Environmental Geology
Chapter 1: PHILOSOPHY and FUNDAMENTAL CONCEPTS

- **Earth's Place in Space –** Approx. 12 to 14 billion years ago-the Big Bang occurred. Approx. 7 billion years ago a Supernova began the process of the creation of the solar system and the Earth formed 4.56 (Approx. 4.6) billion years ago as particles condensed from a spinning cloud of dust and gas (also known as the "Nebular Hypothesis").

- **Earth History -** Change has occurred over time: 3.5 billion years ago life begins to form. Fossil record shows that life has changed over time; sometimes gradually with extinction of species, and sometimes with major/mass extinctions of many species at the same time- Possibly caused by climate/environment changes or catastrophic events (e.g. asteroid impacts)

- **New "Kids" on the Block**
  We are the "new kids". Humans have only been around for about 0.0004% (1-2 million years) of the time that Earth has been in existence.

- **Global Warming and Cooling** - There have been many periods of global cooling and warming. Global warming has occurred **naturally** since the end of the last ice age, but is likely to have increased due to **human activities** (e.g., burning of fossil fuels) in the last 200 years from the release of carbon dioxide and other **greenhouse gases.**

- **What is Geology?** *Geology* is the study of the materials (rocks, minerals), structures (mountains, valleys, continents), and processes (volcanism, earthquakes, erosion) that occur on and within the Earth, and of the history of Earth and its *biosphere – the sum total of all living organisms on Earth*

- **James Hutton** (1785) "father of geology": **Earth as a superorganism** (e.g. water=blood & oceans=heart)

- **James Lovelock**: revives James Hutton's idea 200 years later with the **Gaia Hypothesis** (Gaia=Greek goddess Mother Earth), which provides a global perspective on the environment-stimulates interdisciplinary research on how Earth works. It states that Earth is a dynamic living organism with complex and inter-related subsystems, that life significantly affects Earth's environment, life modifies the environment for the betterment of life, and life deliberately or consciously controls the global environment

- **The "Environment"** is a complex system with physical, biological, geological, ecological, and geopolitical aspects. Studying it requires multidisciplinary research (e.g. Environmental geology, environmental chemistry, global climate change, biological diversity and ecosystems, environmental economics, environmental ethics, environmental law, etc)

- **Environmental Crisis** - *Deforestation*, *strip mining*, and *overdevelopment of water resources* has led to environmental crises throughout the world. The major problem is not one of entirely "destroying the Earth", but rather of destroying the *quality* of Earth environment w.r.t. humans (and other large organisms). Example: Over stripping of the resources of Easter Island by people during the ~1000 years they lived there led to a societal collapse that left the island uninhabitable due to lack of resources. This is a stark reminder of what could happen on a global scale if we don't learn to be better stewards of our environment.

  - **Why environmental geology?** Earth is a source for habitats and resources, and there is a geologic aspect in every environmental problem. **Environmental geology** is "applied geology" and *a branch of environmental science. The goals are to* better understand environmental problems, use geologic knowledge for problem solving, minimize environmental degradation, to resolve conflicts related to land use, and optimize the use of resources to maximize environmental benefits for the society. Main areas of study include, Earth Materials, Hazards, Land Use Planning and Environmental Impact, Hydrologic Processes, and Mountain building, erosion and deposition (piling up of sediments) processes

  - **Human Population Growth – The #1 Environmental Problem**
    Population "time bomb": Exponential growth - There are over 7 billion people on Earth now. The growth rate (G) is measured as a percentage, and the doubling time (D) is calculated:
    D = 70/G
    - Example: At 2% growth rate, the population would double in 35 years (70/2=35)
    - Current doubling time is about 50 years
    - Example: At 2% growth rate, the population would double in 35 years (70/2=35)

- **Earth's carrying capacity limited –**We are probably nearing the ***carrying capacity*** (perhaps ~10-15 billion population). The **carrying capacity** is the maximum population Earth can hold without causing environmental degradation that reduces the ability of the planet to support the population. As we use more resources, we need more land space, & generate more waste. The Earth is the only suitable habitat for the forseeable future & resources are limited.

4 big reasons for the high rate of growth

1. **Agriculture**
2. **Modern Medicine**

3. **Sanitation**
4. **Energy Resources**

- **Is there reason for hope?** Annual increase in population peaked in the 1980s. Currently, the annual increase is similar to 1970s levels**.**

- **Uneven growing pace and distribution**
By 2050 there will be 3 billion more people. Almost all of the growth is in developing countries. There is little access to, or use of, modern family planning methods in less developed countries. There is no easy answer to the population problems. However, education is paramount, especially woman's education. As people become more educated, the population growth rate tends to decrease. There is some good news. The rate of population growth is decreasing.
    - Africa: Home to a larger share of world population over next half century
    - Asia: Many nations over-populated
    - India, over one third of its population is under 15 years old
    - Likely the largest population by mid-century

- **Sustainability -** One definition: Development which ensures that future generations will have equal access to the resources our planet offers (or) using resources in ways that continue to supply our needs for the future.
    - **Sustainability involves using resources at a rate and in a manner that allows replenishment/replacement in ways that are not harmful to the environment, that increase the quality of life, and that are economically viable.**

    Requires careful resource allocation, large-scale development of new technology for resource use, recycling, and waste disposal. We must understand Earth's systems and how they change to solve environmental problems

- **Earth's Systems and Changes –** Earth is a dynamic system. There are two engines behind its dynamics: Internal and external (the Sun) heat sources. There are four interconnected subsystems that mutually adjust to one another, including the **Lithosphere, Atmosphere, Hydrosphere, and the Biosphere**-***the sum total of all living organisms on Earth.***

- **The Challenge** To predict how changes will occur that may be important to society, and how societal changes may feed back into these systems. Good urban planning will take such matters into account. Climate change, like **global warming**, is an example of this.

- **Open vs. Closed Systems – An open system** is a system through which matter and energy can flow freely (i.e., be added to and taken from)

  - How can we evaluate change in a system? Through tools like an Input-Output Analysis-analyzing change in an **open system**
    - Rates of change: Average residence time
      - T = S/F
        (T: residence time, S: total size of stock (e.g. pond or reservoir), F: average rate of transfer)

- ## Predicting Future Changes

  - **Uniformitarianism – James Hutton (1785**) came up with the idea that **the <u>present is the key to the past.</u>** Things that happen now have happened in the past. We can observe what occurs and look for evidence of what used to happen. And **t<u>he present is the key to the future.</u>** So, we can use what *is happening* to predict what *may happen.*
    Here are some examples of how this can be applied…..
    Rivers have flooded and will continue to flood. So, will paving change the magnitude or frequency? Or, landslides have occurred in an area in the past. So, will a new housing development be at risk/increase the risk of landslides

- **Geologic Processes are Typically Slow**
  Here are some examples:
  Mountain uplift – takes millions of years to build mountains several km high
  Erosion of land – takes millions to hundreds of millions of years to wear away a mountain range
  Creep of soil and rock downhill under pull of gravity - ~1000 years to move 1 m
  Coastal erosion – as high as 1 m/year
  Glacier flow – 1m/year – 1 m/day
  Lava flow – m's/day to m's/second
  River flow during flooding – m's/second
  Debris avalanche – 100s of km/hour
  Earthquake rupture; asteroid impact – 1 to 10s of km/second\

- **Things happen slowly…. Or do they?**
  - Geologic processes are slow….. However…..

  ✓ **Human activities may accelerate the rates of some processes**

Hazardous Earth Processes

In the past 20 years natural hazards have killed several million people (e.g. storms,floods,earthquakes,landslides, volcanic eruptions

- Annual loss of life: About 150,000
- Financial loss: ~ $20 billion

Here is an **emerging concept** - As a result of human activity (e.g. population increase, mining, agriculture, etc) disasters are becoming catastrophes.

In the past 20 Years there has been more life loss from a major natural disaster, particularly in a developing country (2003 Iran quake, ~30,000 people; 2004 Indonesian tsunami, ~280,000 people; 2005 Hurricanes Katrina+Rita, ~1,800 people). More property damage occurs in a more developed country (Iran quake, ~$0.5B; Katrina+Rita, ~$60B; 1995 Kobe (Japan) quake, ~$126Billion; 5,100 dead)

We use the Scientific Method to help solve problems– Steps in the method (from your textbook)

1. **Pose a question**
2. **Make observations (e.g. field or laboratory work)**
3. **Refine the question**
4. **Pose an answer (form a hypothesis)**
5. **Test the hypothesis**
6. **If your conclusion supports the hypothesis -> it is accepted and may become a theory**
7. **If it does not support the hypothesis -> form a new hypothesis and retest**

A theory is a well tested hypothesis

Precautionary Principle

Scientific certainty is not required to take a precautionary approach to a serious environmental problem (Example: Global Warming)
Scientific proof is not possible in dealing with many environmental problems
Leads to a proactive approach with an emphasis on environmental unity (one action causes a chain or series of effects) – Extremes in either direction prevent progress on issues.

Why is Solving Environmental Problems So Difficult?

- **Changes in conditions may occur rapidly**
- **Lag time between when a change happens and when it is recognized as a problem.**
- **Environmental problems tend to be complex**
- **Some changes are of irreversible nature (e.g., extinctions)**
- **Remediation may be *slow* and *very expensive***
- **Remediation can be inconvenient**
- **And finally ....We are not far removed (in time) from cave people!**

Solutions we choose to solve environmental problems depend on how we **value** people and the environment can be tricky, since our genetics are essentially identical to ice-age hunter/gatherers, and many of our core attitudes evolved then/there.

What is environmental risk? We all have different perceptions of what constitutes a risk to us. Public attitude toward risks can vary from NIMBY (not in my backyard) to BANANA (build absolutely nothing, anywhere, near anyone). Public acceptance of risks is related to our everyday lives and what we are willing to live with. We all have a threshold for living with dangers that face us every day. Public awareness of environmental risks can help us make good planning decisions, e.g., floodplain development, waste disposal, and take collective actions, including anticipatory measures and mitigation planning.

Land ethic – We are citizens and caretakers, not just conquerors, of the environment, and should work to preserve it. This is a new idea within the past century or so. The creation of our national parks, monuments, forests, and wilderness areas are examples of applying this land ethic.

WSE 8/2012 …….. Revised 12/2015