplines, reinforced by close relationship with the local and regional communities. Using seminars, studios, research, and design/build experiments, ecological experts endeavor to understand the opportunities and responsibilities of creating a more sustainable, healthy, vibrant and resilient world.

5.3 Green Abilities

Throughout their education and practice, architects must obtain various abilities in multiple disciplines to become a successful architect. Different from the traditional architectural skills, green abilities are considered a field of expertise where the practice of sustainable, ecological architecture can be realized. Ecological abilities is a framework for increasing the quality of the built environment, and involves maximizing existing natural systems to minimize water use. These abilities can be summarized as;

Appropriate Geological Location

An architect should be able to identify the properties of the land to avoid the development of inappropriate sites and reduce the environmental impact from the location of a building on a site. He/she should be able to channel development to urban areas with existing infrastructure, protect green fields, and preserve habitat and natural resources. He/she should be able to rehabilitate damaged sites where development is complicated by environmental contamination and to reduce pressure on undeveloped land. An ecological architect should make intelligent design decisions to reduce pollution and land development impacts from automobile use. He/she should conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity. As well as limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from storm water runoff and eliminating contaminants.

Efficient Use of Water

Due to reoccurring drought conditions worldwide, using water inefficiently is increasingly unviable. An ecological architect should be able to know and incorporate multiple water efficiency technologies and strategies in the design process, or in the construction process. Understanding the requirements for each of these water efficiency design strategies is critical for the architect. He/she should possess the knowledge to develop a waste water management plan.

Efficient use of Energy

Green buildings often include measures to reduce energy consumption – both the embodied energy required to extract, process, transport and install building materials and operating energy to provide services such as heating and power for equipment. An ecological architect should know the inefficiencies of buildings and the impact of excessive energy use and be able to make intelligent design decisions to minimize the energy use of the building during and after the construction. He/she should be able to understand the heating and cooling loads of the building and possess knowledge to select appropriate mechanical systems. Being able to understand the on and off site renewable energy options for the buildings is also a very import skill for the ecological architect.

Knowledge of Building Materials

40% of the carbon dioxide that contributes to our warming planet comes from buildings. While some of that is a secondary effect of operational needs such as electricity, A/C, and heating, many arise from resource extraction, manufacturing and production of the building materials themselves. An ecological architect should be able to choose ingredients wisely, being sure that the materials selected, and the resources it took to produce them, are a part of the whole picture of a sustainable environment. He/she should be able to reuse building materials and products to reduce demand for virgin materials and reduce waste, thereby lessening impacts associated with the extraction and processing of virgin resources. An ecological architect should be able to know and demand for building products that incorporate recycled content materials. He/she should have knowledge about building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation.

Indoor Environmental Quality

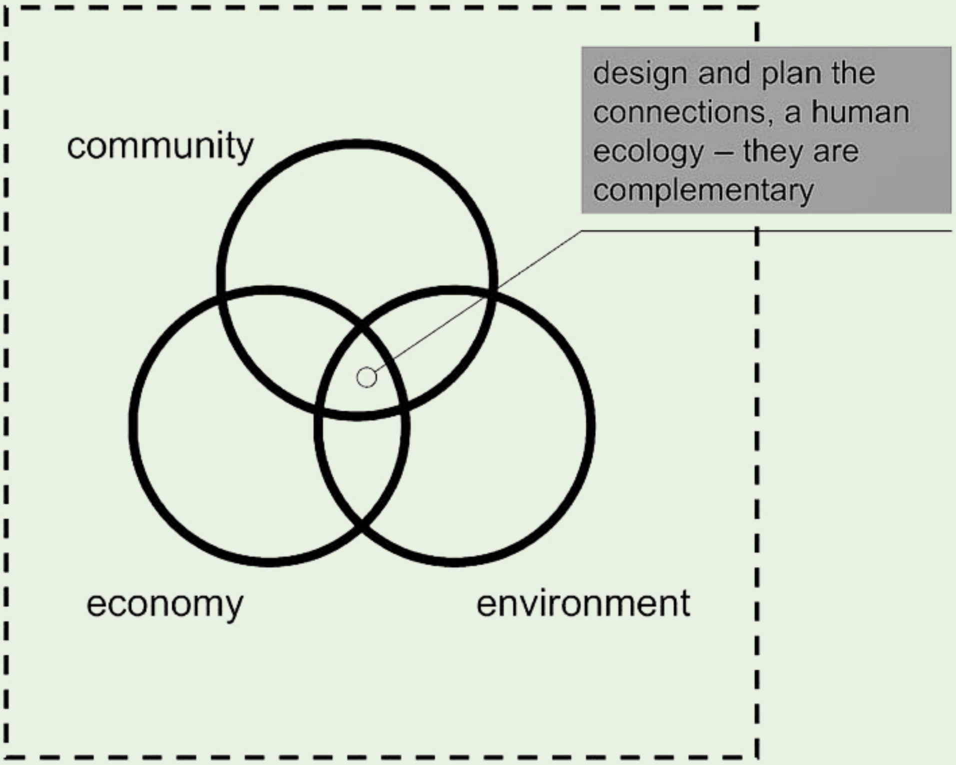
Indoor environmental quality refers to the quality of a building's environment in relation to the health and wellbeing of those who occupy space within it. Indoor environmental quality is determined by many factors, including lighting, air quality, and damp conditions. Indoor environments are highly complex and building occupants may be exposed to a variety of contaminants (in the form of gases and particles) from office machines, cleaning products, construction activities, carpets and furnishings, perfumes, cigarette smoke, water-damaged building materials, microbial growth (fungal, mold, and bacterial), insects, and outdoor pollutants. Other factors such as indoor temperatures, relative humidity, and ventilation levels can also affect how individuals respond to the indoor environment. An ecological architect should be able to understand the sources of indoor environmental contaminants and control them.

Pollution and Waste Management

Pollution and the growing volumes of solid and hazardous wastes are major threats to the environments and sustainable development of the world. The lack of controls on chemicals and the lack of capacity for managing pollutants threaten to undermine the quality and health of vulnerable ecosystems. An ecological architect should understand the impact of pollution and waste management during and after the construction on the local and regional level.

5.4 What can an architect learn from ecological systems?

Typically, sustainability is illustrated as three intersecting circles connecting community, economy, and the environment. But the overwhelming majority of problems, issues, and corresponding solutions are, like ecology, three-dimensional. As three dimensional problem solvers, architects are well suited to lead the change toward sustainability. That architects are three-dimensional problem solvers is central to the resolution of nonlinear, spatial problems. Most professions do not work this way, and most people do not think spatially. The three spheres of sustainability, much like the three elements in Vitruvius' (An ancient Architect) Principles—firmness, commodity, and delight—must be solved simultaneously, and spatial thinkers are best at doing that. Since these spatial relationships are essential and connected parts of sustainable design, spatial thinkers are best equipped for the challenge, responsibility, and stewardship of multidimensional solutions.



Design is a powerful process, and as such, when it is informed by the knowledge gleaned from truly sustainable systems, design has the potential of changing how buildings, communities, and societies function. Design has the power of both satisfying a need and providing value. The unsustainable approaches to designing and building energy-consumptive structures must evolve to place-based energy and self-sufficient designs, and they need to evolve rapidly.

Design and designers are at a unique position in history globally. Design can, within this next generation, illustrate that architects and planners are not only agents of the change toward sustainability but quite possibility the most central and effective agents for making this change happen. With upward of 40 percent of the energy consumed in the World directly related to a building or community's location (planning), its construction (design), and maintenance (design), the reduction of negative impacts would be substantial and the benefits would be significant.

5.5 How an ecological understanding of systems may contribute to architectural design?

Remarkably few cities or municipalities have development plans for the next 10 years, not to mention for the next 100 years. Yet any neighborhood, town, or city that wants to assure the quality of its future must actively design and plan for that quality, or it will not happen. Design and planning, in part, mean that proactive steps are being taken to assure that something necessary and desired will happen. Sustainable planning assures that the changes that occur will be desired and powered by sustainable energies and resources.

Most pollution problems can be abated by redesigning the source of the pollution or by distributing the pollutant to existing natural-system processes that use the pollution as part of their energy and nutrient requirement. Thinking of design as a systems problem challenges the designer to define the problem or scope as a process of reconnecting or looking for possible connections and compatibilities. The complexity of today's problems has increased as the population has increased, so multidimensional thinkers need to give form and pattern to multiple issues and solve them simultaneously.

As the design professions adopt sustainable design—design a chair, design a good chair, design a great chair, or design a sustainable chair—the thinking changes as well. Although the object is the same, the objective and process are considerably different. The same is true of designing a sustainable building or community. How the architect defines the problem and understands his or her responsibility to solve it dramatically impacts the design process and, consequently, the solution.

5.6 How can an architect contribute to a sustainable world?

At a time when the known nonrenewable reserves of fossil fuel are getting more costly to tap, producing less net energy and producing harmful global warming, it is prudent to start designing structures and communities that function well without them.

As energy costs soar, fossil fuel–powered comfort, water availability, transportation, and food will become less available and affordable—impacting the cost and functioning of everything. Since less net energy, coupled with the associated pollution and health issues, is the apparent future for nonrenewable-energy use, it poses a compelling challenge: how to design structures that are powered by renewables on the site and region and how to design into the project the ability to fully function without nonrenewables.

Three scalar elements should be considered in the initial design process:

- Connectivity: Design to reinforce the relationship between the project, the site, the community, and the ecology. Make minimal changes to the natural system functioning. Reinforce and steward those natural characteristics specific to the place.
- Indigenous: Design with and for what has been resident and sustainable on the site for centuries.
- Long life, loose fit: Design for future generations while reflecting past generations.

5.7 What worked in the past, what is working now and what might work in the future?

Just over fifty years ago the concept of ‘sustainable architecture’ would have been inconceivable. The issues were simply absent from the agenda. Indeed at that time we stood on the threshold of the period when the most resource-consuming structures in the entire history of building were about to be constructed. Across the globe buildings that were reliant on energy-hungry mechanical systems within sealed envelopes, with permanent artificial lighting and air-conditioning, began to replace the historic dominance of daylight and natural ventilation as the essential mode of environmental provision. The same period, however, saw the modest beginnings of a counter-view of the environmental nature of architecture. In this the emphasis was upon establishing a more deliberate link between buildings and the ambient environment. Such design is known as ‘low-energy’, ‘passive solar’, 'energy-conscious’, ‘green’, among other titles, and, as the movement has grown, a substantial body of significant works now exist designed by a growing band of ecological architects.

Rating systems for Sustainable Buildings

Rating systems have been developed to measure the sustainability level of Green Buildings and provide best-practice experience in their highest certification level. With the given benchmarks, the design, construction and operation of sustainable buildings will be certified. Using several criteria compiled in guidelines and checklists, building owners and operators are given a comprehensive measurable impact on their buildings’ performance. The criteria either only cover aspects of the building approach to sustainability, like energy efficiency, or they cover the whole building approach by identifying performance in key areas like sustainable site development, human and environmental health, water savings, materials selection, indoor environmental quality, social aspects and economical quality.

Furthermore, the purpose of rating systems is to certify the different aspects of sustainable development during the planning and construction stages. The certification process means quality assurance for building owners and users. Important criteria for successful assessments are convenience, usability and adequate effort during the different stages of the design process. The result of the assessment should be easy to communicate and should be showing transparent derivation and reliability.

How do the regional, urban, and architectural scales work as a system?

It is up most important for the architect to ask the following questions and able to not only understand but also answer them.

Site to Region:

- What are the relevant urban, agricultural, and natural characteristics of the project site?
- What cultural and economic assets exist?
- What are the climate characteristics of the bioregional system that have formed the general attributes of the biome?
- What role do natural disasters have as part of the land use, climate, and geological region, and what impact do they have on the design and post-disaster planning?

Site to Site:

- What is the relationship between the site and its neighboring site, specifically in terms of context, scale, view corridors, materials, geometric relationships, neighborhood characteristics, and proportions that can inform your building?
- What are all the usable relationships derived from the site and environmental analysis that can be introduced into your design?
- What microclimates are present, and how do they inform design choices?
- What are the vegetation types and the soil and water retention characteristics? How do they impact temperature, air movement, and humidity on the site?
- What parts of the site's microclimate related to seasonal and diurnal changes are impacted by adjacent land uses?

Site to Architecture:

- What are the synergistic relationships between the site's climate and those of human needs and comfort?

- Is the microclimate of the site approaching human-comfort zones and meeting user needs (e.g., the air movement and humidity and temperature levels)? Chart the times of the year when special adjustments need to be made in air movement and temperature to provide interior comfort and suggest interventions to effect comfort.
- What are the areas of the site's microclimate (e.g., ground temperature for thermal-mass storage for heating or cooling the space) that can be introduced into the design solution?

Where to start in terms of ecology and architecture?

If the imperative is to be sustainable, the design program for buildings and communities is simple. The projects should meet the following criteria:

- Be developed within existing urban boundaries and within walking distance to transit options. New projects would preferably be built on a cleaned-up brownfield.
- Use green energy and be unplugged from nonrenewables.
- Be fully useful for intended function in a natural disaster, a blackout, or a drought.
- Be made of materials that have a long and useful life—longer than its growth cycle—and be anchored for deconstruction (every design should be a storehouse of materials for another project).
- Use no more water than what falls on the site.
- Connect impacts and wastes of the building to useful cycles on the site and in the environment around it. Be part of a cycle.
- Be compelling, rewarding, and desirable.

The following questions should be asked of designs to gauge a project's sustainability:

- Is the project accessible without fossil fuel?
- Did the project improve the neighborhood?
- If the climate outside is comfortable, does the design take advantage of this free sustainable comfort?
- If there is sufficient daylight, do the lights remain on? Do they have to?
- Does the storm water flow into an engineered underground system, or does it stay on the site for future needs while improving the natural system microclimate and pedestrian experience?
- Is irrigation done with pumped chlorinated–potable water?

- Are the toilets usable when the power is off?
- Is there sufficient natural ventilation?
- Is comfort personally controlled?

There are limits to all resources. Technological solutions often cause problems greater than those they were intended to solve, requiring additional cleanup, storage of toxic materials, and additional taxes to pay for such services.

To achieve an interactive network of humanity and nature—a landscape that has a place for both the needs of humans and the functions of nature—planning and design must reorient itself from using more to the view that there are limits. It then becomes the combined mission of science, planning, and design to discover these limits and work within them, to put form to a common vision and to develop incremental steps and strategies on how to get from here to there.

5.8 Best Practices, Case Studies

The drive towards sustainability in the built environment represents both a challenge and an opportunity for architects. It is something we simply cannot ignore. Our buildings are responsible for almost half of our global carbon footprint and they are dependent upon the world's natural resources.

As architects we know that good design improves our quality of life, in all areas of work, rest and play and impacts on our health. Our work as professionals seeks to create a healthy built environment which enhances the environment, society and our economy. This is a long term aim for a long-term project. We need to build, collect and share knowledge and experience right now. International and European policy, as well as forward-thinking policy makers, are driving a rapidly moving sustainability agenda. We need to gain and maintain skills to stay abreast of legislative changes vital for the years ahead and for the future of our planet. Following are case studies from around the world, which integrate systems for the practice of ecological architecture.

5.8.1 Steinhude Sea Recreation Facility

The Steinhude Sea Recreation Facility on Bath Island is a recreational island facility, located on the largest freshwater lake in Northern Germany. This is a forty-six thousand square meter island for recreation and nature preservation. As part of Expo 2000, the local community chose to add a solar-powered facility with a small boat dock for solar-powered recreational boats. In fact most of the building's roof form is clad in photovoltaic. The building is small. Its services include public toilets, lifeguard facilities, a small café, a small observation deck, boat storage for the lifeguards, and a generator for supplemental power for the kitchen.

Energy self-sufficiency is achieved with photovoltaic panels, solar hot water collectors, a seed-oil-fueled cogeneration micro turbine, day lighting, natural ventilation, passive solar design, building automation, and high-performance materials. These systems provide complete lighting and power needs for the building, as well as enough energy to recharge a fleet of eight photovoltaic-powered rental boats, with excess electricity to sell back to the utility grid. Other sustainability features include gray water reuse and rainwater harvest systems, sustainable materials, and waste reduction.

The facility was a Top Ten Green Building selected by the American Institute of Architects. The island ecosystem consists of a beach area, green fields, a nature walk, a children's play area, and a bird sanctuary. This project aesthetically synthesizes the island's recreation and vacation culture.

5.8.2 Chicago Center for Green Technology

The Chicago Center for Green Technology is a 3,200 m² US Green Building Council LEED Platinum certified building located on a plot of 69,000 m² in Chicago's East Garfield Park Community built to showcase green technologies. This was the first municipal and brownfield site to win a LEED Platinum award.

The Chicago Center for Green Technology uses about 40% less energy than a building of the same size due to the multiple ways it gathers and conserves its energy. Solar panels on the roof, on awnings around the building, and an array of solar panels in a lot behind the building provide 20% of the building's energy. Passive heating is provided by large double-paned and insulated glass windows that also provide large amounts of light. Another source of heat or air-conditioning, depending on what season it is, comes from 28 vertical wells beneath the building that go to a depth of 70m, at which point the temperature is relatively constant. Water is pumped down the wells and then extracted, which helps cool the building in the summer and heat it in the winter. A smart lighting system throughout the building detects the amount of natural light and adjusts the amount of light provided by electricity. Scrap cork flooring and recycled glass bathroom tiles make up part of the building materials, which come from more than 40% recycled material.

The Center for Green Technology has a green roof, which consists of 76 mm of soil and plant matter. The green roof helps to absorb rainwater and insulate the building. Rainwater is released from downspouts into the soil, as opposed to the public sewer system, in order to reduce the amount of run-off contaminants in the sewers. The landscaping around the building is irrigated with rain water that is stored in cisterns, which helps reduce the amount of treated water from the city.

5.8.3 Federal Environmental Agency, Dessau Germany

The Offices for the Federal Environmental Agency present a case study for sustainable building. Located near the main train station in the home of modern movement Bauhaus, this project reinforces modern concepts of design and aesthetic. It was built on a contaminated brownfield with curved stripes of building snaking around. The prefabricated wood facade panels are stacked between multicolored shades and glazing. An elaborate structure of aluminum louvers and motorized vents in the central public space interrupts this environmentalist design with a new concept for environmental sustainability, using machinery and metal to lessen our footprint. This project melds Bauhaus modernism with sustainable and green design.

Active and passive strategies for the reduction of energy consumption and carbon dioxide production are realized in an architecture that combines spatial and material economy with a deliberate stimulation of the senses. The location in a former industrial area was selected to demonstrate the possibilities (and challenges) presented by a brownfield site. Contaminated land has been treated, and both a small existing railway station and a former gas appliance factory were integrated into the complex. The overall form of the new building was designed such that a large portion of the site remains accessible to the citizens of Dessau as a public park.

The new building is entered via the “Forum”, a crescent-shaped space that draws the park into the building and acts as a link between the public areas, including a library and a lecture hall. The offices are then accessed through a landscaped, covered atrium, around which the various departments of the Agency are arranged. The new building combines a compact volume and a high degree of thermal insulation with strategies of intelligent engineering and the use of renewable energy sources. In particular, it benefits from the use of a large geothermal heat exchange system and solar panels. Building materials were chosen according to their ecological suitability, the most visible element being a panel façade made entirely of timber, which is prototypical for Germany.

5.8.4 Kiowa County Schools

Following the devastating tornado that destroyed its town and schools, Unified School District 422 chose a bold strategy to combine its schools into a single K–12 facility that would retain a distinct identity for each school function: elementary, middle and high school. The design utilizes a highly flexible, sustainable approach that constantly maintains a student-centered focus.

The design reinforces this rural community's sustainable comprehensive master plan by placing the school's front door along Main Street. The building is organized around a courtyard gathering space for all ages. The north wing houses the high school and gymnasiums. The south wing houses the lower-school curricula, which are zoned to identify their unique characteristics. The plan maximizes daylight and natural ventilation to positively impact student performance. The new school serves as a major community focal point, a catalyst for future buildings, and a tool to promote student health, productivity and enhanced learning. The school itself serves as an active teaching tool and has been integrated into the curriculum.

In direct alignment with the town's Sustainable Comprehensive Master Plan, the USD decided to rebuild to LEED Platinum. This decision led the way for the city, which later mandated that all public buildings attain a Platinum rating. This K–12 facility combines the resources of three rural community school districts into a single facility, thereby right-sizing at a regional scale.

The USD understood the importance of day lighting for increasing student academic performance and focus, so the design optimizes day lighting and natural ventilation in all classrooms. Separate zones for kindergarten and elementary, middle, and high school grades allow students the unique learning and social opportunities that each age group requires. The design also integrates the students in key ways in order to build a sense of community, encourage mentoring, and instill a desire for achievement.

The school has a variety of community-use spaces to encourage social involvement. Fitness and athletic spaces meet the larger community's social and recreational needs. Spaces that accommodate adult education and senior citizens' activities are included as well. The program is fully optimized beyond school hours because it connects this small rural community by serving as a centralized community meeting place.

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