

# Chapter 1

## An Introduction to Environmental Science

PowerPoint® Slides prepared by  
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ENVIRONMENTAL  
ESSENTIAL

THIRD EDITION

THE  
SCIENCE  
BEHIND  
THE  
STORIES

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# This lecture will help you understand:

- The meaning of the term environment
- The importance of natural resources
- That environmental science is interdisciplinary
- The scientific method and how science operates
- Some pressures facing the global environment
- Sustainability and sustainable development



# Environment: the total of our surroundings

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

# Humans exist within the environment

- Humans exist within the environment and are part of nature.
  - Our survival depends on a healthy, functioning planet.
- The fundamental insight of environmental science is that we are part of the natural world.
  - Our interactions with its other parts matter a great deal.

# Humans and the world around us

- Humans depend completely on the environment for survival.
  - Enriched and longer lives, increased wealth, health, mobility, leisure time
- But natural systems have been degraded
  - 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 vice versa
- With environmental problems come opportunities for solutions.

# Natural resources: vital to human survival

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



## Renewable natural resources

- Sunlight
- Wind energy
- Wave energy
- Geothermal energy



## Nonrenewable natural resources

- Crude oil
- Natural gas
- Coal
- Copper, aluminum, and other metals

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- **Renewable resources:**
  - Perpetually available: sunlight, wind, wave energy
  - Renew themselves over short periods of time: timber, water, soil
    - These can be destroyed
- **Non-renewable resources:** can be depleted
  - Oil, coal, minerals

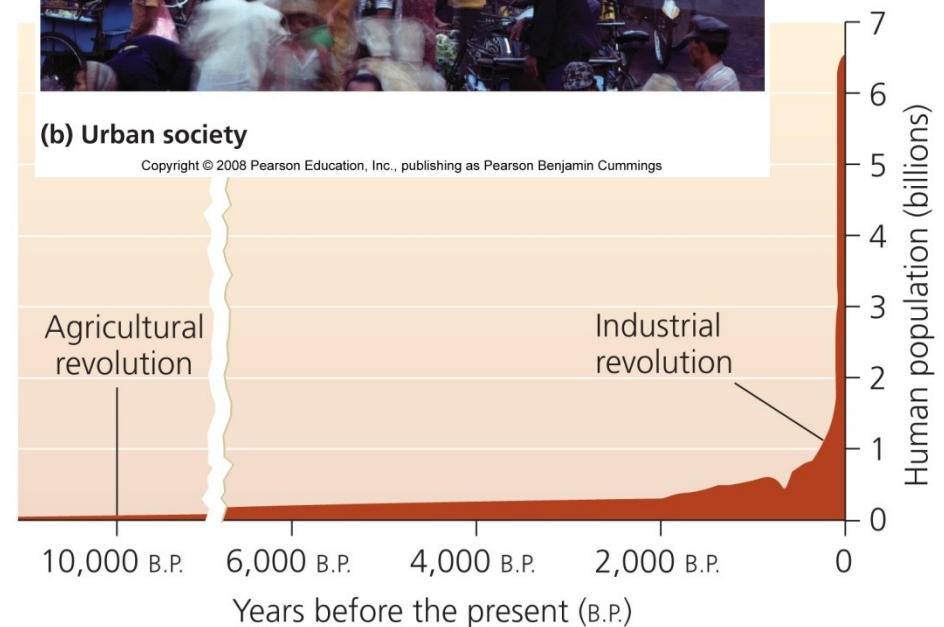
# Global human population growth

- 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



(b) Urban society

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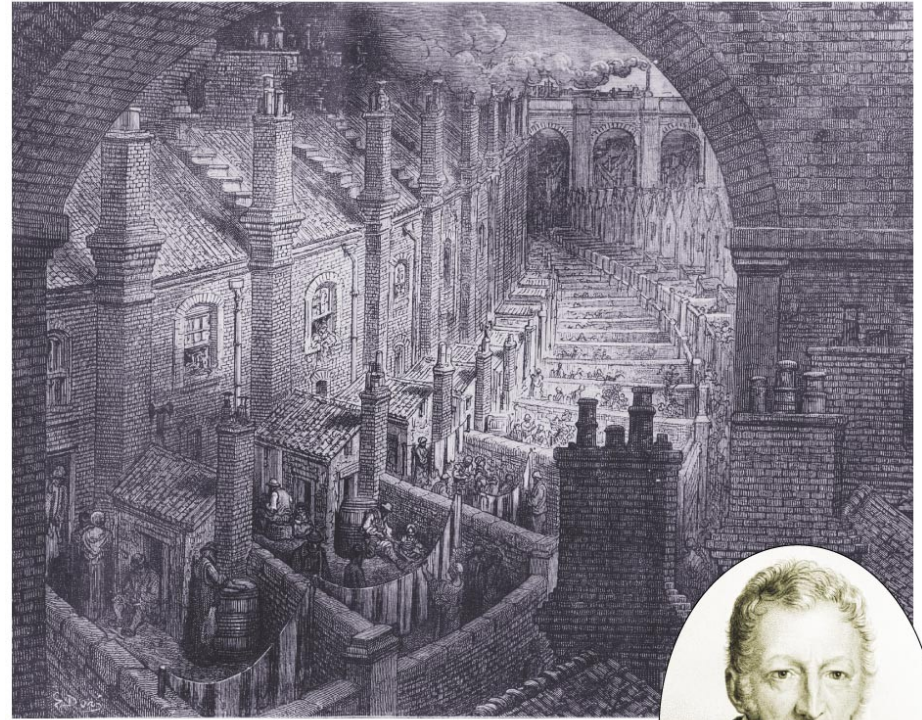


(a) World population growth

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# Thomas Malthus and human population

- Thomas Malthus
  - Population growth must be controlled, or it will outstrip food production.
  - Starvation, war, disease
- Neo-Malthusians
  - Population growth has disastrous effects.
  - Paul and Anne Ehrlich, *The Population Bomb* (1968)
  - Agricultural advances have only postponed crises.



(a) 18th-century London, England



(b) Thomas Malthus



# Resource consumption exerts impacts

- Garret Hardin's "tragedy of the commons" (1968)
  - Unregulated exploitation causes resource depletion
    - Grazing lands, forests, air, water
  - No one has the incentive to care for a resource.
  - Everyone takes what he or she can until the resource is depleted.
- Solution?
  - Private ownership?
  - Voluntary organization to enforce responsible use?
  - Governmental regulations?

# The “ecological footprint”

- The environmental impact of a person or population
  - Amount of biologically productive land + water
  - For resources and to dispose/recycle waste
- **Overshoot:** humans have surpassed the Earth’s capacity to support us



*We are using 30% more of the planet’s resources than are available on a sustainable basis!*

# Environmental science

- Can help us avoid mistakes made by past civilizations
  - Human survival depends on how we interact with our environment.
  - Our impacts are now global.
  - Many great civilizations have fallen after depleting their resources.



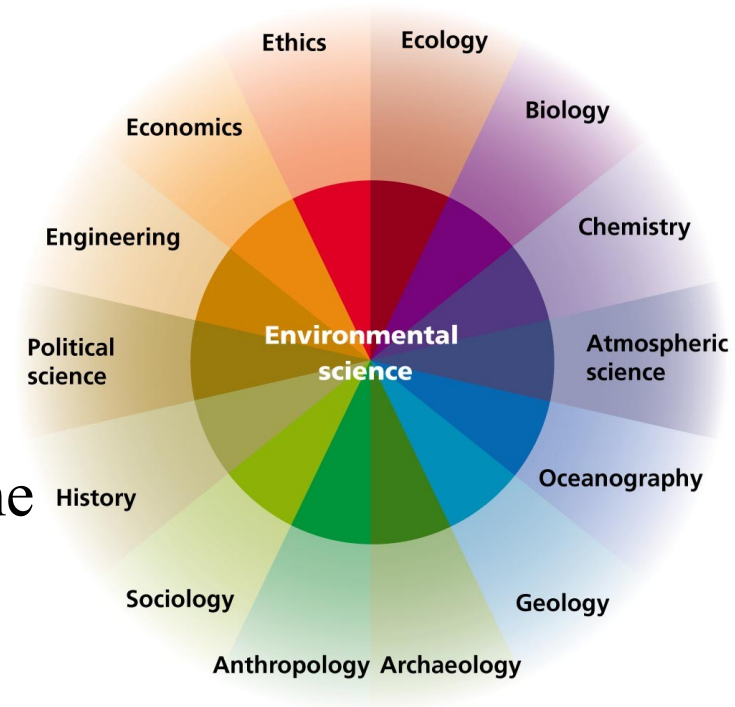
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*The lesson of Easter Island: people annihilated their culture by destroying their environment. Can we act more wisely to conserve our resources?*

# Environmental science: how the natural world works

Environment ← impacts → Humans

- Its goal: developing solutions to environmental problems
- An interdisciplinary field
  - Natural sciences: information about the natural world
    - Environmental Science programs
  - Social sciences: study human interactions and behavior
    - Environmental Studies programs



# Environmental science is not environmentalism

## • Environmental science

- The pursuit of knowledge about the natural world
- Scientists try to remain objective

## • Environmentalism

- Environmental activism
- A social movement dedicated to protecting the natural world



# The nature of science

- **Science:**
  - A systematic process for learning about the world and testing our understanding of it
  - The accumulated body of knowledge that results from a dynamic process of observation, testing, and discovery
- Science is essential:
  - To sort fact from fiction
  - Develop solutions to the problems we face

# 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*

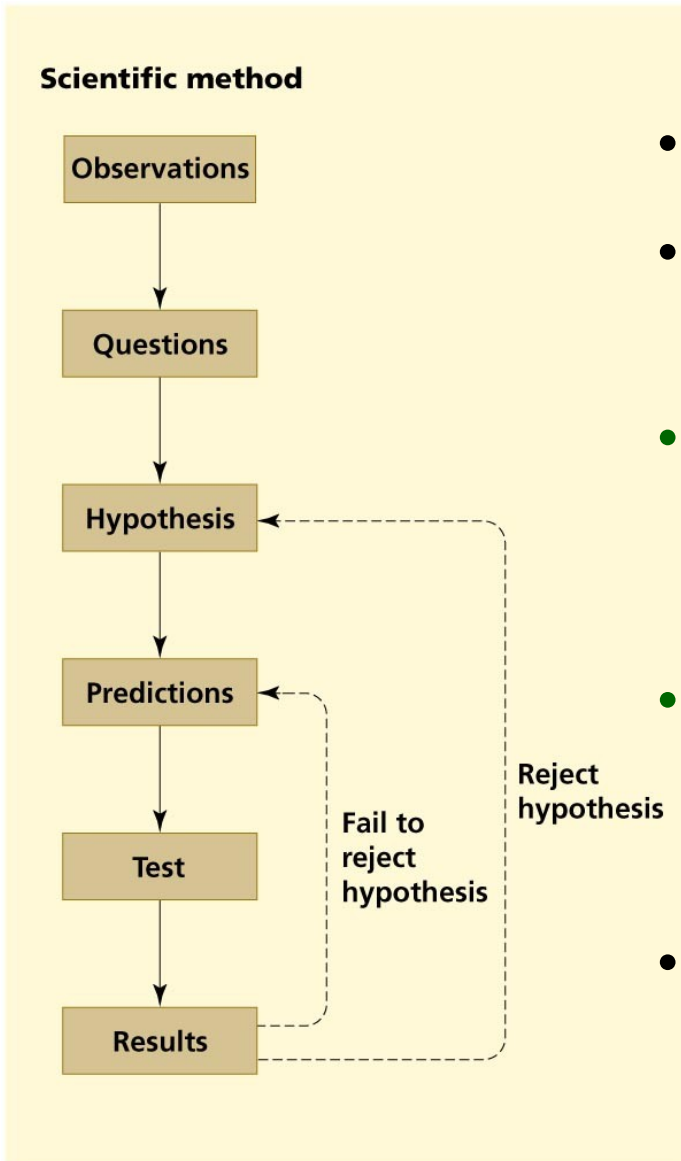
*Restoration of forest ecosystems altered  
by human suppression of fire*

# Scientists test ideas

- Scientists examine how the world works by observing, measuring, and testing
  - Involves critical thinking and skepticism
- **Observational (descriptive) science:** scientists gather information about something not well known or that cannot be manipulated in experiments
  - Astronomy, paleontology, taxonomy, molecular biology
- **Hypothesis-driven science:** research that proceeds in a structured manner using experiments to test hypotheses through the scientific method



# The scientific method



- A technique for testing ideas
- A scientist makes an **observation** and asks **questions** of some phenomenon.
- The scientist formulates a **hypothesis**, a statement that attempts to answer the question.
- The hypothesis is used to generate **predictions**: specific statements that can be **tested**.
- The **results** support or reject the hypothesis.

# Testing predictions

- **Experiment:** an activity that tests the validity of a hypothesis
- **Variables:** conditions that can be manipulated and/or measured
  - **Independent variable:** a condition that is manipulated
  - **Dependent variable:** a variable that is affected by the manipulation of the independent variable
- **Controlled experiment:** one in which all variables are controlled
  - **Control:** the unmanipulated point of comparison
  - **Treatment:** the manipulated point of comparison
- **Data:** information that is generally quantitative (numerical)

# Experiments test the validity of a hypothesis

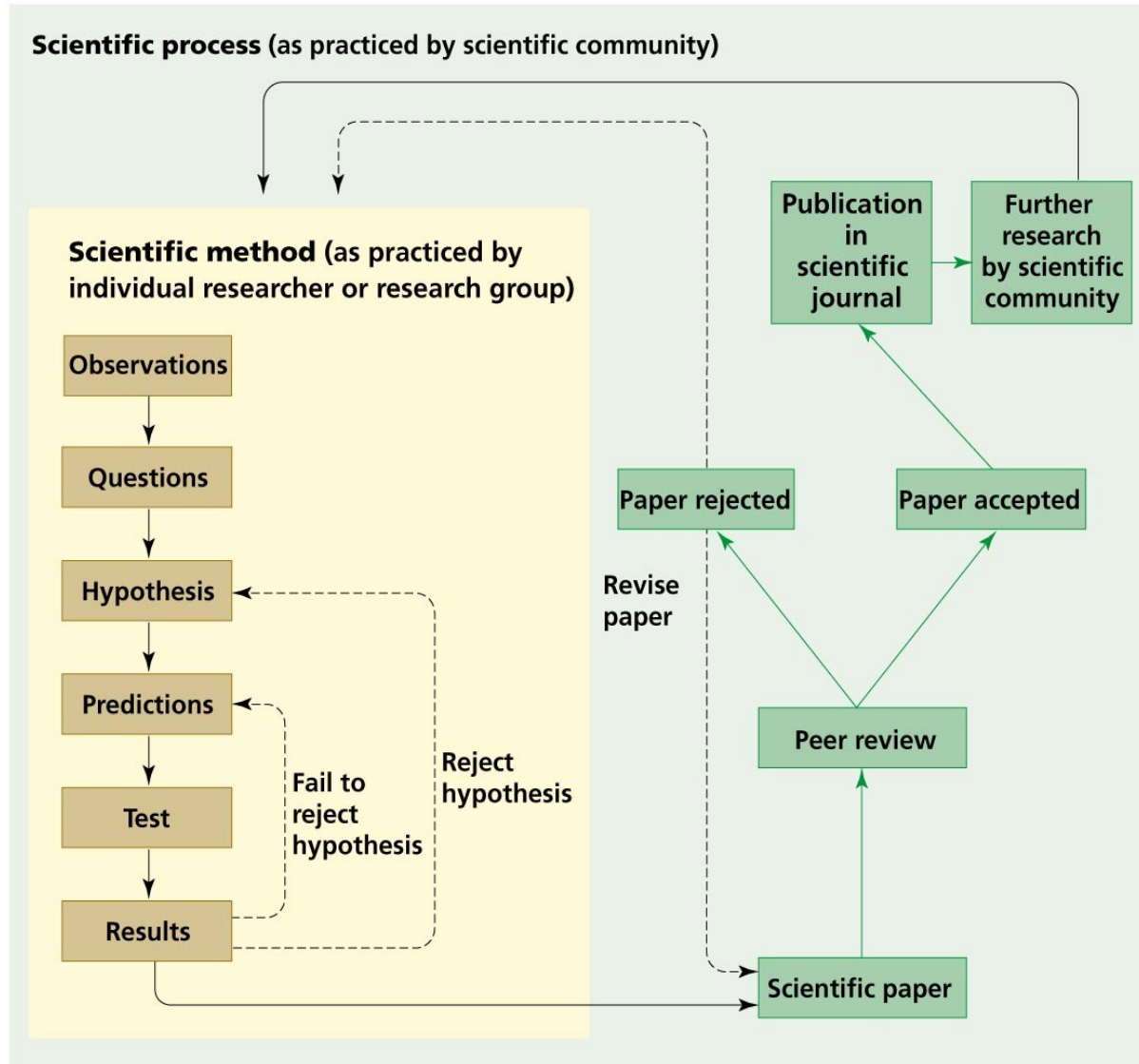
- **Manipulative experiments** yield the strongest evidence
  - Provides the strongest type of evidence
  - Reveal causal relationships: changes in independent variables cause changes in dependent variables
  - But many things can't be manipulated: long-term or large-scale questions (i.e., global climate change)
- **Natural** experiments show real-world complexity
  - Only feasible approach for ecosystem or planet-scale
  - Results are not so neat and clean, so answers aren't simply black and white

# The scientific process is part of a larger process

**Peer-review:** other scientists provide comments and criticism

- Guards against faulty science
- Conference presentations improve the quality of the science
  - Scientists interact with their colleagues
- Grants and funding come from private or government agencies.
  - Can lead to conflict of interest if the data show the funding source in an unfavorable light
  - The scientist may be reluctant to publish or doctor the results.

# The scientific community



# Theories and paradigms

- A consistently supported hypothesis becomes a **theory**, a widely accepted explanation of one or more cause-and-effect relationships
  - Has been extensively and rigorously tested, so confidence in a theory is extremely strong
    - Darwin's theory of evolution, atomic theory, cell theory, big bang theory, plate tectonics, general relativity
  - Differs from the popular meaning of theory, which suggests a speculative idea without much substance
- With enough data, a **paradigm shift** — a change in the dominant view — can occur.

# Ethics

- **Ethics:** the study of good and bad, right and wrong
  - The set of moral principles or values held by a person or society that tells us how we ought to behave
  - People use criteria, standards, or rules when making judgments.
  - Different cultures or worldviews lead to different values, which lead to different actions.
- **Relativists:** ethics vary with social context
- **Universalists:** right and wrong remains the same across cultures and situations

# Ethical standards

- **Ethical standards:** criteria that help differentiate right from wrong
  - Classical standard = virtue
  - The golden rule: treat others as you want to be treated
  - **Utility:** something right produces the most benefits for the most people



# Environmental ethics

- **Environmental ethics:** application of ethical standards to relationships between human and non-human entities
  - Hard to resolve; depends on the person's ethical standards
  - Depends on the person's domain of ethical concern

Should we conserve resources for future generations?

Is it OK to destroy a forest to create jobs for people?

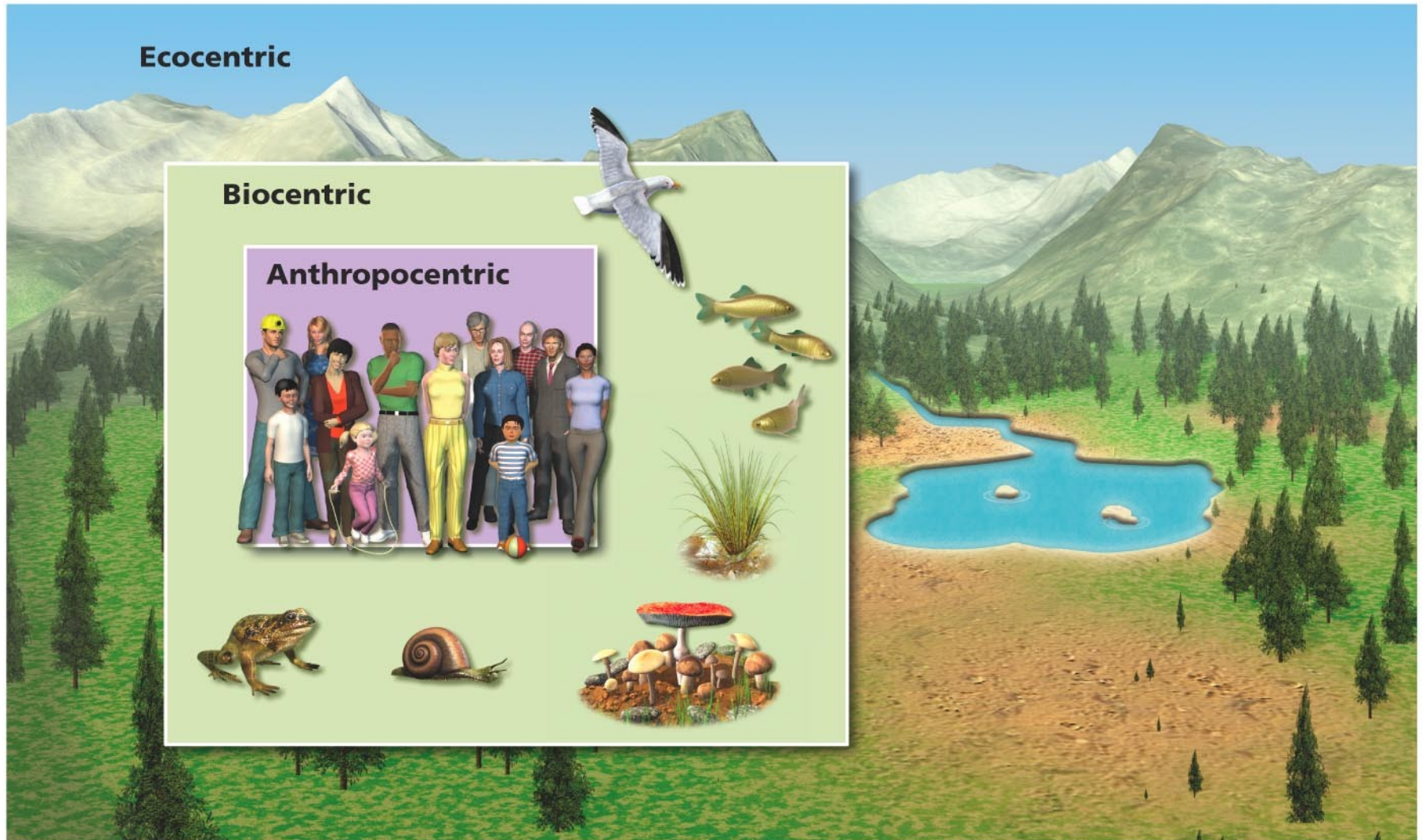
Should we drive other species to extinction?

Is it OK for some communities to be exposed to excess pollution?

# Three ethical perspectives

- **Anthropocentrism:** only humans have rights
  - Costs and benefits are measured only according to their impact on people
  - Anything not providing benefit to people has no value
- **Biocentrism:** certain living things also have value
  - All life has ethical standing
  - Development is opposed if it destroys life, even if it creates jobs
- **Ecocentrism:** whole ecological systems have value
  - Values the well-being of species, communities, or ecosystems
  - Holistic perspective, stresses preserving connections

# Expanding ethical consideration



# The preservation ethic



- Unspoiled nature should be protected for its own inherent value.
  - We should protect our environment in a pristine state, because it promotes human happiness and fulfillment.
  - John Muir (*right, with President Roosevelt at Yosemite National Park*) had an ecocentric viewpoint.

# The conservation ethic



- Use natural resources wisely for the greatest good for the most people
  - A utilitarian standard that calls for prudent, efficient, and sustainable resource extraction and use
  - Gifford Pinchot had an anthropocentric viewpoint.

# The land ethic



- Healthy ecological systems depend on protecting all parts.
  - Aldo Leopold believed that humans should view themselves and the land as members of the same community.
  - We are obligated to treat the land ethically.
  - The land ethic will help guide decision making.

# Ecofeminism

- In the 1960s and 1970s, feminist scholars saw parallels in how people treated nature and how men treated women.
  - Degradation, social oppression
- Ecofeminism: a patriarchal (male-dominated) society is a root cause of both social and environmental problems
  - Female worldview: interrelationships and cooperation
  - Male worldview: hierarchies, competition, domination, and conquest

# Environmental justice (EJ)

- Involves the fair treatment of all people with respect to the environment, regardless of race, income, or ethnicity
- The poor and minorities are exposed to more pollution, hazards, and environmental degradation.
  - Despite progress, significant inequalities remain.



*The U.S. has still not ratified the Basel Convention, which prohibits the international export of waste, particularly to poor nations.*



# Sustainability

- A guiding principle of environmental science
- Living within our planet's means
  - The Earth can sustain humans AND other organisms for the future
  - Leaving our descendants with a rich, full world
  - Developing solutions that work in the long term
  - Requires keeping fully functioning ecological systems

# Sustainability

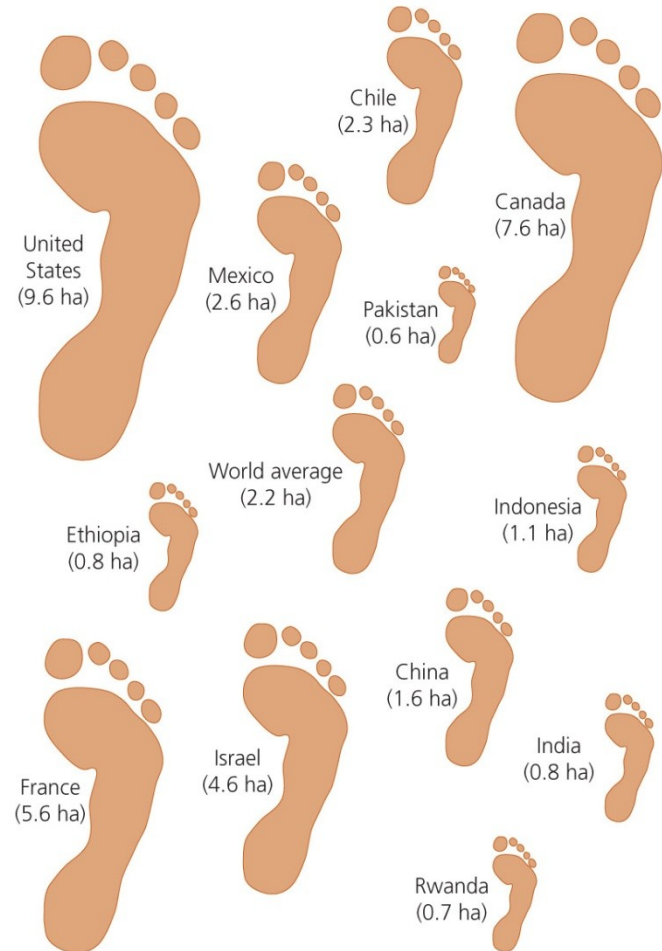
- We are increasing our burden on the planet each year.
  - Population growth, affluence, consumption
- **Natural capital:** the accumulated wealth of Earth
  - We are withdrawing our planet's natural capital 30% faster than it is being produced
- **Natural capital =** the accumulated wealth of Earth
  - We are withdrawing our planet's natural capital 30% faster than it is being produced.

# We are increasing our burden on the planet

- Human population growth amplifies all environmental problems
  - *The growth rate has slowed, but we still add over 200,000 people to the planet each day.*
- Our consumption of resources has risen even faster.
  - Life has become more pleasant for us so far.
  - However, rising consumption increases the demands we make on our environment.
  - The rise in affluence has not been equal. The gap between rich and poor has doubled in the past 40 years.

# Ecological footprints are not all equal

- The ecological footprints of countries vary greatly.
  - The U.S. footprint is much greater than the world's average.
  - Developing countries have much smaller footprints than developed countries.



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# The 2005 Millennium Ecosystem Assessment

- The most 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 work.

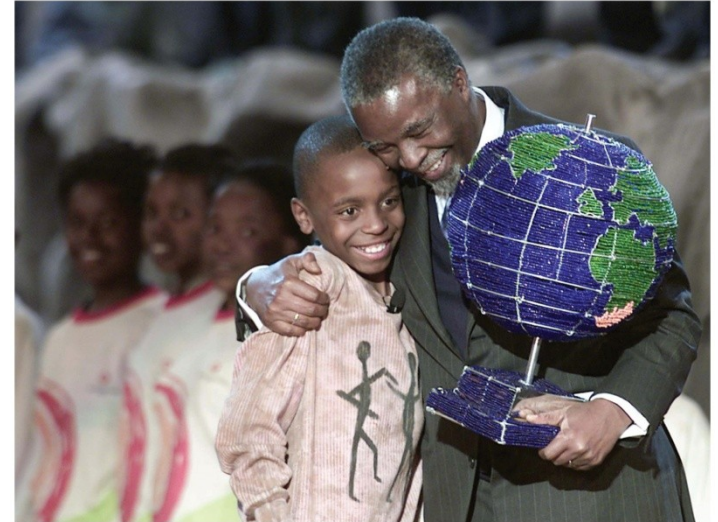
# Sustainable solutions abound

- **Sustainable development:** using resources to satisfy current needs without compromising future availability of resources
- Sustainability involves:
  - Renewable energy sources
  - Soil conservation, high-efficiency irrigation, organic agriculture
  - Pollution reduction
  - Habitat and species protection
  - Recycling
  - Fighting global climate change

*Humanity's challenge is to develop solutions that further our quality of life while protecting and restoring the environment.*

# Will we develop in a sustainable way?

- Sustainable solutions must meet:
  - Environmental goals
  - Economic goals
  - Social goals
- Requires that humans limit our impact while promoting economic well-being and social equity
  - Apply science to solve problems



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*The single most important question we face is: "Will we develop sustainably?"*

# Conclusion

- Finding ways to live sustainably on Earth requires a solid ethical grounding and scientific understanding of our natural and social systems.
- 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 toward health, longevity, peace, and prosperity.
  - Environmental science can help find balanced solutions to environmental problems.



# QUESTION: Review



The term “environment” includes:

- a) Living things, such as animals and plants
- b) Non-living things, such as rivers and soil
- c) Buildings and cities
- d) All of the above are included in this term

# QUESTION: Review



A Neo-Malthusian would say that predicted massive human starvation has not yet occurred because:

- a) Diseases have been eradicated
- b) Enough people are dying from war and conflict
- c) Agriculture has postponed massive starvation
- d) People are too dumb to limit their population growth

# QUESTION: Review



Which of the following is correct about the term “environmentalism”?

- a) It involves pursuing knowledge to understand the natural world.
- b) It is a social movement to protect the environment.
- c) It usually does not include advocacy for the environment.
- d) It requires trying to remain objective.

# QUESTION: Review



Which is the correct order of the scientific method?

- a) Observation, hypothesis, predictions, testing, results
- b) Hypothesis, observation, testing, predictions, results
- c) Observation, predictions, testing, results, hypothesis
- d) Predictions, observation, hypothesis, testing, results

# QUESTION: Review



An anthropocentric worldview would consider the impact of an action on:

- a) Plants only
- b) Animals only
- c) Humans only
- d) All living things
- e) All non-living things

# QUESTION: Review



Which ethic holds that resources should be wisely used?

- a) Preservation ethic
- b) Land ethic
- c) Conservation ethic
- d) Deep ecology
- e) Biocentrism

# 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) Letting each country decide what is its best interest
- d) Using resources to satisfy current needs without compromising future availability

# QUESTION: Weighing the Issues



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

- b) Sell the resource to a private entity
- c) Let organizations themselves decide if they want to participate in protecting the resource
- d) Enact governmental regulations
- e) Do nothing and see what happens



# QUESTION: Weighing the Issues



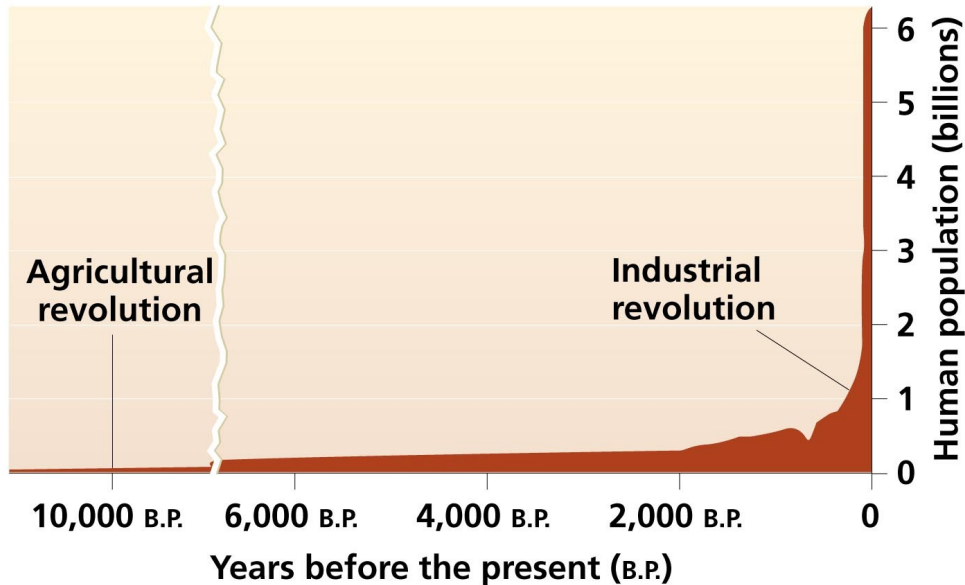
Do you think the rest of the world can have an ecological footprint as large as the footprint of the United States?

- a) Yes, because we will find new technologies and resources to overcome environmental problems.
- b) Yes, because the footprint of the United States is not really that large compared to other countries.
- c) Definitely not. The world does not have that many resources.
- d) It does not matter. It's not that important.

# QUESTION: Interpreting Graphs and Data



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



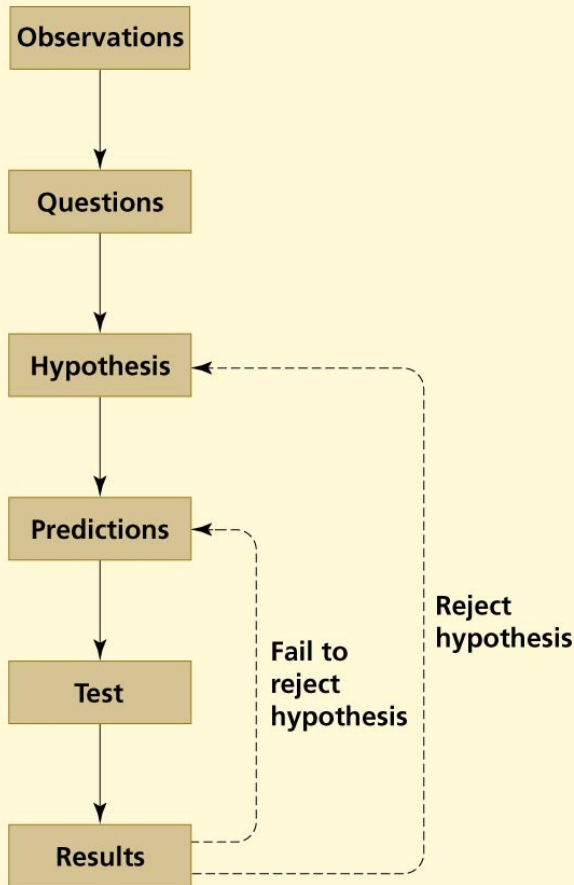
(a) World population growth

- a) It has grown enormously.
- b) It has grown slower than food production.
- c) It has decreased.
- d) It has slowed down recently.

# QUESTION: Interpreting Graphs and Data



## Scientific method



What happens if test results reject a hypothesis?

- c) The scientist formulates a new hypothesis.
- d) It shows the test failed.
- e) The scientist should be fired.
- f) The scientist used faulty data .