

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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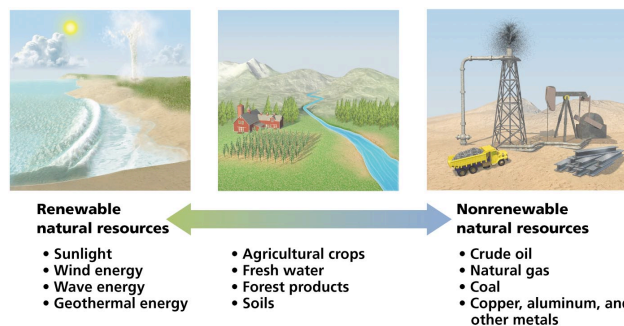
Humans and the world around us

- 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

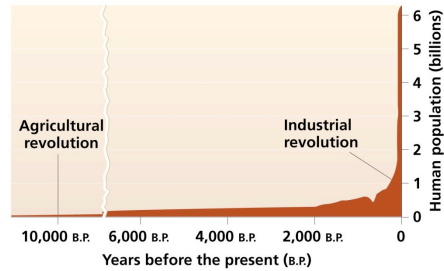


- **Renewable resources:**
 - Perpetually available: sunlight, wind, wave energy
 - Renew themselves over short periods: timber, water, soil, hot springs
 - These can be destroyed if used faster than renewed (unsustainably)
- **Nonrenewable resources:** can be depleted
 - Oil, coal, minerals

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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



(a) World population growth

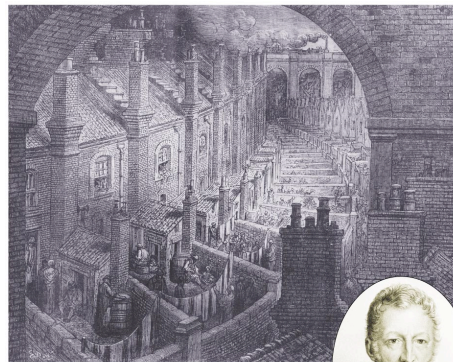


(b) Urban society

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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?



(a) 18th-century London, England



(b) Thomas Malthus

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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.



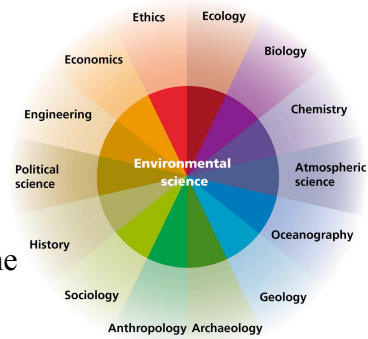
The lesson of Easter Island: people may have annihilated their culture by destroying their environment. (or maybe Europeans killed them?!). Can we act more wisely to conserve our resources or are we doomed?

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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

Technology



(b) Methanol-powered fuel-cell car

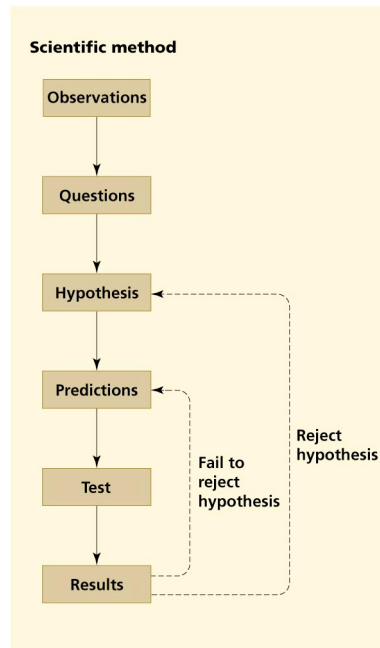
Energy-efficient methanol-powered fuel cell car from DaimlerChrysler

Restoration of forest ecosystems altered by human suppression of fire

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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



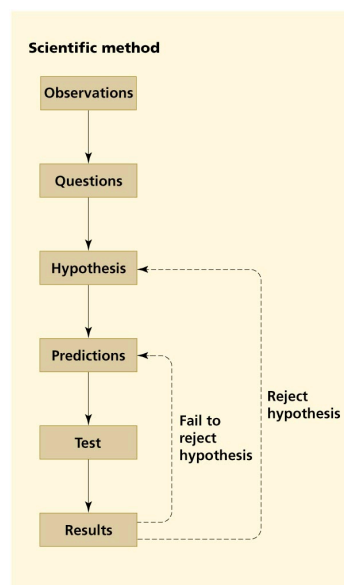
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Not obvious assumptions hold!

- 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



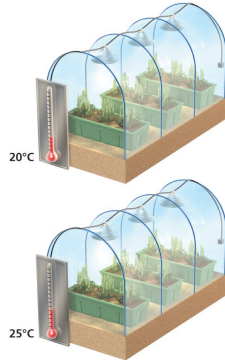
- A scientist makes an **observation** and asks **questions** of some phenomenon
- The scientist formulates a **hypothesis**, a statement that attempts to explain the scientific question.
- The hypothesis is used to generate **predictions**, which are specific statements that can be directly and unequivocally **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)

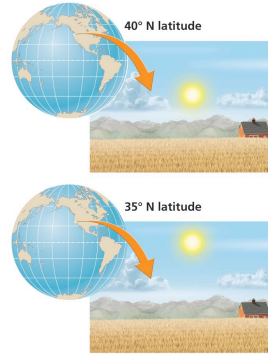
- But, lots of things can't be manipulated



(a) Manipulative experiment

Natural or correlational tests show real-world complexity

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

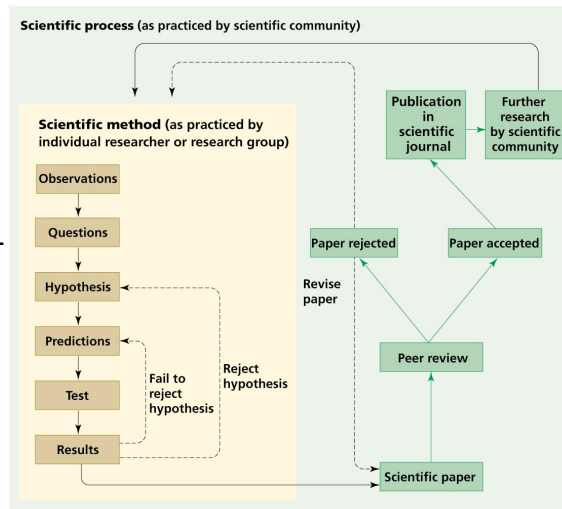


(b) Natural experiment, or correlational study

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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

◆ Is science subject to the same political/belief biases as the rest of the population?

- A. Yes
- B. No
- C. Other
-
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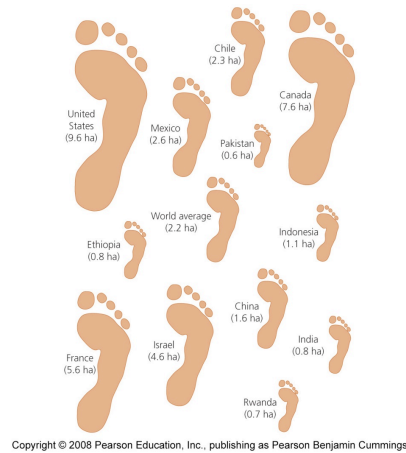
Drivers of the problems: Population & consumption

- 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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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 probably 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

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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 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, 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



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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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: Review



What is the definition of “sustainable development”?

- a) Using resources to benefit future generations, even if it means lower availability now
- b) Letting future generations figure out their own problems
- c) Using resources to satisfy current needs without compromising future availability
- d) Letting each country decide what is its best interest

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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

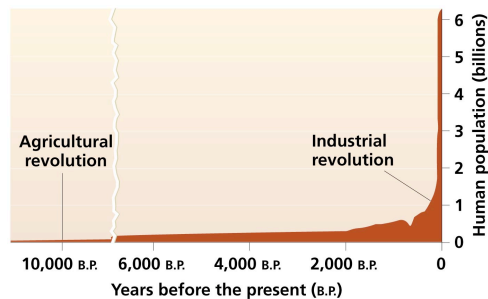
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3. For a theory to be "scientific" it must
- a. be proven true
 - b. be testable, i.e. be able to be proven false
 - c. be widely accepted by the majority of the population
 - d. be widely accepted by the majority of other scientists
 - e. be able 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?

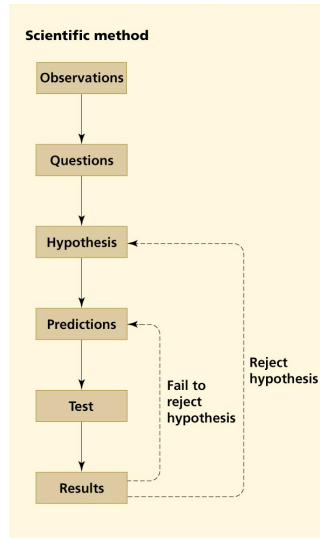


(a) World population growth

- 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