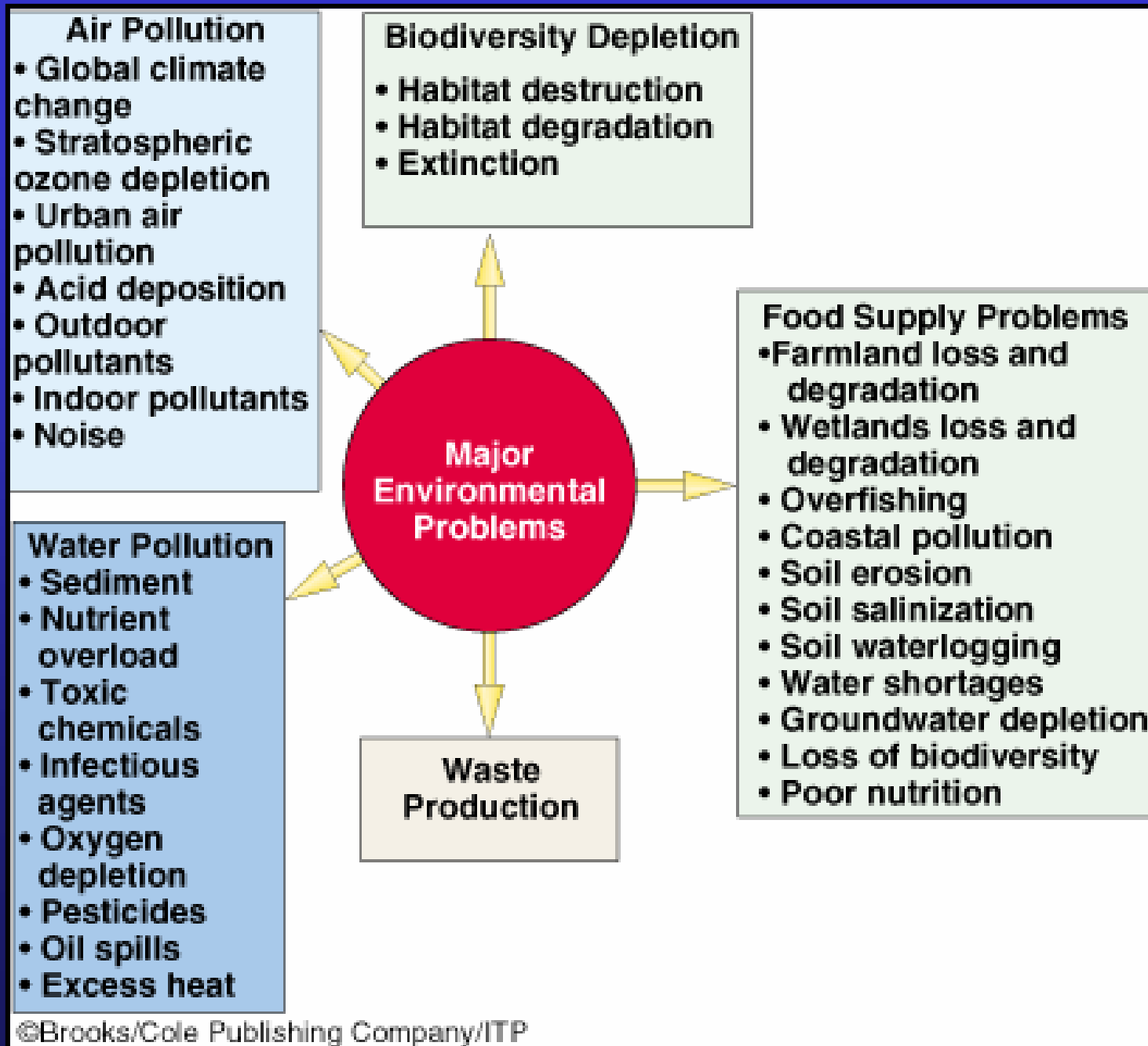


Environmental Problems, Their Causes, & Sustainability

tutorial by Paul Rich



OUTLINE

1 The Scope of Environmental Science

definitions, concepts, wealth gap

2 Resources

ecological vs. economic

renewable vs. non-renewable

3 Pollution

definitions, point vs. non-point sources

chemical nature, concentration, & persistence

4 Sustainability

cultural changes; scientific consensus

5 Problems & Their Causes

major problems, root causes; overpopulation; worldviews

1. Scope of Environmental Science

- **Environment** — all external conditions & factors that affect living organisms
- **Ecology** — study of the relationships between living organisms & their environment
- **Environmental Science** — interdisciplinary study of the role of humans on the Earth

Major Fields of Study That Contribute to Environmental Science

Biology is the study of living organisms.

Zoology is the study of animals.

Botany is the study of plants.

Microbiology is the study of microorganisms.

Ecology is the study of how organisms interact with their environment and each other.

Earth science is the study of the Earth's nonliving systems and the planet as a whole.

Geology is the study of the Earth's surface, interior processes, and history.

Paleontology is the study of fossils and ancient life.

Climatology is the study of the Earth's atmosphere and climate.

Hydrology is the study of Earth's water resources.

Physics is the study of matter and energy.

Engineering is the science by which matter and energy are made useful to humans in structures, machines, and products.

Chemistry is the study of chemicals and their interactions.

Biochemistry is the study of the chemistry of living things.

Geochemistry, a branch of geology, is the study of the chemistry of materials such as rocks, soil, and water.

Social sciences are the study of human populations.

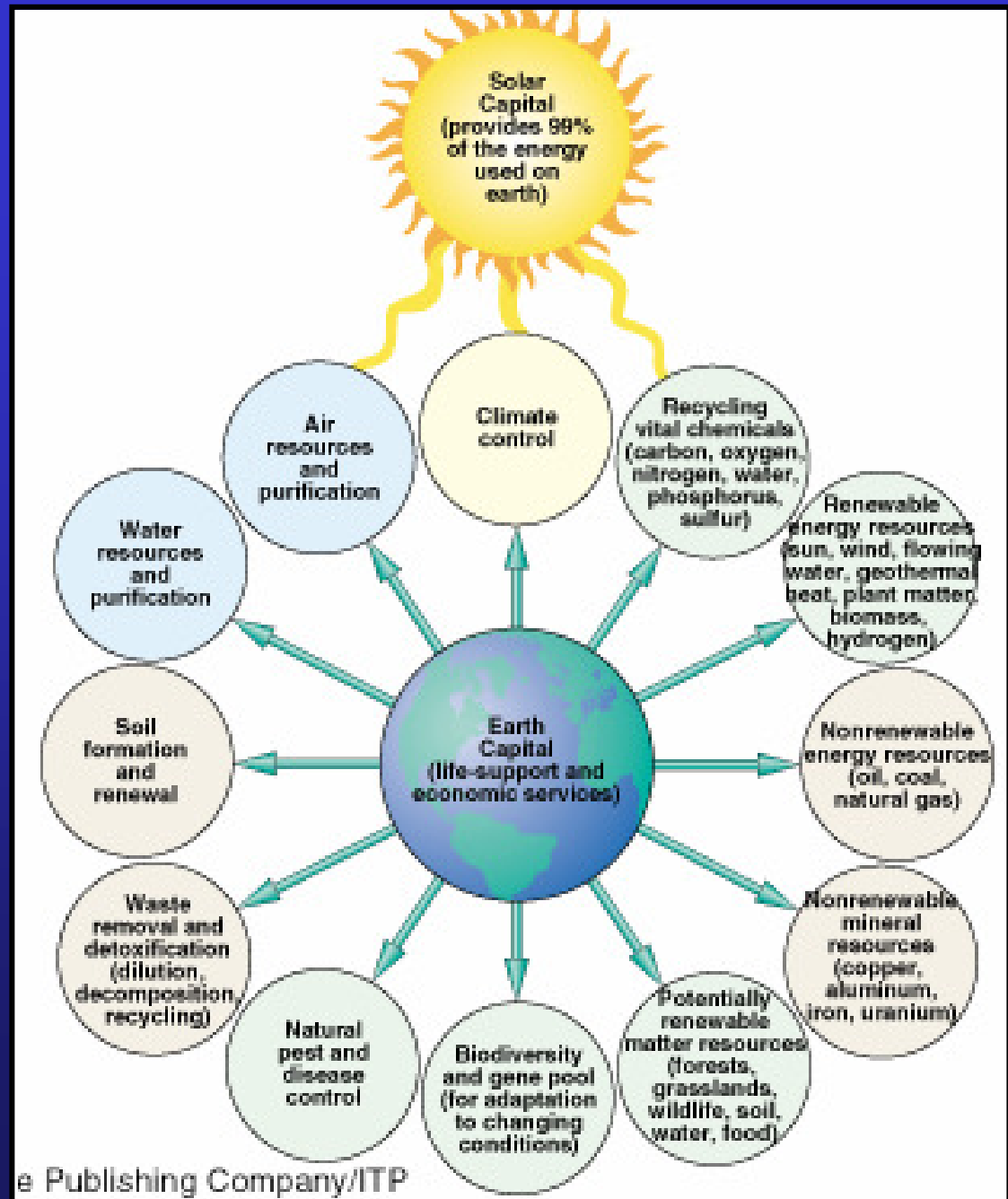
Geography is the study of the relationship between human populations and Earth's features.

Anthropology is the study of the interactions of the biological, cultural, geographical, and historical aspects of humankind.

Sociology is the study of human population dynamics and statistics.

Solar Capital vs. Earth Capital

Both are resources and processes that support and sustain all life and all economies



Capital Question

Are we depleting and degrading our earth capital at an accelerating rate as our population and demands increase exponentially?

OR

Are there no limits to human population growth and economic growth that can't be overcome by human ingenuity and technology?

Sustainability - persistence of a system through time

“A **sustainable society** manages its economy and population size without exceeding all or part of the planet’s ability to absorb environmental insults, replenish its resources, and sustain human and other forms of life over a specified period, usually hundreds to thousands of years...”

Can a desirable human environment be sustainable?

A sustainable society must learn how to live within its...

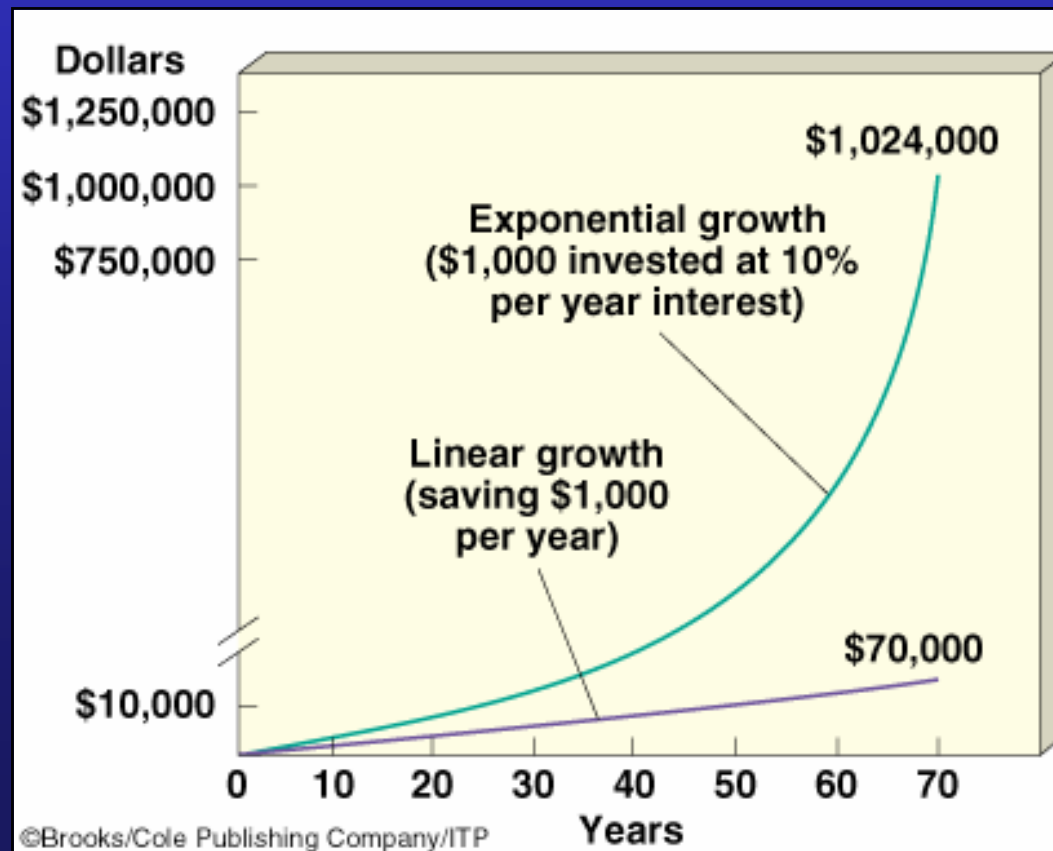
Carrying Capacity - number of organisms that can be sustained in a particular environment

- Is carrying capacity a fixed number?
- How many people can the Earth support?
- Is there a trade-off between quantity of people & quality of life?

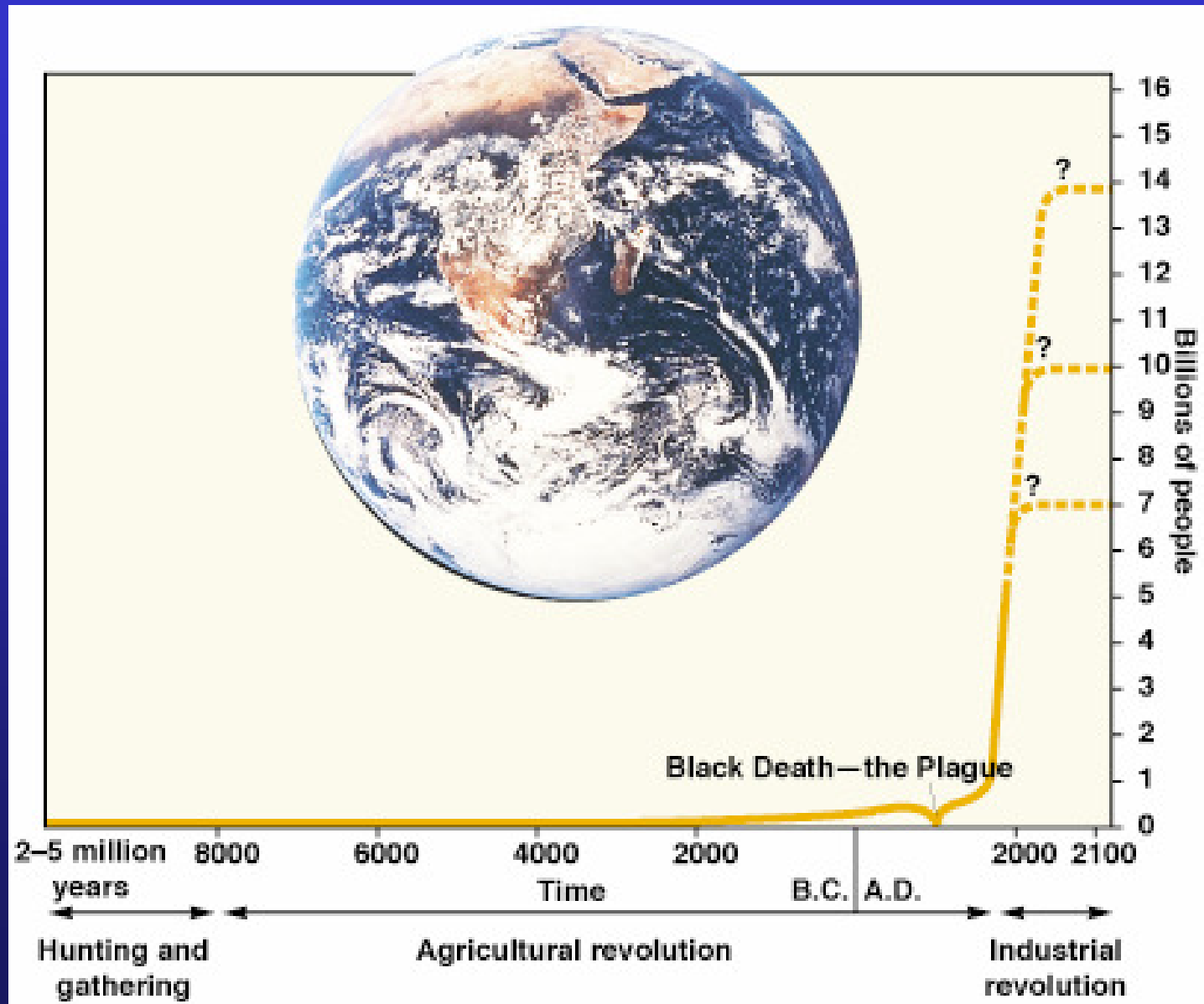
Patterns of Growth

Linear Growth – quantity is increasing by a constant amount per unit of time (ex. 1, 3, 5, 7, 9)

Exponential Growth – quantity increases by a fixed percentage of the whole in a given time as each increase is applied to the base for further growth (ex. 2, 4, 8, 16, 32)



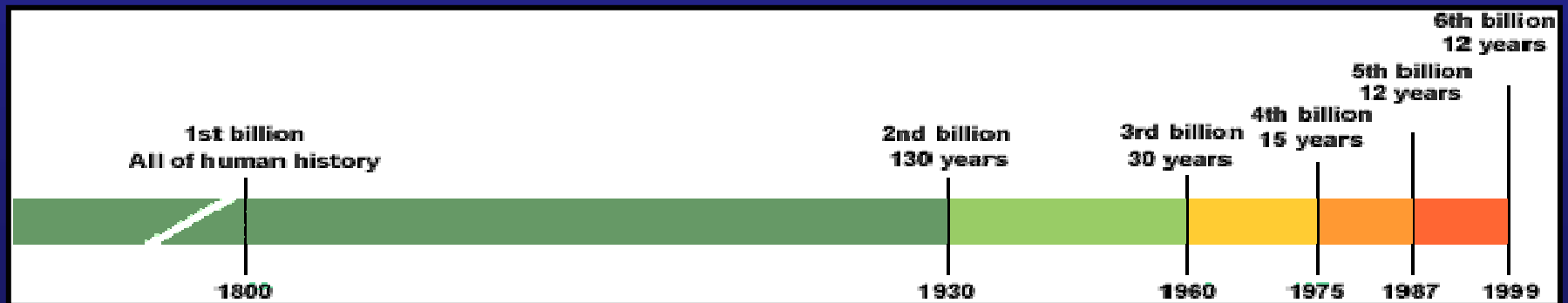
Linear vs. Exponential Growth



Doubling Rate

How long does it take for the human population to double itself?

- It took 60,000 years to reach 1 billion.
- It took 130 years to reach 2 billion.
- It took 45 years to reach 4 billion.
- It should take less than 45 years to reach 8 billion!



Doubling rates are calculated using the rule of 70...

$70 \div \text{percentage growth rate} = \text{doubling rate in years}$

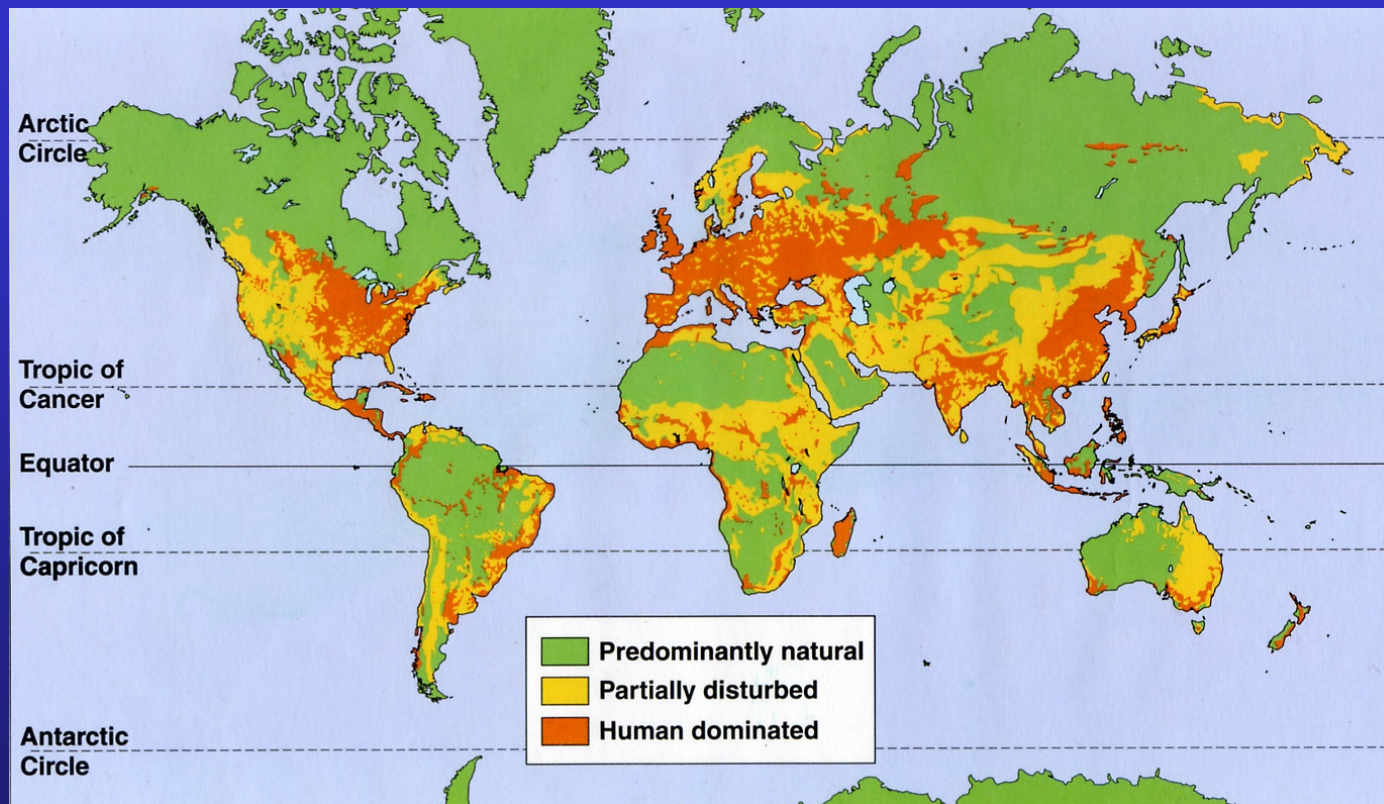
Ex. The current world population is 6.9 billion & rising.

The world's current annual growth rate is 1.13%.

$$70 \div 1.13 = 62 \text{ years}$$

In other words, if the current growth rate remains the same, the 2073 world population will be nearly 14 billion!

“73% of the habitable area of the planet has been altered by human activities.”



What will happen as the human population continues to increase exponentially?

7 Billion

Economic Growth

Virtually all countries seek **economic growth**, an increase in their capacity to provide goods and services for people's final use

- Goods and services are produced by increasing the flow of matter and energy resources through an economy
- Economic growth is measured by an increase in a country's **gross national product (GNP)**, the market value in current dollars of all goods and services produced by a country during a year

Developed verses Developing Countries



Developed vs. Developing Countries

DEVELOPED COUNTRIES	DEVELOPING COUNTRIES
Are highly industrialized	Have little industrialization
Have high average per capita GNPs (above \$4000)	Have low to moderate per capita GNPs
Contain 20% of world's population	Contain 80% of world's population
Command 85% of world's wealth and income	Command 15% of world's wealth and income
Use 88% of world's natural resources	Use 12% of world's natural resources
Generate 75% of world's pollution and wastes	Generate 25% of world's pollution and wastes
Ex. US, Canada, Japan, Germany	Ex. Most countries in Africa, Asia, Latin America

Population & Development

Population is increasing faster in developing countries than in developed countries.

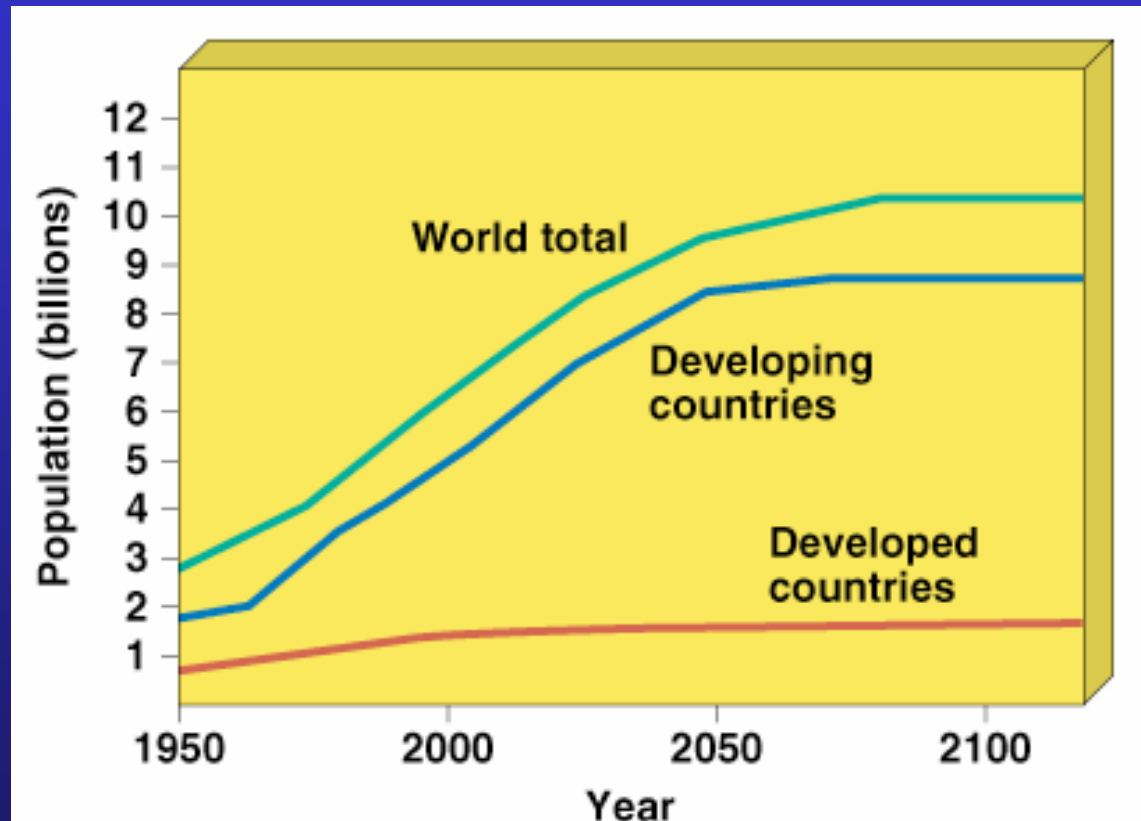
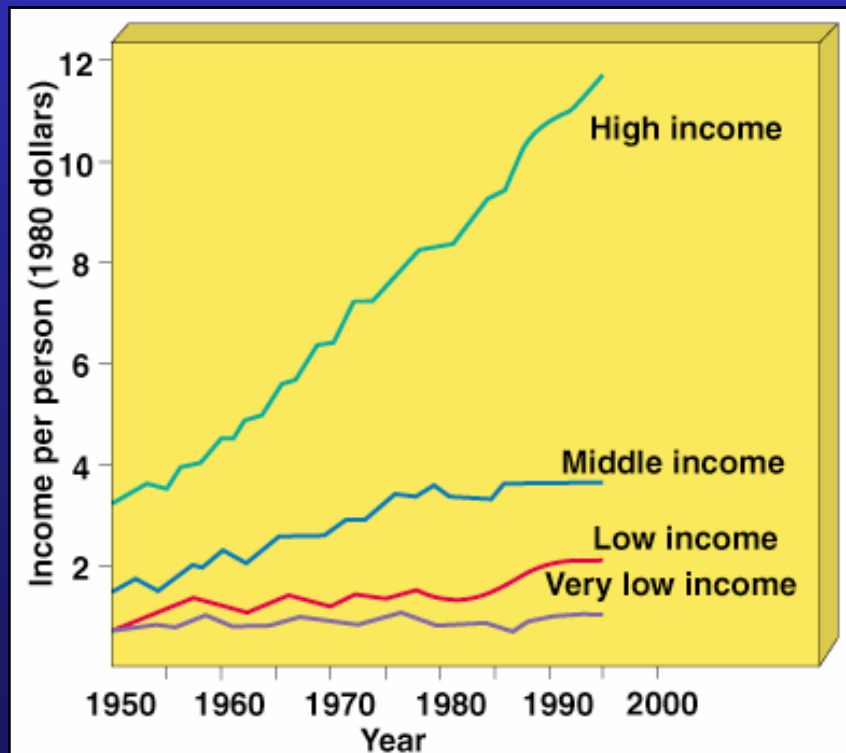


Fig. 1-7

The Wealth Gap

Since 1960 the gap between per capita gross national product (GNP) of rich, middle income, & poor has widened.



*“Today...
one person in five lives in
luxury...
the next three get by...
the fifth struggles to survive on
less than \$1 a day.”*

Hans Rosling: Global Health Expert & Data Visionary

A professor of global health at Sweden's Karolinska Institute, his current work focuses on dispelling common myths about the so-called developing world, which (he points out) is no longer worlds away from the West. In fact, most of the Third World is on the same trajectory toward health and prosperity, and many countries are moving twice as fast as the west did.



<http://www.itcork.ie/images/components/RADImageGallery/2/large/Hans%20Rosling.jpg>

Statistics guru Hans Rosling debunks myths about the so-called "developing world"

http://www.ted.com/speakers/hans_rosling.html

2. Resources

Ecological resources - anything required by an organism for normal maintenance, growth, & reproduction (e.g., habitat, food, water, shelter)

Economic resources - anything obtained from the environment to meet human needs & wants (e.g., fresh water, soil, plants & animals, fossil fuels)

Renewable vs. Nonrenewable Resources

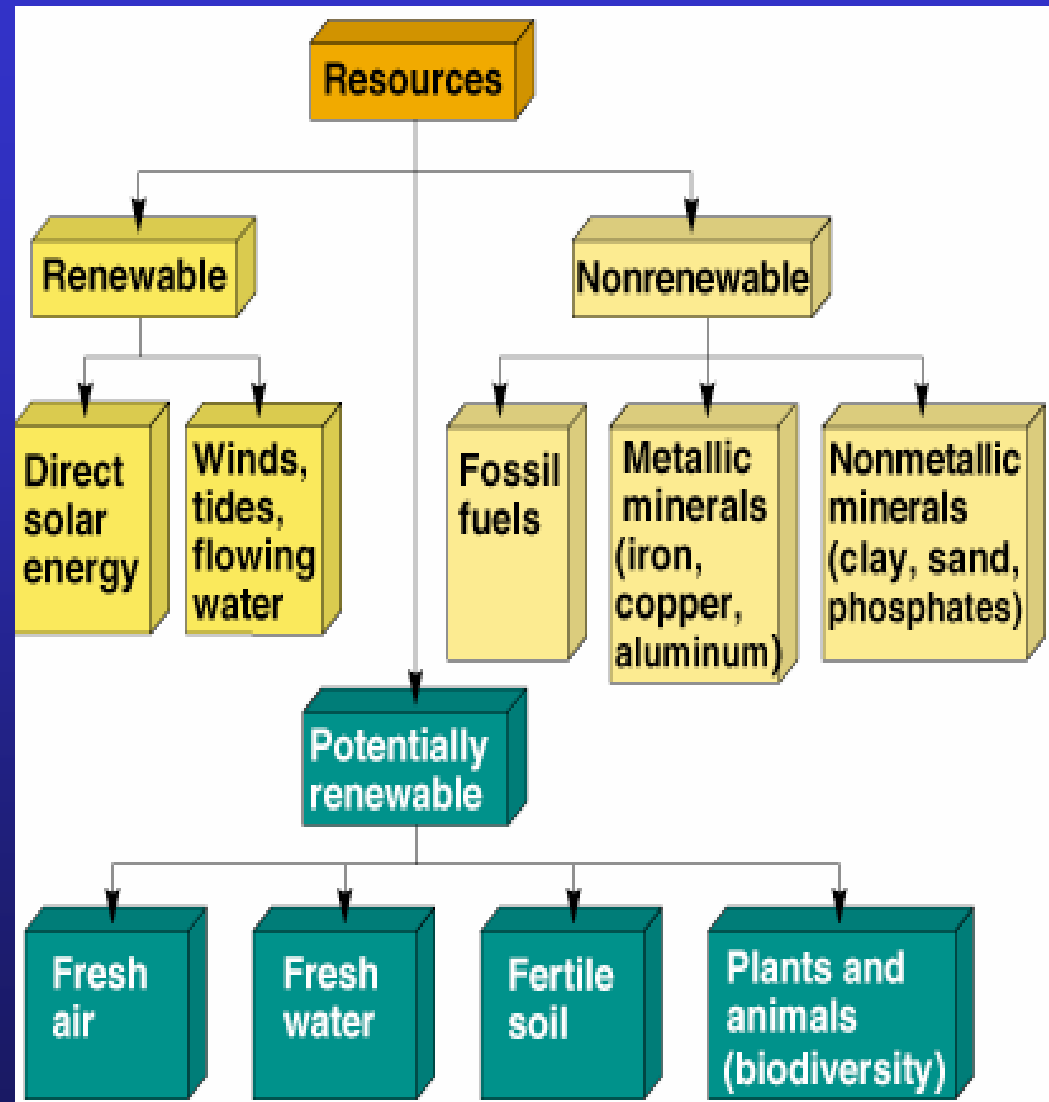


http://images1.wikia.nocookie.net/_cb20080107010221/uncyclopedia/images/b/b7/Stop_Sign.png

- What's the difference between **renewable**, **potentially renewable**, and **nonrenewable resources**?
- What are some examples of each?

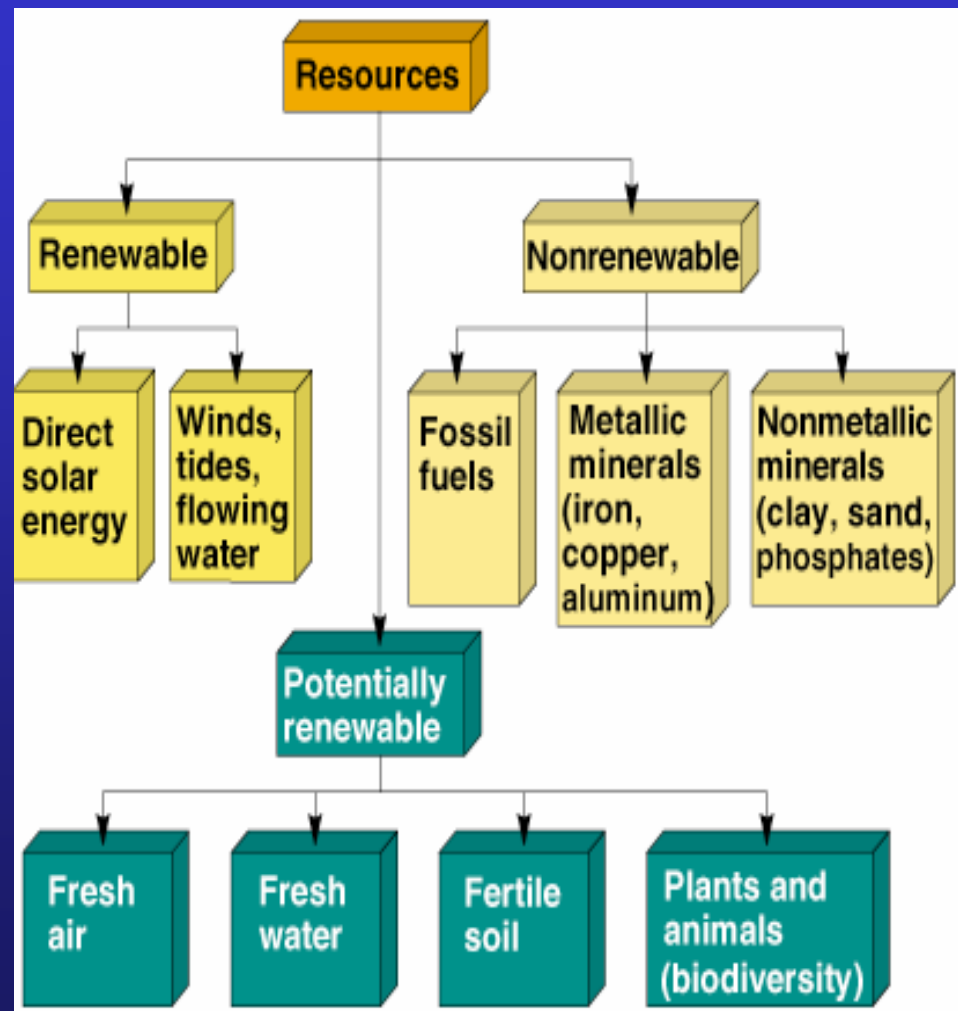
Renewable vs. Nonrenewable Resources

- **Renewable resources** - can be replenished relatively rapidly
- **Nonrenewable resources** - can be exhausted & not renewed in human time scales



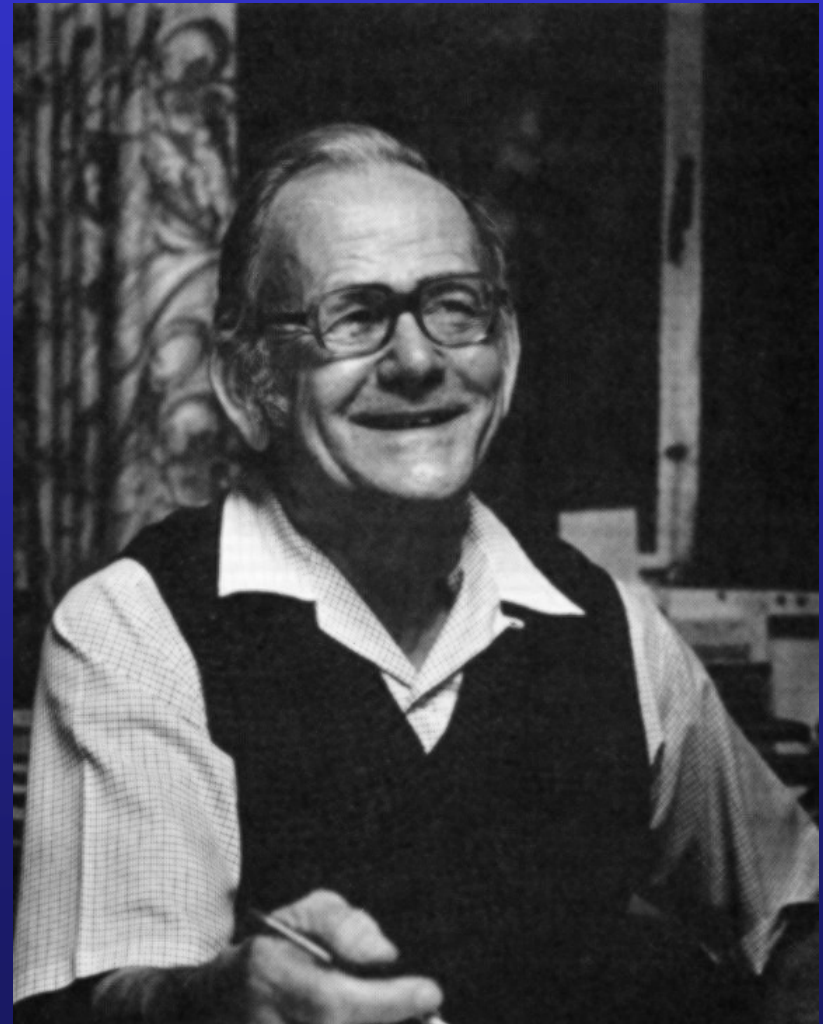
Renewable vs. Nonrenewable Resources

- Air, water, soil, & wildlife are typically classified as renewable, but actually only potentially renewable, since they can be depleted.
- The highest rate at which a potentially renewable resource can be used indefinitely without reducing its available supply is called **sustainable yield**.
- Exceeding sustainable yield leads to **environmental degradation**.



The Tragedy of the Commons

- Essay written by ecologist Garrett Harden in 1968
- Common-property resources (owned by no one or jointly by everyone such as air, ocean, publicly owned lands, etc.) are very susceptible to environmental degradation.
- Harden argued that the main difficulty in solving env'tal problems is the conflict b/t short-term interests of individuals and long-term welfare of society

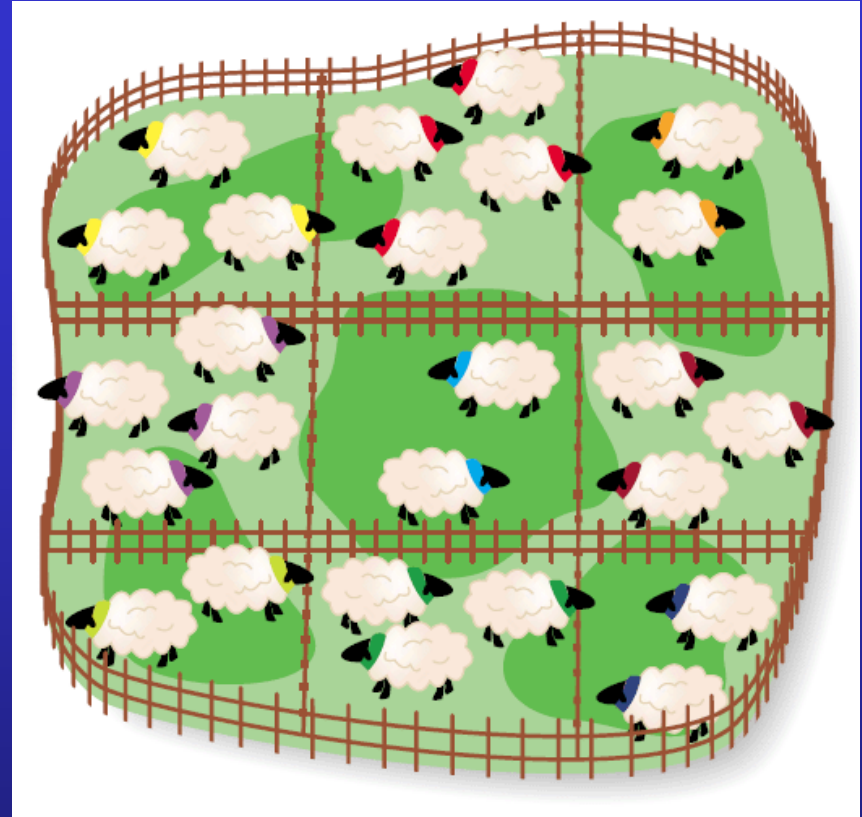


<http://www.pioneerfund.org/hardin.jpg>

- If land is held in common, individuals tend to graze as many animals as possible, leading to destruction of land
- "If I don't use it, someone else will."
- "The little bit I use won't make a difference."



- When commons are replaced by enclosed fields owned by individuals, people tend to graze only the number of animals the land can support.



Hardin vs. Social Nature

- Hardin predicted people would deplete natural resources to the point of society's collapse by acting in their own self-interest
- Opponents consider the social nature of humans
 - Live in groups and depend on each other
 - Solve problems by planning, organizing, considering scientific evidence, proposing solutions
 - Solution may override individuals' short-term interests but will improve env'tal quality for everyone in the long run

Tragedy of the Commons BLOG

- Post your response to the prompts below then reply to **two** of your classmates' posts
 - Give another example of a real-live “Tragedy of the Commons.”
 - Do you agree or disagree with Garrett Hardin? Why or why not?

3. Pollution

Pollution - undesirable change in physical, chemical, or biological characteristics of air, water, soil, or food that can adversely affect humans or other living organisms. Can also include noise, heat, etc.

- **Point Source** - single identified sources of pollution (e.g., smoke stack or effluent discharge).
- **Nonpoint Source** - dispersed & often difficult to identify sources (e.g., agricultural runoff).



Determining Severity of Pollutants

Chemical Nature...

How active & harmful to living organisms?

“We know little about the possible harmful effects of 90% of the 72,000 synthetic chemicals now in commercial use and the roughly 1,000 new ones added each year. Our knowledge about the effects of the other 10% of these chemicals is limited, mostly because it is quite difficult, time-consuming, and expensive to get this information.”

Concentration ... How much is present the environment?

One part per million (ppm) is:

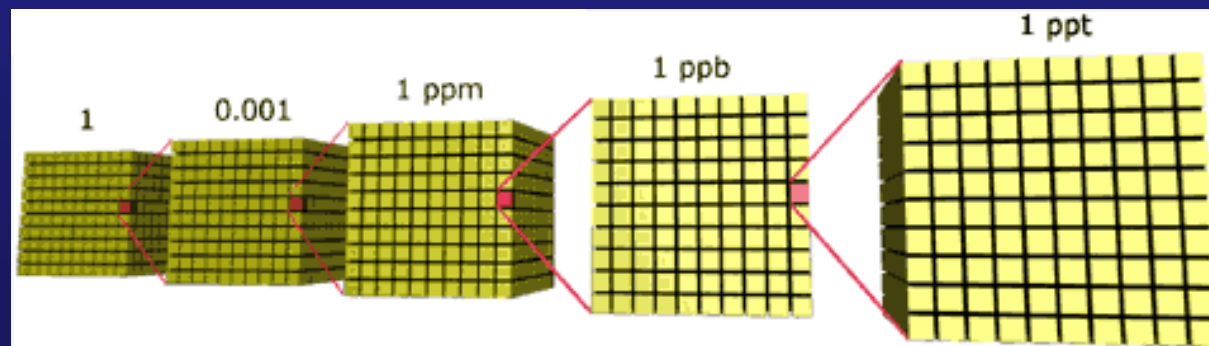
- One ounce of salt in 62,500 pounds of sugar
- One square inch in the infield of a baseball diamond
- One inch in 16 miles
- One second in 11 days

One part per billion (ppb) is:

- One square foot in 36 square miles
- One inch in 16,000 miles
- One second in 32 years

One part per trillion (ppt) is:

- One inch in 16,000,000 miles (33 round trips to the moon)
- One pinch of salt in 10,000 tons of potato chips
- One second in 320 centuries



Persistence...

How long does it take to break down to acceptable levels?

- **Degradable (nonpersistent) pollutants** are broken down completely or reduced to acceptable levels by natural, physical, chemical, and biological processes (ex. human sewage in a river).
- **Slowly degradable (persistent) pollutants** take decades or longer to degrade (ex. DDT & plastics).
- **Nondegradable pollutants** cannot be broken down by natural processes (ex. lead & mercury).

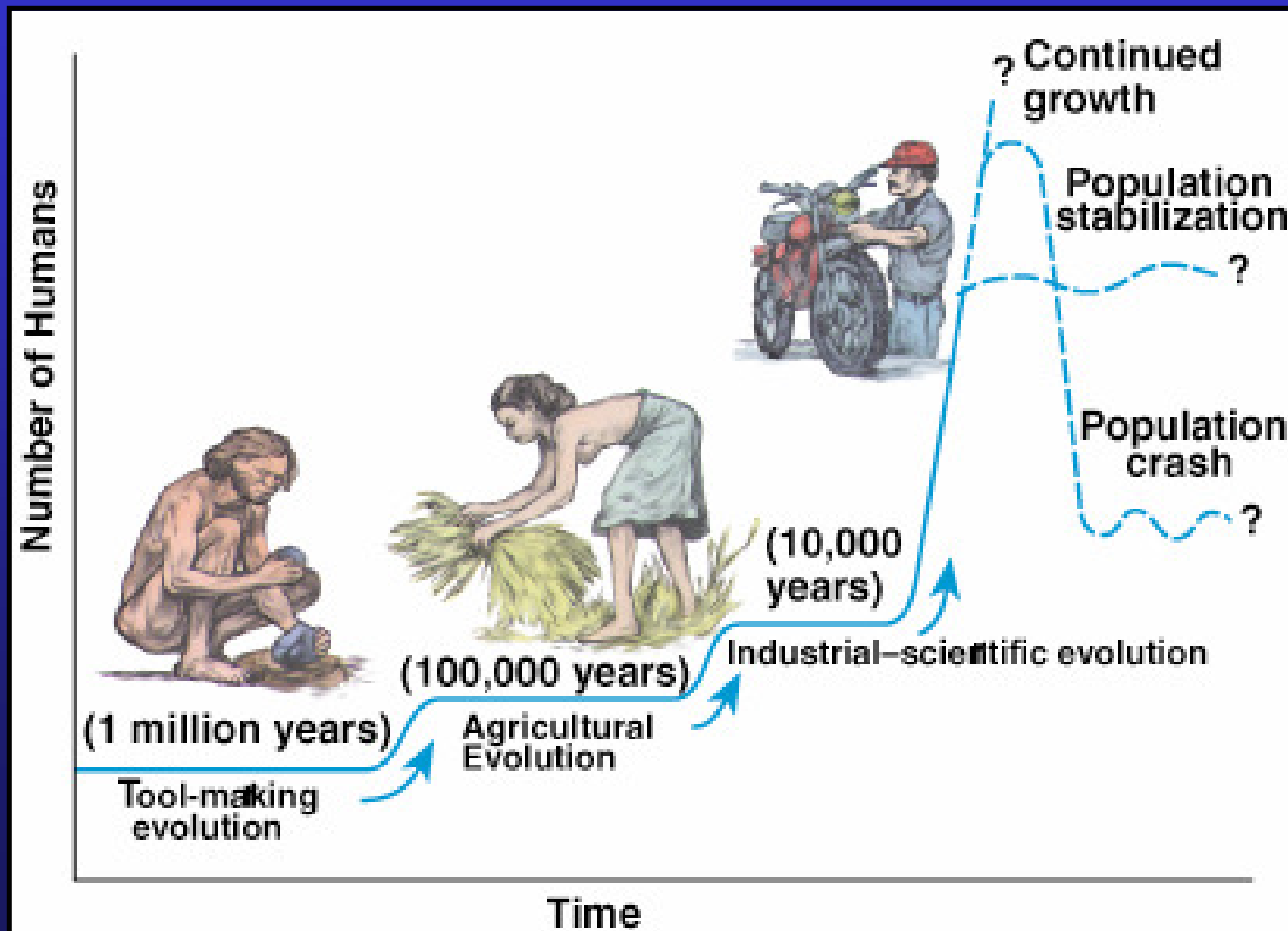
Which is better...preventing pollution from reaching the environment or cleaning it up if it does?

Pollution clean-up is often just a bandage as long as population and consumption levels continue to grow without corresponding improvements in pollution control technology.

- Pollution clean-up often removes a pollutant from one part of the environment only to cause pollution in another.
- Once pollutants have entered and become dispersed in the air, water, soil, etc. at harmful levels, it is usually too expensive to reduce them to acceptable levels.

4. Sustainability

Earth's carrying capacity has expanded due to cultural change.



The Hunter-Gatherers

Lifestyle

- Had few possessions
- Used only three energy sources: sun, fire, muscle power
- Survived through “earth wisdom,” expert knowledge of natural surroundings (resources, weather, migrations)
- High infant mortality and low life expectancy (30-40)
- Population grew very slowly



<http://marcisegal.files.wordpress.com/2010/07/hunter-gatherers.jpg>

The Hunter-Gatherers

Environmental Impact

- Used fire to flush game from forests and destroy vegetation to promote growth of plants they could eat...converted forests to grasslands
- Stampeded herds into traps or over cliffs, often killing more than they needed...possibly led to extinction of large game (saber-toothed tigers, mammoths, etc.)
- Carried plant seeds and roots as they moved to new areas...altered distribution of plants and animals which fed from them

The Agriculturalists

Lifestyle

- Used domesticated animals as work power to cultivate plants
- Developed **shifting cultivation** techniques, built irrigation systems for larger fields, increased urbanization



http://brokenworld.wikispaces.com/file/view/kolkhoz_v_rabote.jpg/30629636/kolkhoz_v_rabote.jpg

- Could grow more than they needed for their families, accumulated as many material possessions as they could afford
- Infant mortality decreased while life expectancy increased
- Population started to grow more quickly

The Agriculturalists

Environmental Impact

- **Slash-and-burn cultivation** degraded or destroyed habitats of wild plants and animals
- Land left with soil depleted of nutrients, erosion, salt build-up...fertile land turned to deserts; topsoil washed away into streams, lakes, etc.
- Conflict between societies over land & water rights
- Shift to urbanization led to demand for nonrenewable resources and increases in wastes, pollution, and disease.

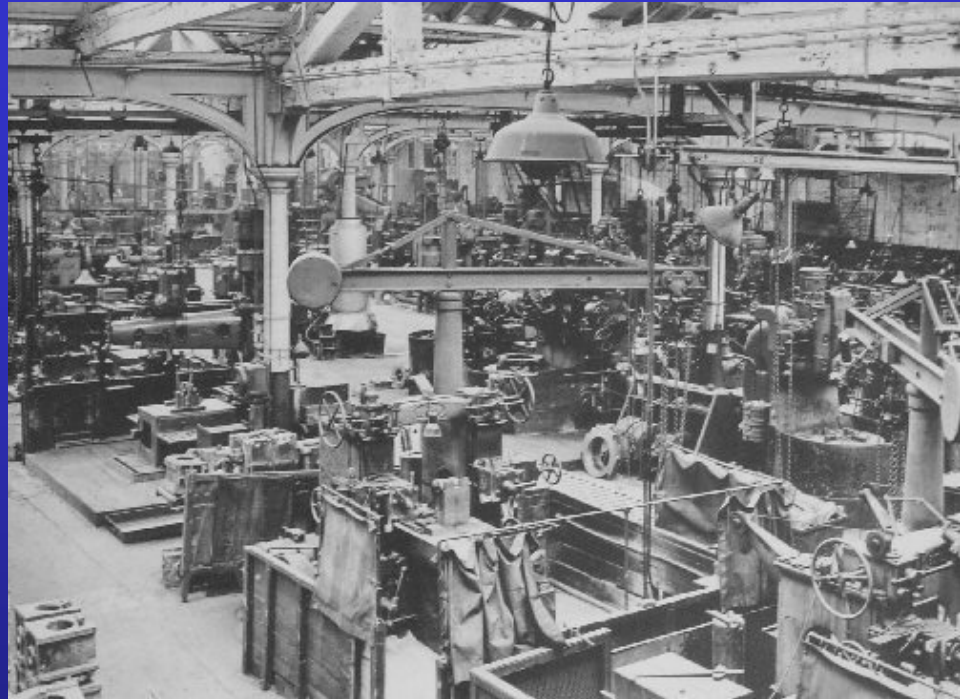


<http://www.env.go.jp/en/wpaper/1990/eae190030010002.gif>

The Industrialists

Lifestyle

- Production, commerce, and trade expanded rapidly with large-scale production of machine-made goods & better farming techniques
- Increased per capita energy consumption with strong dependence on nonrenewable fossil fuels (coal, oil, natural gas)
- Eventual lower infant mortality and higher life expectancy with advances in sanitation, hygiene, nutrition, and medical care
- Population sky-rocketed



<http://gdl.cdlr.strath.ac.uk/springburn/springwor/springworleg03.jpg>

The Industrialists

Environmental Impact

- Pollution problems from burning fossil fuels
- Better farm machinery and farming techniques actually protected biodiversity by increasing per acre crop yields and reducing the need for more cropland
- Population boom led to greater resource consumption

Population and Consumption

Indicators of Development for the United States, Japan, Mexico, and Indonesia

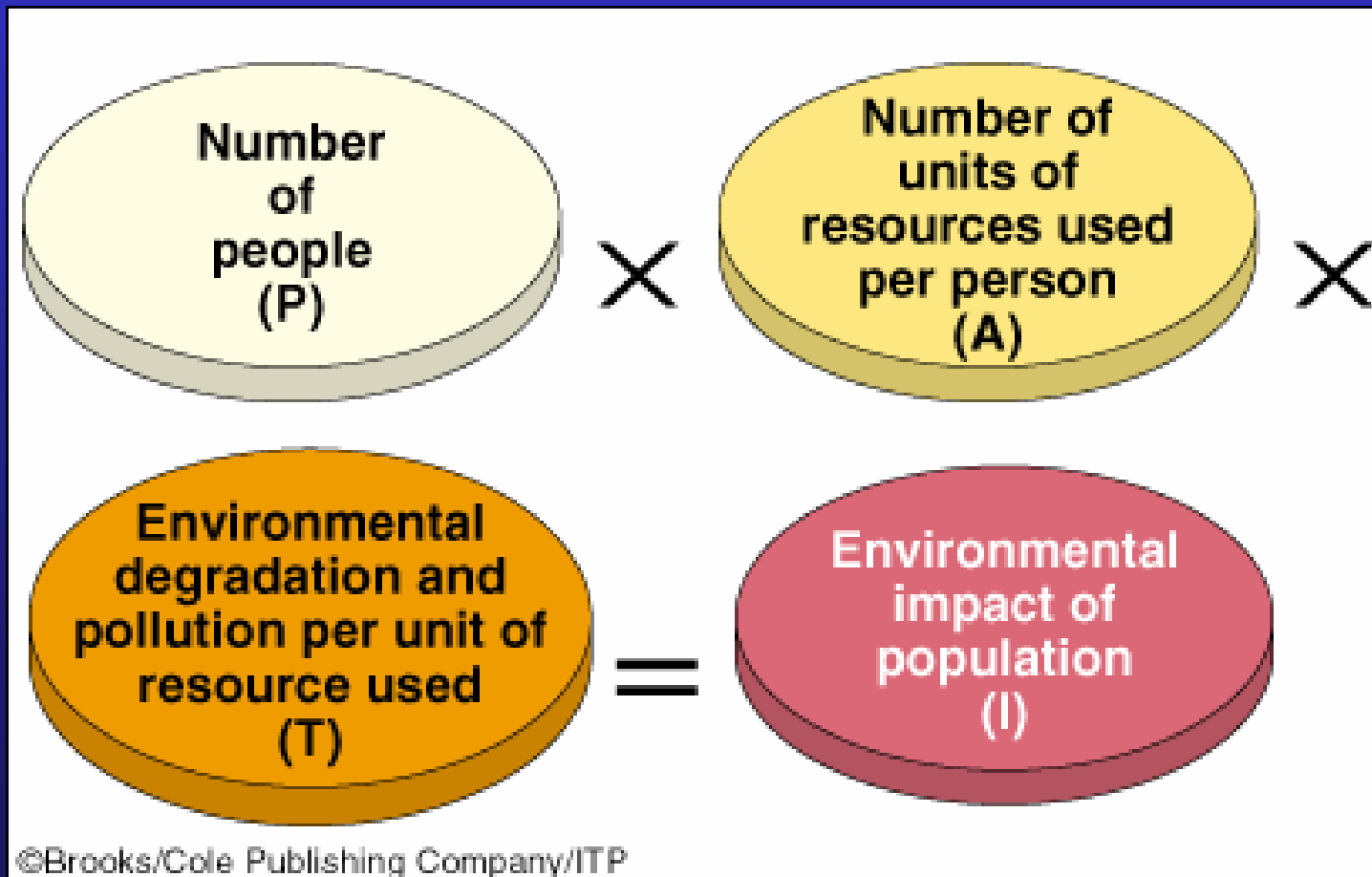
	Measurement	U.S.	Japan	Mexico	Indonesia
Health	life expectancy in years	77	81	71.5	68
Population growth	per year	0.8%	0.2%	1.7%	1.8%
Wealth	gross national product per person	\$29,240	\$32,350	\$3,840	\$640
Living space	people per square mile	78	829	133	319
Energy use	per person per year (Btu)	351	168	59	18
Pollution	carbon dioxide from fossil fuels per person per year (tons)	20.4	9.3	3.5	2.2
Waste	garbage produced per person per year (kg)	720	400	300	43

Population and Consumption



5. Connecting Problems & Their Causes

According to a simple model, a given area's total environmental degradation and pollution (a.k.a. the environmental impact of population) depends on three factors:



People Overpopulation



Number of people

x



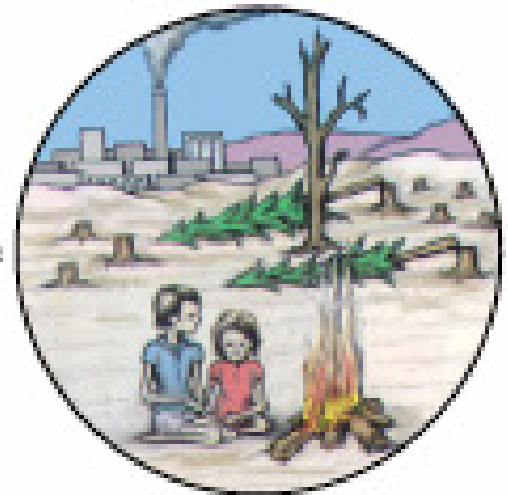
Number of units of resources used per person

x



Environmental impact per unit of resource used

=



Environmental impact of population

Consumption Overpopulation



x



x

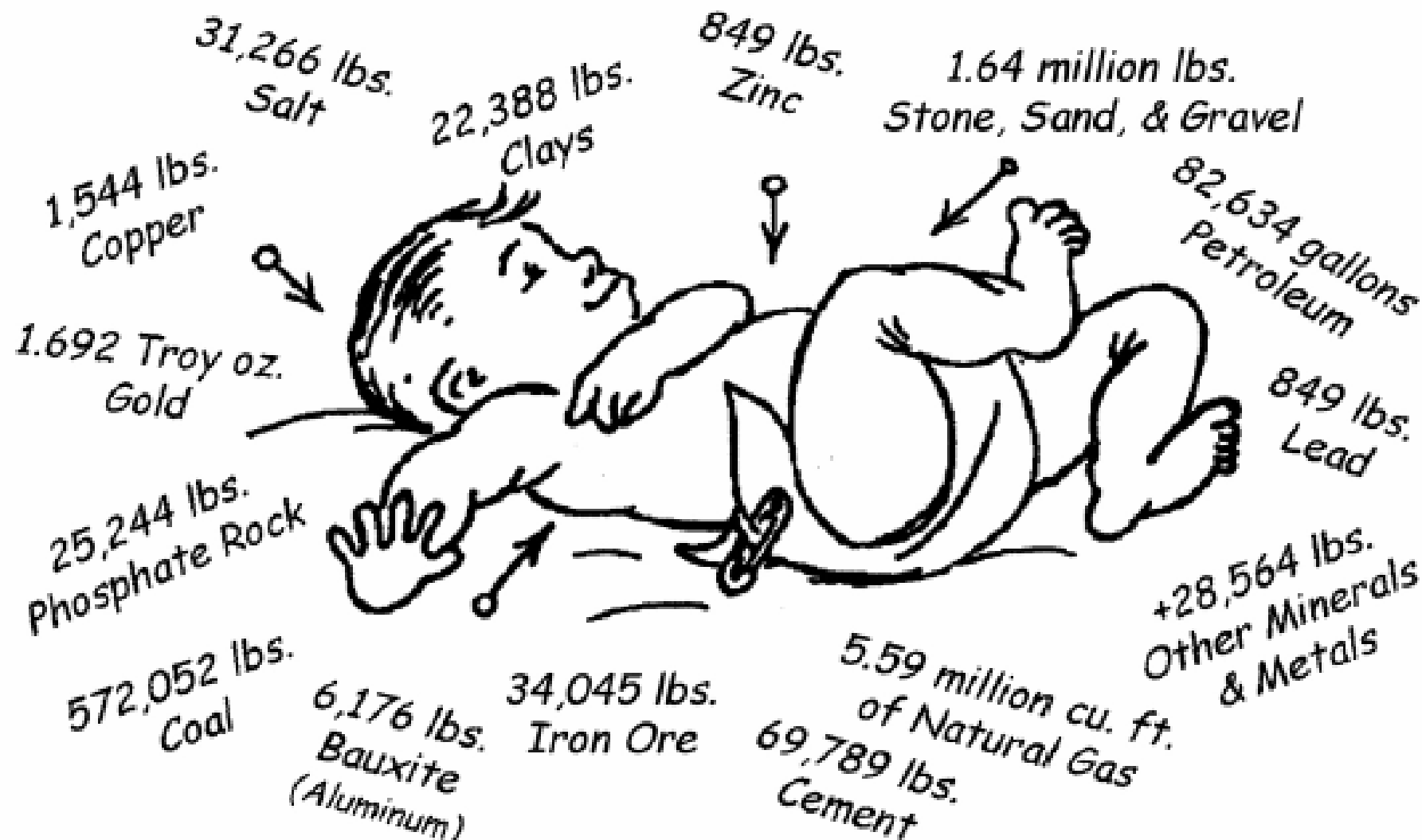


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Fig. 1-19

Every American Born Will Need . . .



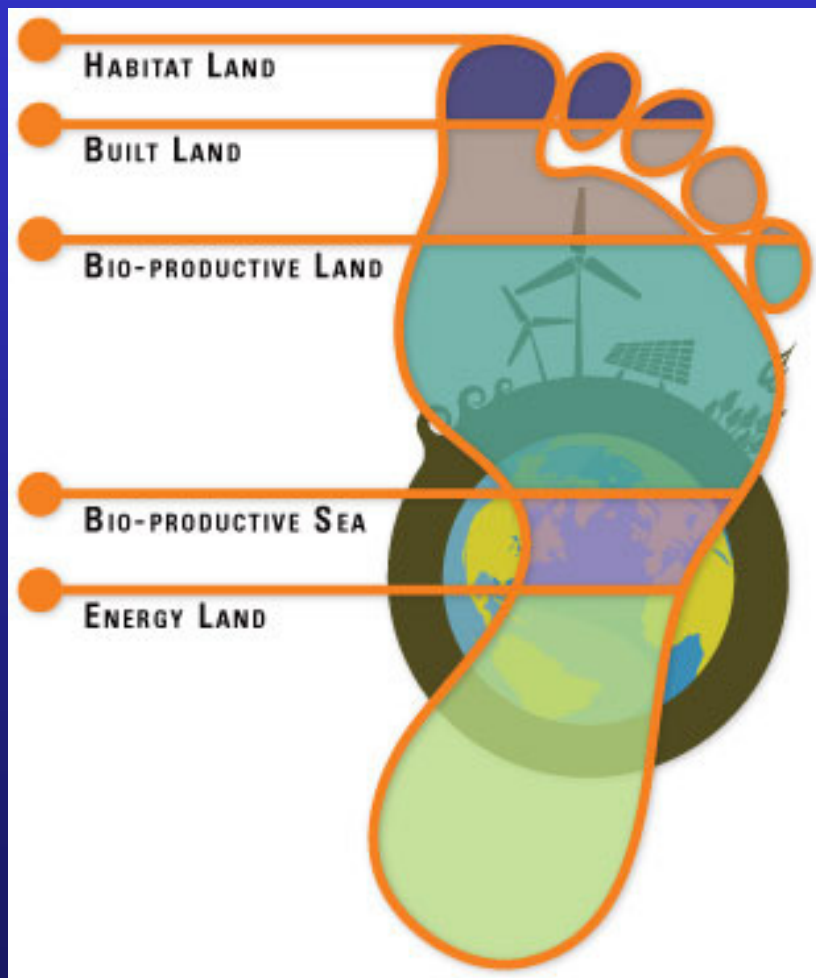
3.6 million pounds of minerals, metals, and fuels in their lifetime

Developing countries have more people, but lower environmental impact per person than developed countries.

“The average US citizen consumes 35 times as much as the average citizen of India and 100 times as much as the average person in the world’s poorest countries.”

“Poor parents in a developing county would need 70-200 children to have the same lifetime environmental impact as 2 children in a typical US family.”

What is your Ecological Footprint?



<http://sunliving.ca/uploads/images/en/footprint-graphic.jpg>

- Are you contributing to a sustainable world?
- What's your **ecological footprint**?
- Go to www.myfootprint.org to find out!

Modern Environmental Worldviews



Modern Environmental Worldviews

Planetary Management Worldview	Earth-Wisdom Worldview
<i>We are the planet's most important species, and we are in charge of the rest of nature.</i>	<i>Nature exists for all of the earth's species, not just for us.</i>
<i>There is always more.</i>	<i>There is not always more.</i>
<i>All economic growth is good, more economic growth is better, and the potential for economic growth is essentially limitless.</i>	<i>Some forms of economic growth are environmentally beneficial and should be encouraged, but some are environmentally harmful and should be discouraged.</i>
<i>Our success depends on how well we can understand, control, and manage the earth's life-support systems for our benefit.</i>	<i>Our success depends on learning to cooperate with one another and with the rest of nature by learning how to work with the earth.</i>

Working Toward Sustainability

Some Guidelines

- Leave the earth as good or better than we found it.
- Take no more than we need.
- Try not to harm life, air, water, soil.
- Protect biodiversity.
- Help maintain Earth's capacity for self repair.
- Don't use potentially renewable resources faster than they are replenished.
- Don't waste resources.
- Don't release pollutants faster than Earth's natural processes can dilute or degrade them.
- Slow the rate of population growth.
- Reduce poverty.