Lesson 2/Week 2

Medical Geographical Approaches

- ✓ **Disease ecology approach**
- ✓ **Landscape epidemiology**
- ✓ **Spatial epidemiology**

The Role of Diseases in Human History

Topic I. Disease Ecology

What is ecology?

✓ **A branch of biology**

✓ **Concerned with <u>relations between organisms and their environment.</u>**

Disease ecology

✓ **Examines the relationships between populations and the changing environment**

✓ **Studies how processes of population interactions support or discourage disease**

"One of the crucial tenets of disease ecology is that population, society, and both the physical and biological environments are in dynamic <u>equilibrium</u>."

"Significant enough <u>stress</u> on this equilibrium can produce cascading effects on any of the aforementioned components."

This means that:

The human-environment relationship, if **disturbed enough by major changes in land use, migration, population pressure, or other** stressors can show significant **maladaptation, as manifested by the** appearance or diffusion of new diseases.

Example

✓ Contact with explorers and settlers: North America

✓ Increase in the incidence of schistosomiasis following the construction of the Aswan Dam.

✓ Spread of malaria following land clearance for rubber plantations in Malaysia.

✓ Increases in vectored diseases with the construction of transportation routes in the Amazon.

✓ The appearance of Lyme Disease in the United States following reforestation in suburban areas in the Northeast.

Human Ecology
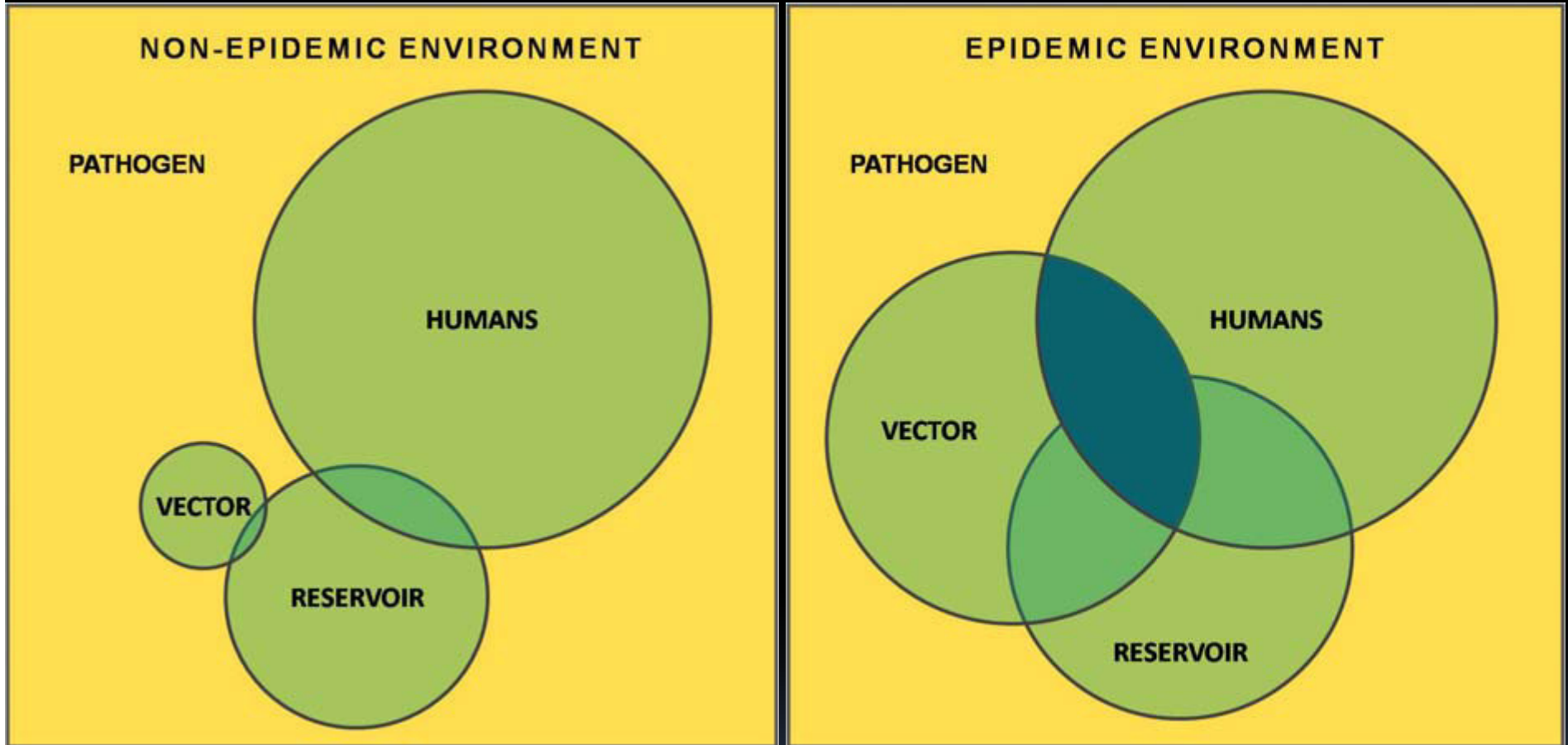
Seasonal epidemics can be measured by the variable amount of the overlap _over time and space._

FIGURE 2. Range of the deer mouse (*Peromyscus maniculatus*) in North America and confirmed cases of hantavirus pulmonary syndrome (HPS) in the United States, as of June 6, 2002
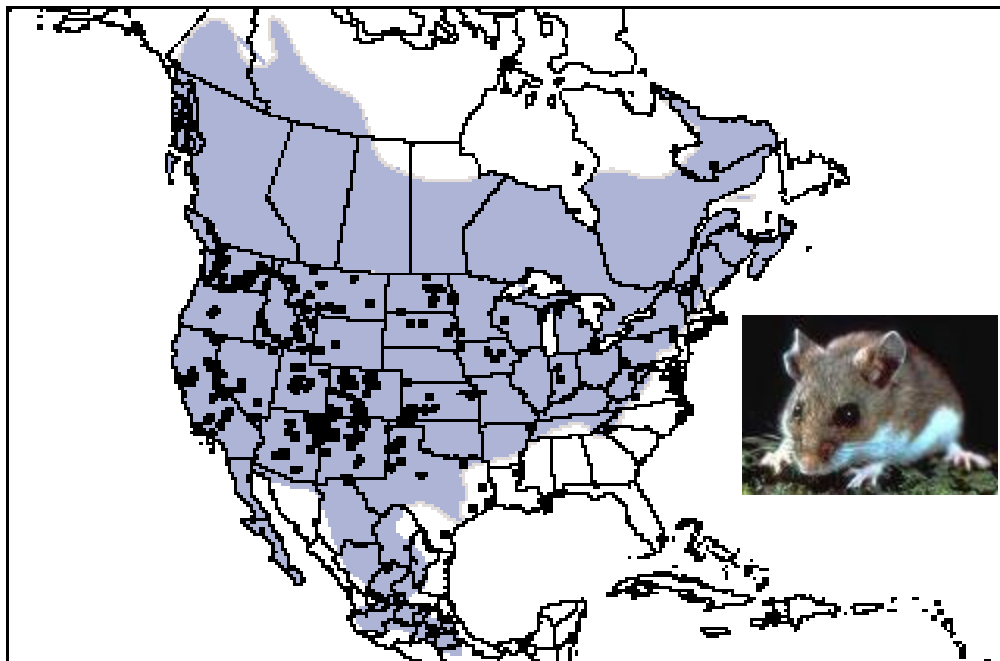
Source: Carleton MD. Systematics and evolution. In: Kirkland GL Jr, Layne JN, eds. Advances in the study of *Peromyscus* (Rodentia). Lubbock, TX: Texas Tech University Press, 1989:7–141

http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5109a1.htm#fig1

The triangle of human ecology: POPULATION, BEHAVIOR, HABITAT.
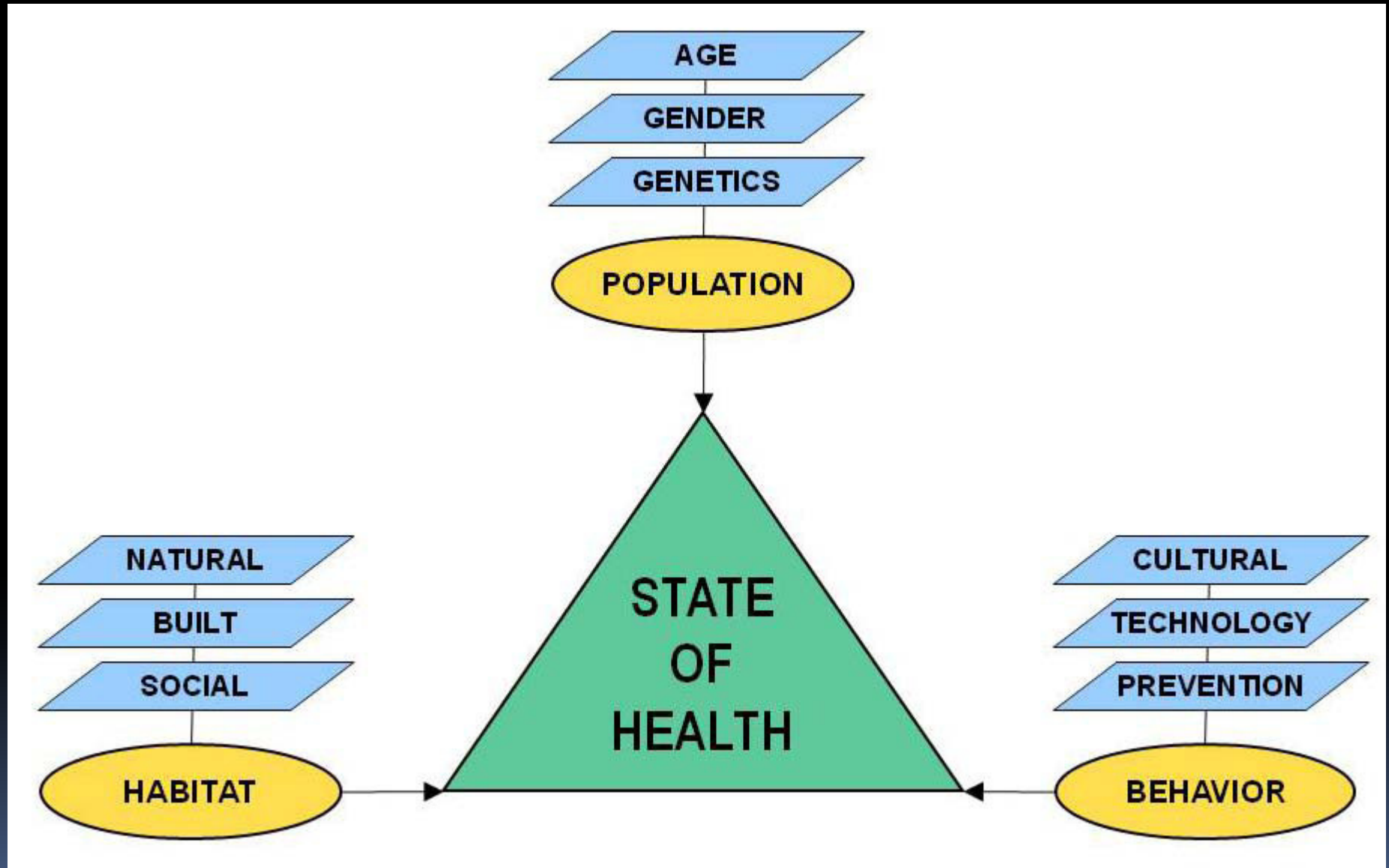
POPULATION

Genetics

Age

Gender

POPULATION *: biological organism that may carry and host disease.*

(1) Genetic susceptibility, (2) age, and (3) gender determine whether or not a host will have an illness or can physically and emotionally cope with an illness.

(1) Genetics:

✓ Genetic risks factors for certain cancers have been described since the time of ancient Rome.

✓ In 1866, Paul Broca, a French physician, reported ten cases of breast cancer spanning four generations of his wife's family.

✓ Recently it has been shown that genetic predisposition accounts for five to ten percent of ovarian and breast cancers.

✓ In the Ashkenazi (not Sephardic) Jewish population (those of Eastern European descent), it has been estimated that one in four individuals is a carrier of one of several genetic conditions

✓ Also Sickle-cell anemia (Africans), Lactose intolerance (Asians).

✓ New terminology "previvor"

(2) Age

Mortality and morbidity increase with age, and dramatically so in old age.

Example stroke:

✓Strokes are clearly a disease of elderly people;
✓ 75% of strokes occur in those aged 65 and older.
✓The incidence of stroke rises steeply with age, being 10 times greater in people aged 75-84 years than in people aged 55-64 years.

**However, these statistics don't hold true everywhere due to the ameliorative or exacerbating impacts of social, economic, and environmental factors (see examples from Europe – next slide).**

Europe 1995: Percentage Reporting Chronic Illness by age (Men)
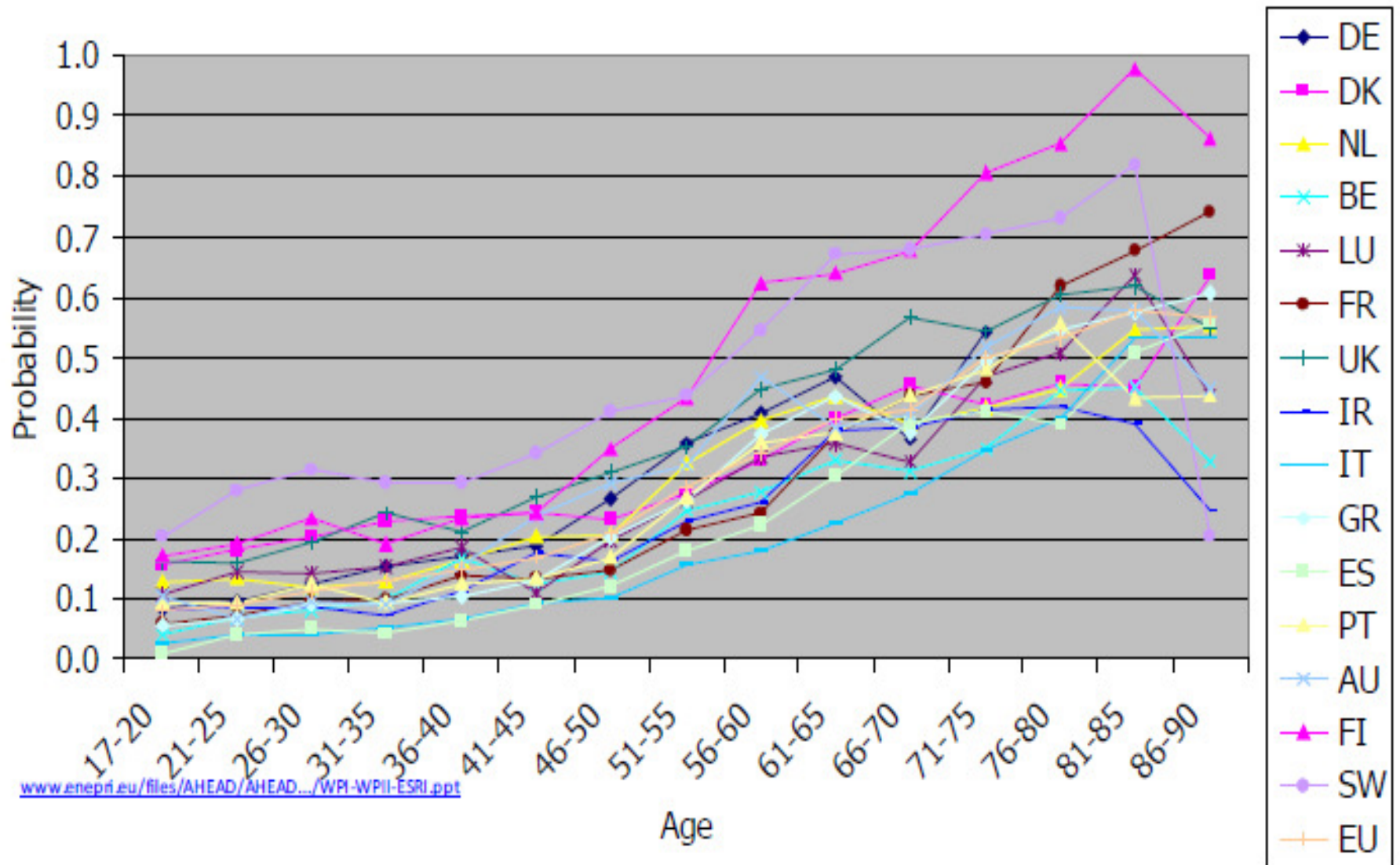
But, Europe is aging fast due to low (and <u>declining</u>) fertility rates, especially in Eastern Europe, and due to low mortality.

Total fertility rate
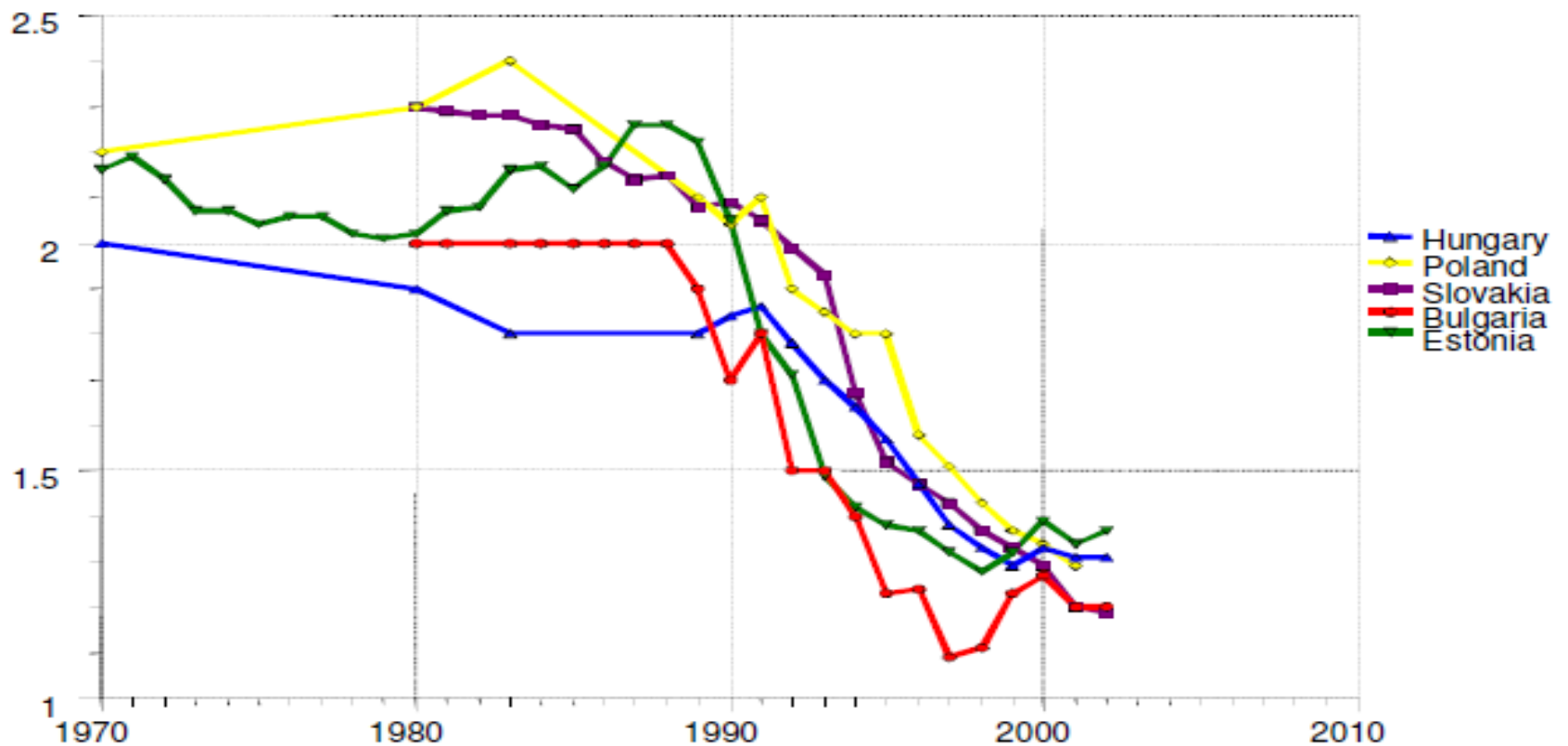
(3) Gender: Some diseases are gender-specific.

Examples

✓ Females have higher life-expectancy due to a higher gender gap in mortality.
✓ Crash fatality rates are much higher among teenage boys than girls.
✓ In the US women had 2.8 times higher Chlamydia infection rate than men in 2008.
✓ In the UK men have at least two times higher death rates than women for suicide, homicide, accidents and cirrhosis of the liver.
✓ In Russia, the difference between male and female life expectancy is 13 years (59 vs. 72).
✓ Higher suicide rates among women in China."
✓ Smaller gender gap in mortality in developing countries due to high maternal mortality and the lower social status women.

HABITAT

Cultural habitat

Natural habitat

Social habitat

Built habitat

HABITAT:

A. Cultural habitat:

Example 1: Marriage customs

The vast **majority**—of girls aged 15–19 in developing countries are married. **Child marriage remains a fact of life in largely rural regions in South** Asia, Latin America, and, crucially, in many sub-Saharan countries that have HIV prevalence above five percent in populations of women attending antenatal clinics (defined as a mature and generalized epidemic).

Example 2: Child labor (Illegal in the US)

"Today, throughout the world, around 215 million children work, many full-time. They do not go to school and have little or no time to play. Many do not receive proper nutrition or care. They are denied the chance to be children. More than half of them are exposed to the worst forms of child labour such as work in hazardous environments, slavery, or other forms of forced labour, illicit activities including drug trafficking and prostitution, as well as involvement in armed conflict."
http://www.ilo.org/global/topics/child-labour/lang--en/index.htm

Example 3. Patterns of movement/migration and disease spread. A few facts to remember:

✓ Disease has frequently followed those pulled to new destinations by opportunity, better conditions, or simple inquisitiveness; or pushed from their homes by events, calamity, or chaos.

✓ The ebbs and flows of populations have often involved a connection between different environmental, socioeconomic, genetic, biological, or behavioral conditions that existed between the migrant and host populations.

✓ The dynamic interaction of the populations and the determinants of health influenced and changed those who were migrating as well as the populations hosting the migrants.

✓ Experiences involving disease and migration have been woven into humankind's social, cultural, and medical history.

B. Natural habitat: Topography, land cover, land use, climate, and weather patterns.

Example 1. Altitude

✓ As you ascend to higher altitudes, atmospheric pressure decreases,

✓ The air is thinner and less oxygen is available.

✓ It is also colder and drier

✓ Ultraviolet rays from the sun are stronger.

✓ Each of these changes affects the body.

✓ On the plus side, research is showing that people living at high elevations have longer life spans (study from Greece) than their counter parts at low altitudes. Most of humanity lives at low altitudes.

Example 2: Aspect (windward vs. leeward)

Hawaii 1920s   "The island's aquifers occupied much of the windward side (the island of Oahu being transected by a central mountain range separating the windward and leeward sides). In a massive hydro-engineering attempt, tunnels were bored through the Koolau Range in order to divert natural water flow from the windward to the leeward side of Oahu. The resulting effects were catastrophic for windward Oahu subsistence farmers. Water supplies from natural aquifers dwindled, causing a host of ecological and environmental upsets."

"Because of these conditions, displaced subsistence farmers sought out a livelihood within the city. This drastic change from rural to urban life brought about a switch in overall lifestyles as well. Urbanized conditions translated into dietary changes, one of the major downfalls of Native Hawaiian health standards. Pre-processed foods, high in protein, fat and cholesterol became a staple of the Native Hawaiian diet due to the fact that access to traditional food staffs became severely limited. These dietary changes soon equated to higher obesity rates, which then led to associated health problems."
http://www.iiirm.org/publications/Articles%20Reports%20Papers/Risk/NatvHwnHealth.pdf

C. Social habitat: *Family, friends, cultural, and spiritual influences.*

✓The social environment consists of the groups, relations, and societies within which people live.
The social environment includes the
✓ Groups to which we belong,
✓ Neighborhoods in which we live,
✓ Organization of our workplaces,
✓ Policies we create to order our lives.

The social environment influences disease pathways.
http://www.annualreviews.org/doi/abs/10.1146/annurev.publhealth.20.1.287?journalCode=publhealth

D. Built habitat: **Includes the buildings we live and work in as well as travel within** during our daily activities, construction materials, sanitation and waste disposal, water sources, building design, air flow and lighting, health care facilities, and transportation.

It also includes:

✓ **Settlement types: urban vs. rural (dispersed vs. clustered)**

✓ Infrastructure -- e.g. water supply, water storage, latrines, improved drainage

✓ Private goods -- e.g. improved cookstoves (Hillary Clinton's new initiative), ventilation in houses, bednets

Example Africa

✓ The African urban population is doubling every 20 years, Increase in the number of vehicles, rapid increase in vehicular pollutants.

✓ The impact of air pollution on health is seen in the rapid increase in respiratory illnesses, heavy-metal-related illnesses, and allergies and skin diseases, which are experienced mostly by children and the poorest.

✓ Environmental pollution is therefore reducing human productivity in Africa.

✓ Air pollution in Africa is worsened by the continued use of leaded gasoline, poor quality fuels, and uncontrolled vehicular emissions.

Old environmental dangers

Lead
Asbestos
Sun-beds
Indoor air pollutants
Outdoor air pollutants
Water pollution
Soil pollution
Electromagnetic fields
Cell phones?
Radon, depleted uranium, nuclear accidents (Chernobyl)
Legionellosis
Heath care waste
Climate change

In the news: Bisphenol A (BPA), Phthalets, Methyl Bromide

Bisphenol A (BPA - used to make **polycarbonate plastics)**
This industrial chemical has been present in many hard plastic bottles and metal-based food and beverage cans since the 1960s.

Phthalates: "Phthalates are nearly ubiquitous in modern society, found in, among other things, toys, food packaging, hoses, raincoats, shower curtains, vinyl flooring, wall coverings, lubricants, adhesives, detergents, nail polish, hair spray and shampoo."

Methyl bromide (used as chemical fumigant)
"California strawberry growers were faced with the possibility of losing one of their most important chemicals, methyl bromide. Methyl bromide was believed to be involved in the depletion of the ozone layer and 162 countries had signed the Montreal Protocol, which would lead to an eventual ban of the chemical."

Topic II. LANDSCAPE EPIDEMIOLOGY

The landscape of a place is characterized by a mosaic of habitats within the ecosystem. The elements and patterns associated with the biotic, abiotic, and cultural processes within a landscape are used to identify the factors that influence disease transmission over time and space.

Landscape epidemiology:

✓Involves the identification of geographical areas where disease is transmitted.
✓**Draws some of its roots from the field of landscape ecology.**
✓ Is a holistic approach that involves the interactions and associations between elements of the physical and cultural environments.
✓ Has the theory **that most vectors, hosts and pathogens are commonly tied to the landscape as environmental determinants control their distribution and abundance.**

Topic III. SPATIAL EPIDEMIOLOGY

Spatial epidemiology is the study of spatial variations in disease <u>risk</u> or <u>incidence</u>.

Several ecological processes can result in strong spatial patterns of such risk or incidence including the following:

✓ Pathogen dispersal might be highly localized,

✓ Vectors or reservoirs for pathogens might be spatially restricted, or susceptible hosts might be lumped.

✓ Pathogens use many different modes to disperse from an infected to an uninfected host.

✓ Some modes involve direct contact (e.g. pathogens transmitted during aggression or sexual encounters), some involve near-direct contact (e.g. pathogens excreted by one host and inhaled or consumed by another), whereas others rely on an arthropod vector.

Continued…..

✓In most cases, the probability of transmission declines dramatically with distance from an infected host.

✓ As a consequence, factors affecting the spatial positions of pathogens, hosts and vectors, and their probability of close encounter, are fundamentally important to disease dynamics.

✓ Spatial epidemiology has arisen as the principal scientific discipline devoted to understanding the causes and consequences of spatial heterogeneity in infectious diseases, particularly in zoonoses (i.e. diseases that are transmitted to humans from non-human vertebrate reservoirs).

The Role of Diseases in Human History

✓Population growth is a recent phenomenon. For almost all of human history since its inception w million years ago, world population growth has been negligible.

✓Until about 1750 high birth rates were matched by high death rates, with periodic catastrophic losses from famine war and, most importantly, disease.

Examples:

✓ The Chinese population declined from 123 million in 1200 to 65 million 1393 due probably to bubonic plague.

✓ In Europe the Black Death killed an estimated 25 million people, reducing the total population by 25-40 per cent.

✓ England, Italy, France, Poland, Russia and the Balkans are said to have lost 50 per cent of their populations.

✓ Labour shortages hit food production; wage labour was introduced to attract workers; wages increased.

✓ Cities became more important - growth of the bourgeoisie.

✓ Net effect – collapse of feudalism, beginnings of capitalism.

Pre-Columbian America

By the time Columbus discovered America there was already a lengthy history of urban civilization in the Americas.

- Olmec civilistion lasted 1200-300 BC.
- Mayan civilisation peaked in second half of first millennium AD.
- Toltecs in mexico 900-1200.
- Aztec and Inca empires in Mexcio and Peru were at their peak in the 15th century.
- Total population of the Americas was about 100 million, with 25-30 million in each of the Aztec and Inca empires.

Early Civilizations of Central and South America

Most of the North America Indian tribes were hunter-gatherers, but there was a major civilization in the Mississippi valley (mound builders).

• Cahokia's population had only been exceeded by Philadelphia at the time of US independence (1775).

Hernan Cortes captured the Aztec empire in 1521 with an army of only 600 Spaniards.

• Francisco Pizarro captured the Inca empire in 1532 with an army of 168 Spaniards.

Why were the newcomers so successful?

Smallpox epidemics had occurred in the Spanish West Indies previously, but a major epidemic arrived from Spain in 1518. This killed one-third to one-half of the Arawaks in Hispaniola and then spread to Cuba and Peurto Rica.

• It was transmitted to Mexico by an infected slave in 1520. Smallpox killed about one half of the Aztecs, paving the way for conquest by Cortes.

Continued……

•Smallpox reached the Incas in 1526. It killed the Inca emperor and his son, resulting in a civil war.

•Resistance to Pizarro was limited.

•By 1530 smallpox had spread south to the pampas and north to the Great Lakes.

•When Spanish explorers reached the Mississippi in the 1540s many towns had already been abandoned, although some still functioned.

•The Mississippi towns had vanished when the French arrived in the 1600s.

•1529: Measles killed two third of the surviving native population of Cuba, before sweeping through Honduras, Mexico and Peru.

•1546: Aztecs and Incas ravaged by typhus.

•1558-59: Americas hit by influenza pandemic.

•1589: Peru hit by unidentified disease. Three quarters of the Indian population of Chile died.

•Diphtheria, mumps, plague, pertussis, scarlet fever, typhoid, typhus, and tuberculosis followed. Also malaria and yellow fever.

Continued…..

- Pilgrim Fathers in 1620 found a landscape depopulated by smallpox which arrived via Nova Scotia.
- Population of Mexico declined from 30 million to 3 million in 50 years, then to 1.6 million by 1602.
- Figures for Inca empire similar: 8 million by 1553, 1million by 1791.
- Main decline was in the first few decades, but it continued into the 19th century.
- Smallpox killed half the Hurons in 1684. Their enemies, the Iroquois, were also halved.
- In 1738, smallpox killed half of the Cherokees in the Charleston area.

Continued

• In the early nineteenth century, smallpox destroyed two-thirds of the Omahas.

• In 1837 the Mandan Indian tribe was totally wiped out by smallpox.

• Overall, native populations reduced by about 90-95 percent.

• What was the impact in the opposite direction? Syphilis would seem to have been the only possible 'export'.

• Why was there so little impact on Europeans? Amerindians carried very few infectious diseases to infect Europeans.

• Why were they so free of infectious diseases? No one knows for certain, but it could be because Amerindians had very few domesticated animals: turkey (Mexico), llama / alpaca (Andes), guinea pig (Andes), muscovy duck (tropics), dog (everywhere).