

## Quick Overview of Environmental Science

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## Environment: the total of our surroundings

- All the things around us with which we interact:
  - Living things
    - Animals, plants, forests, fungi, etc.
  - Nonliving things
    - Continents, oceans, clouds, soil, rocks
  - Our built environment
    - Buildings, human-created living centers
  - Social relationships and institutions

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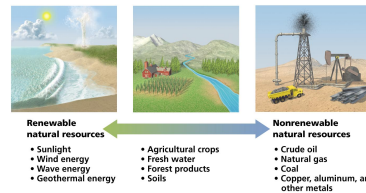
## Humans and the world around us

- Humans change the environment, often in ways not fully understood
- We (and all life) depend completely on the environment for survival
  - Increased wealth, health, mobility, leisure time
  - But, natural systems have been degraded
    - i.e., depletion, pollution, erosion and species extinction
  - Environmental changes threaten long-term health and survival
- **Environmental science** is the study of:
  - How the natural world works
  - How the environment affects humans (and other life forms) and vice versa

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## Natural resources: vital to human (& all life) survival

**Natural resources** = substances and energy sources needed for survival and other uses

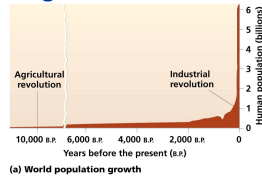


- **Renewable resources:**
  - Perpetually available: sunlight, wind, wave energy
  - Renew themselves over short periods: timber, water, soil, hot springs
  - These can be destroyed if used faster than renewed (unsustainably)
- **Nonrenewable resources:** can be depleted
  - Oil, coal, minerals, ancient ground water, some soil

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## Global human population growth

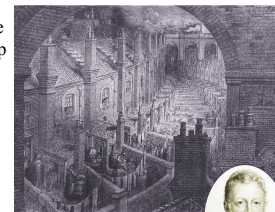
- More than 6.7 billion humans
- Why so many humans?
  - Agricultural revolution
    - Stable food supplies
  - Industrial revolution
    - Urbanized society powered by fossil fuels
    - Sanitation and medicines
    - More food
  - Humans learned to completely dominate and control the environment for their own purposes



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## Thomas Malthus and human population

- Thomas Malthus (1766-1834)
  - Population growth must be restricted, or it will outstrip food production
  - Starvation, war, disease
- Neo-Malthusians
  - Population growth has disastrous effects
  - Paul and Anne Ehrlich, *The Population Bomb* (1968)
- 200 years later still hasn't happened; wrong or yet to come?



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## Question

Which is closest to your sense or viewpoint?

- A. Human population will continue to grow; technology will solve problems that arise (cornucopian viewpoint)
- B. Human population will continue to grow; disaster will occur with many deaths (Neo-Malthusian viewpoint)
- C. Humans will learn to control our population; standards of living will continue to increase
- D. Humans will learn to control our population, but somewhat too late; standards of living will decline
- E. Other, or no viewpoint at this time

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## Garrett Hardin's Tragedy of the Commons (1968)

- Example of cows grazing on common meadow
- Resource users will increase use until the resource is gone
- => Unregulated exploitation leads to resource destruction
- Applies to any common ownership: e.g. Soil, air, water, forests, fish, buffalos
- Basically privatizes profit and socializes loss!
- Solution?
  - Governmental regulations?
  - Private ownership?
  - Voluntary organization to enforce responsible use?

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## The "ecological footprint" (aka "ecological Impact")

- The environmental impact of a person or population
  - Amount of land, water, air, energy, etc. used
  - for both raw materials and to dispose/recycle waste
- **Problem:** humans have surpassed the Earth's capacity



*We are currently using more of the planet's resources than are available on a sustainable basis!*

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## Environmental science

... can help us avoid mistakes made by past civilizations.



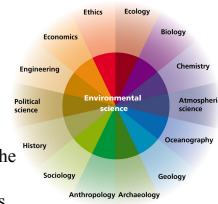
*The lesson of Easter Island: people may have annihilated their culture by destroying their environment. (or maybe Europeans killed them?!) Can we act more wisely to conserve our resources or are we doomed?*

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## Environmental science: how does the natural world work?

Environment ← impacts → Humans

- It has an applied goal: developing solutions to environmental problems
- An interdisciplinary field
  - Natural sciences: information about the world
    - Environmental Science programs
  - Social sciences: values and human behavior
    - Environmental Studies programs



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## What is an "environmental problem"?

- The perception of what constitutes a problem varies between individuals and societies
- Ex.: DDT, a pesticide
  - In developing countries: welcome because it kills malaria-carrying mosquitoes
  - In developed countries: not welcome, due to health risks



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## Environmental science is not environmentalism

### •Environmental science

- The pursuit of knowledge about the natural world
- Scientists must remain objective: be willing to change their minds when facts demand it



### •Environmentalism

- A social movement dedicated to protecting the natural world

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## The nature of science

### • Science:

- A systematic process for learning about the world and testing our understanding of it
- A dynamic process of observation, testing, and discovery
- The accumulated body of knowledge that results from this process

### • Science is essential

- To sort fact from fiction
- Develop solutions to the problems we face

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## Applications of science

Policy decisions and management practices



(a) Prescribed burning

Restoration of forest ecosystems altered by human suppression of fire

Technology



(b) Methanol-powered fuel-cell car  
Energy-efficient methanol-powered fuel cell car from DaimlerChrysler

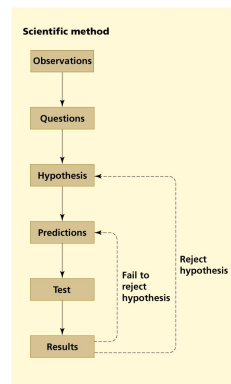
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## The scientific method

### • A technique for testing ideas with observations

### • Assumptions:

- The universe works according to unchanging natural laws
- Events arise from causes, and cause other events
- We use our senses and reason to understand nature's laws



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## Not obvious assumptions hold!

- So many things in life seem unpredictable and not caused by anything
- Over 400 years humans have found some things that are predictable and governed by understandable laws: these are the subject of science. Other things (e.g. ethics/politics) are not.
- Mathematics is the main modeling tool: numbers are key, testability is key, reproducibility is key

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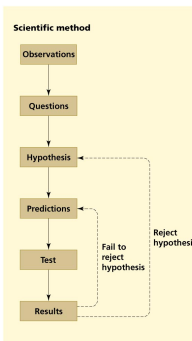
## The scientific method

• A scientist makes an **observation** and asks **questions** of some phenomenon

• The scientist formulates a **hypothesis**, a statement that attempts to explain the scientific question.

• The hypothesis is used to generate **predictions**, which are specific statements that can be directly and unequivocally **tested**.

• The test **results** either support or reject the hypothesis; scientists must be willing to give up their ideas when experiments show they are wrong.

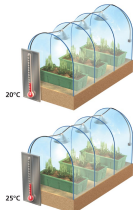


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## Experiments test the validity of a hypothesis

**Manipulative experiments** yield the strongest evidence (can prove causality)

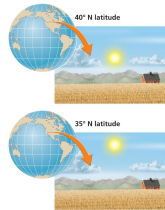
- But, lots of things can't be manipulated



(a) Manipulative experiment

**Natural or correlational tests** show real-world complexity

- Causality not proven so much more evidence needed. Counter-examples are important.

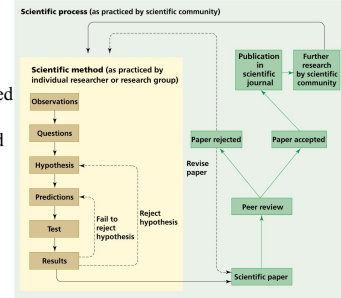


(b) Natural experiment, or correlational study

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## The scientific process is part of a larger process

- The scientific process includes peer review, publication, and debate
- A consistently supported hypothesis becomes a **theory**, a well-tested and widely accepted explanation
- With enough data, a **paradigm shift** – a change in the dominant view – can occur



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## Science is an amazing human development

- Allows life work of genius's to be recorded and used as a starting point for next generation of scientists
- Has moved us far, far beyond the experience and capability of an individual
  - Electronics, lasers, MRI, DNA, radio, space craft, airplanes, modern medicine, atomic bomb, GPS, etc., etc.
- Allows us to prove true and gain acceptance for even extremely unpopular or dangerous (to ruling power) ideas
  - Earth not center of universe, humans arose from evolution, plate tectonics, etc., etc.

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## Question

- ♦ Are scientists subject to the same political/belief biases as the rest of the population?

- A. Yes
- B. No
- C. Other
- 

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## Question

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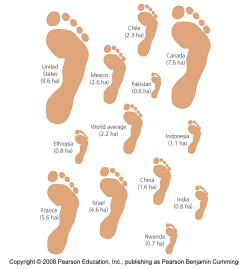
## Drivers of the problems: Population & consumption

- Human population growth at root of most environmental problems
  - *The growth rate has slowed, but we still add more than 200,000 people to the planet each day*
- Our consumption of resources has risen even faster than our population growth.
  - Life has become more pleasant for us so far
  - However, rising consumption amplifies the demands we make on our environment.

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### Ecological footprints are not all equal

- The ecological footprints of countries vary greatly
  - The U.S. footprint is almost 5 times greater than the world's average
  - Developing countries have much smaller footprints than developed countries
  - Example: U.S. uses 25% of the world's energy, but only contains 5% of the people. We use 5 times our "fair" share of energy.



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### Methods of the Past have not been optimal

- Input is amount of resources used (causes depletion)
- Output is waste afterward (usually causes pollution)
- In the past effort has focused on dealing with output since pollution/toxics has been main concern. Increasing input was taken for granted as standards of living rose.
- In future reducing input may be best method: reduces both depletion and pollution. But will comfort level of humans go down?
- Conflict between developing and developed regions.

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### We face challenges in agriculture

- Expanded food production led to increased population and consumption
- It's one of humanity's greatest achievements, but at an enormous environmental cost
  - Nearly half of the planet's land surface is used for agriculture (most non-sustainably)
    - Chemical fertilizers
    - Pesticides
    - Erosion
    - Changed natural systems

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### We face challenges in pollution

- Waste products and artificial chemicals used in farms, industries, and households



*Each year, millions of people die from pollution; Many species are being depleted or driven to extinction; ecosystems destroyed*

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### We face challenges in climate

- Science has firmly concluded that humans are changing the composition of the atmosphere
- The Earth's surface is warming
  - Melting glaciers
  - Rising sea levels
  - Impacted wildlife and crops
  - Increasingly destructive weather

*Since the Industrial Revolution, atmospheric carbon dioxide concentrations have risen by 37%, to the highest level in 650,000 years; science says this must change the climate; and the worst is yet to come.*

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### We face challenges in biodiversity

- Human actions have driven many species extinct, and biodiversity is declining dramatically
  - We are at the onset of a mass extinction event



*Biodiversity loss may be our biggest environmental problem; once a species is extinct, it is gone forever*

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## The Millennium Ecosystem Assessment

- A comprehensive scientific assessment of the condition of the world's ecological systems
- Major findings:
  - Humans have drastically altered ecosystems
  - These changes have contributed to human well-being and economic development, but at a cost
  - Environmental degradation could get much worse
  - Degradation can be reversed, but it requires much work
- Check out [www.millenniumassessment.org](http://www.millenniumassessment.org)

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## Our energy choices will affect our future

- The lives we live today are due to fossil fuels
  - Machines
  - Chemicals
  - Transportation
  - Products
- Fossil fuels were created millions of years ago and are a one-time bonanza; supplies will certainly decline

*We have used up 1/2 of the world's oil supplies; how will we handle this imminent fossil fuel shortage?*

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## Sustainable solutions exist

- Thinking long term, we should develop solutions that enable both our quality of life and the environment
- Organic agriculture
- Technology
  - Reduces pollution
- Biodiversity
  - Protect species
- Waste disposal
  - Recycling
- Alternative energy/fuels



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## Are things getting better or worse?

- Many people think environmental conditions are better
  - **Cornucopians:** Human ingenuity will solve any problem
- Some think things are much worse in the world
  - **Cassandras (aka neo-malthusians):** predict doom and disaster
- How can you decide who is correct?
  - Are the impacts limited to humans, (or just your nation? Are other organisms or systems involved?)
  - Are the proponents thinking in the long or short term?
  - Are they considering ALL the costs and benefits?

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## Sustainability: a goal for the future

- How can humans live within the planet's means?
  - Humans cannot exist without functioning natural systems
- **Sustainability**
  - Leaves future generations with a rich and full Earth
  - Conserves the Earth's natural resources
  - Maintains fully functioning ecological systems
- **Sustainable development:** the use of resources to satisfy current needs without compromising future availability of resources
  - May require substantial changes to the ways things are done; but humans have made many large changes in the past ( horses to cars, end of slavery, women's rights, electronic communication<sub>2</sub>, etc.)

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## But how to move towards sustainability?

- Humans seem never to have done it! (tragedy of the commons)
- Idea: Regulations requiring paying true costs (e.g. fees for clean-up, carbon dioxide emission, habitat destruction, resource depletion, etc., adjusted to motivate change (how to set prices and avoid black markets?))
- Idea: Policies to change technologies, reduce usage, substitute resources with less impact (e.g. solar energy, recycled paper, local agriculture, home insulation, etc.)
- Policies to reduce human population (e.g. educate women, reduce poverty, make contraceptives available)
- Individual efforts (do they matter? Example of redwood)
- Will these things happen? Will they be enough?

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## Conclusion

- Environmental science helps us understand our relationship with the environment and informs our attempts to solve and prevent problems.
- Identifying a problem is the first step in solving it
- Solving environmental problems can move us towards health, longevity, peace and prosperity
  - Environmental science can help us find balanced solutions to environmental problems

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## QUESTION: Review

The term “environment” includes

- a) Animals and plants
- b) Oceans and rivers
- c) Soil and atmosphere
- d) All of the above are included in this term

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## QUESTION: Review

Adding various amounts of fertilizer to plants in a laboratory is a \_\_\_\_\_ type of experiment

- a) Correlative
- b) Natural
- c) Manipulative
- d) Rare

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## QUESTION: Weighing the Issues

Which do you think is the best way to protect commonly owned resources (i.e., air, water, fisheries, forests)?

- a) Sell the resource to a private entity
- b) Voluntary organizations to encourage responsible use
- c) Governmental regulations to enforce responsible use
- d) Don't do anything rash; let nature run its course

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## QUESTION: Weighing the Issues

Do you think the rest of the world can have an ecological footprint as large as the footprint of the United States?

- a) Yes, because we will find new technologies and resources
- b) Yes, because the footprint of the United States is not really that large
- c) Definitely not; the world does not have that many resources
- d) It does not matter; it's not that important

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1. A large piece of ordinary paper is folded in half 45 times. How thick is it after folding?

- A. 2 inches
- B. 2 feet
- C. 2 miles
- D. 2 million miles

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2. Do you consider yourself a cornucopian or a neo-Malthusian?

- A. Cornucopian
- B. Neo-Malthusian
- C. In between
- D. Don't know
- E. Don't care

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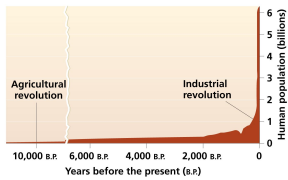
3. For a theory to be "scientific" it must

- a. be proven true
- b. be testable, i.e. be able to be proven false
- c. be widely accepted by the majority of the population
- d. be widely accepted by the majority of other scientists
- e. be able to explain a wide variety of phenomena

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### QUESTION: Interpreting Graphs and Data

According to this graph, what has happened to the population over the last 500 years?

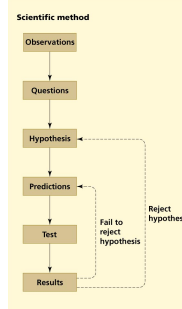


- a) It has grown exponentially
- b) It has grown linearly
- c) It has decreased
- d) It has slowed down recently

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### QUESTION: Interpreting Graphs and Data

What happens if test results reject a hypothesis?



- a) The scientist formulates a new hypothesis
- b) It shows the test failed
- c) The hypothesis was supported
- d) The predictions may not have been correct

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### QUESTION: Review

Which of the following is correct about the term "environmentalism"?

- a) It is very science-oriented
- b) It is a social movement to protect the environment
- c) It usually does not include advocacy for the environment
- d) It involves scientists trying to solve environmental problems

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