Occurrence of disease
Epidemiology (III)
L 8

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Learning objectives :

- to explain basic models of disease cause action.
- to understand the etiology or causes of disease and altered production.
- to understand the theory of disease causation

Models of disease causation

1. Germ theory of disease
2. Epidemiological Triad
3. Epidemiological Tetrad
4. Web of Causation theory
5. Wheel theory

Germ Theory of Disease

- Proposed by Robert Koch and Louis Pasteur.

- Every human disease is caused by a microbe or germ, which is specific for that disease, and one must be able to isolate the microbe from the diseased human being.

- It is proposed mainly for infections.

Biological criteria (Koch's Postulates).

1. Agent is regularly found in the lesion of each case
2. Agent is isolated in pure culture.
3. Agent causes similar disease in experimental animals
4. Agent is recovered from lesions in experimental animal.

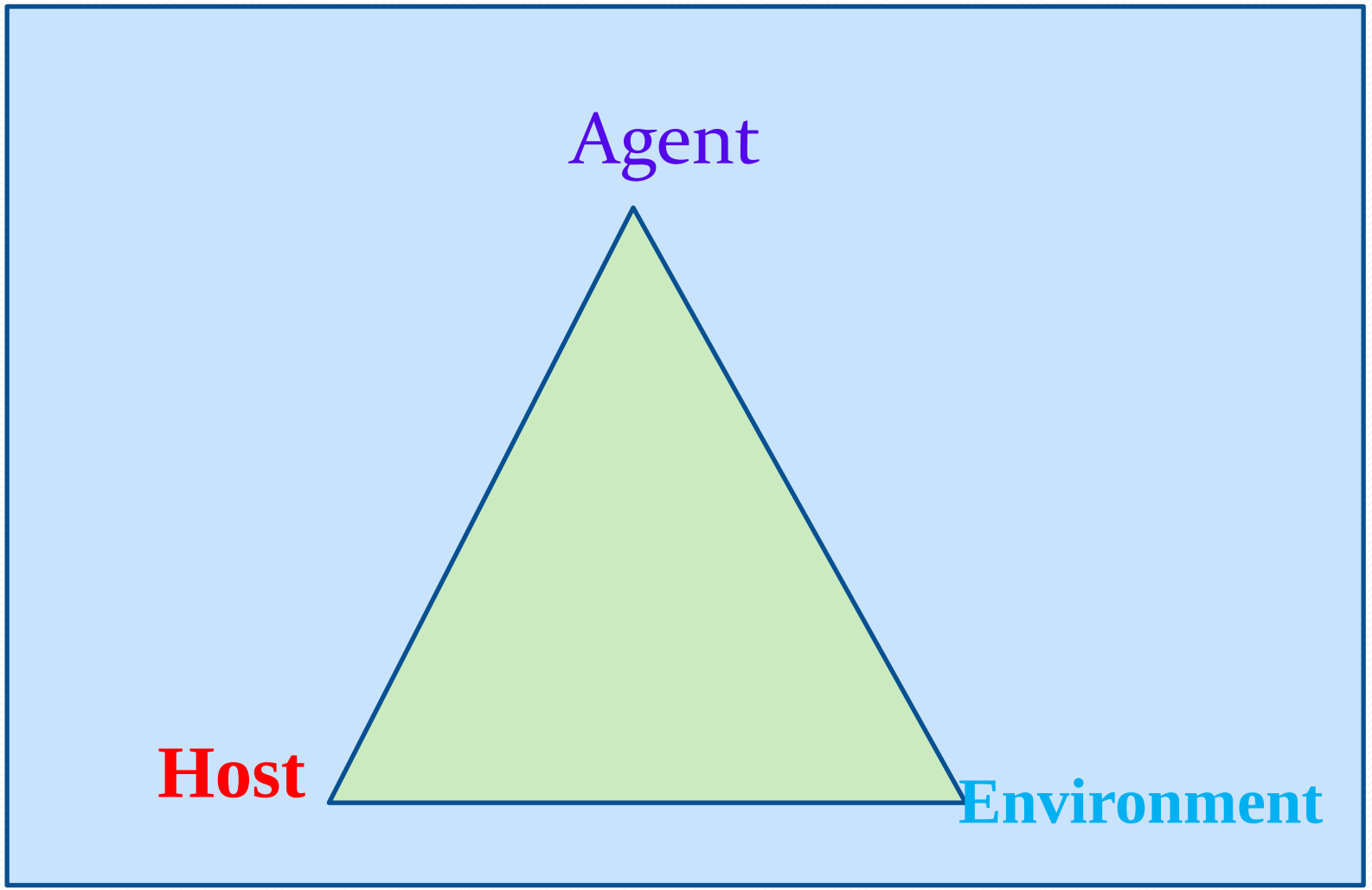
Anthrax was the first disease demonstrated to meet these rules, which have since proved useful with many other infectious diseases and with chemical poisoning.

Koch's postulates are of most value when :

- the specific cause is a highly pathogenic infectious agent.
- chemical poison or other specific factor, and
- there are no healthy carriers of the pathogen: a relatively uncommon occurrence

Epidemiological Triad (Triangle)

- Agent
- **Host**
- **Environment**



Agent

- Is an element or substance, animate or inanimate, the presence (or absence) of which may initiate or effect a disease process.

- A disease may have a single agent, several independent alternative agents or complex of two or more factors whose combined presence is essential for the development of the disease.

Classification of agents:

- Biological
- Nutrient
- Physical
- Chemical
- Mechanical
- Absence or insufficiency or excess of a factor necessary to health
- Social

Agent factors

•Infectious agents:

Agent might be microorganism—virus, bacterium, parasite, prions, other microbes and others (poisonous creatures). Generally, these agents must be present for disease to occur as essential causal factor.

•Nutritive:

Excesses or deficiencies (Cholesterol, vitamins, proteins) .

•Chemical agents:

(carbon monoxide, drugs, medications, Toxins and pollutants) Toxicity dose, Penetrability , Stability, Half-life etc.

•Physical agents :

Ionizing radiation, sound, winds, floods, draughts, soil etc…

Agent characteristics

Infectivity refers to the proportion of exposed persons who become infected.

Pathogenicity refers to the proportion of infected persons who develop clinical disease.

Virulence refers to the proportion of persons with clinical disease who become severely ill or die.

Agent characteristics

- Hepatitis A virus in children has low pathogenicity and low virulence, since many infected children remain asymptomatic and few develop severe illness.

- In persons with good nutrition and health, measles virus has high pathogenicity but low virulence, since almost all infected persons develop the characteristic rash and illness but few develop the life- threatening presentations of measles (pneumonia, encephalitis).

- In persons with poor nutrition and health, measles is a more virulent disease, with mortality as high as 5-10%.

- Rabies virus is both highly pathogenic and virulent, since virtually 100% of all infected persons (who do not receive treatment) progress to clinical disease and death.

Host

- In epidemiological terminology, the human host is referred to as "soil" and the disease agent as "seed".

- A person or other living animal, that affords subsistence or lodgment to an infectious agent under natural condition.

- Host factors: Intrinsic factors that influence an individual's:
  - exposure,
  - susceptibility, or
  - response to a causative agent.

Host factors

Demographic factors:

- Age
- Sex
- Ethnicity

Biological factors:

- Genetic factors
- Blood groups
- Enzymes
- Immunological factors

Socio-economic factors:

- Socio-economic status
- Education
- Occupation

Life style factors:

- alcohol
- Drug abuse
- Smoking
- Nutrition
- Physical activity

Environmental Factors

Physical environment

- Non living things and physical factors:
  - air,
  - water,
  - soil,
  - housing,
  - heat,
  - light,
  - Radiation

Biological environment

- Microbial agents,
- insects,
- animals,
- plants and
- man himself.

Psychosocial environment

- Lifestyle,
- poverty,
- urbanization,
- community life,
- income,
- education,
- stress etc.

Triangle of Epidemiology

In addition to agent, host and environment , time factor is added.

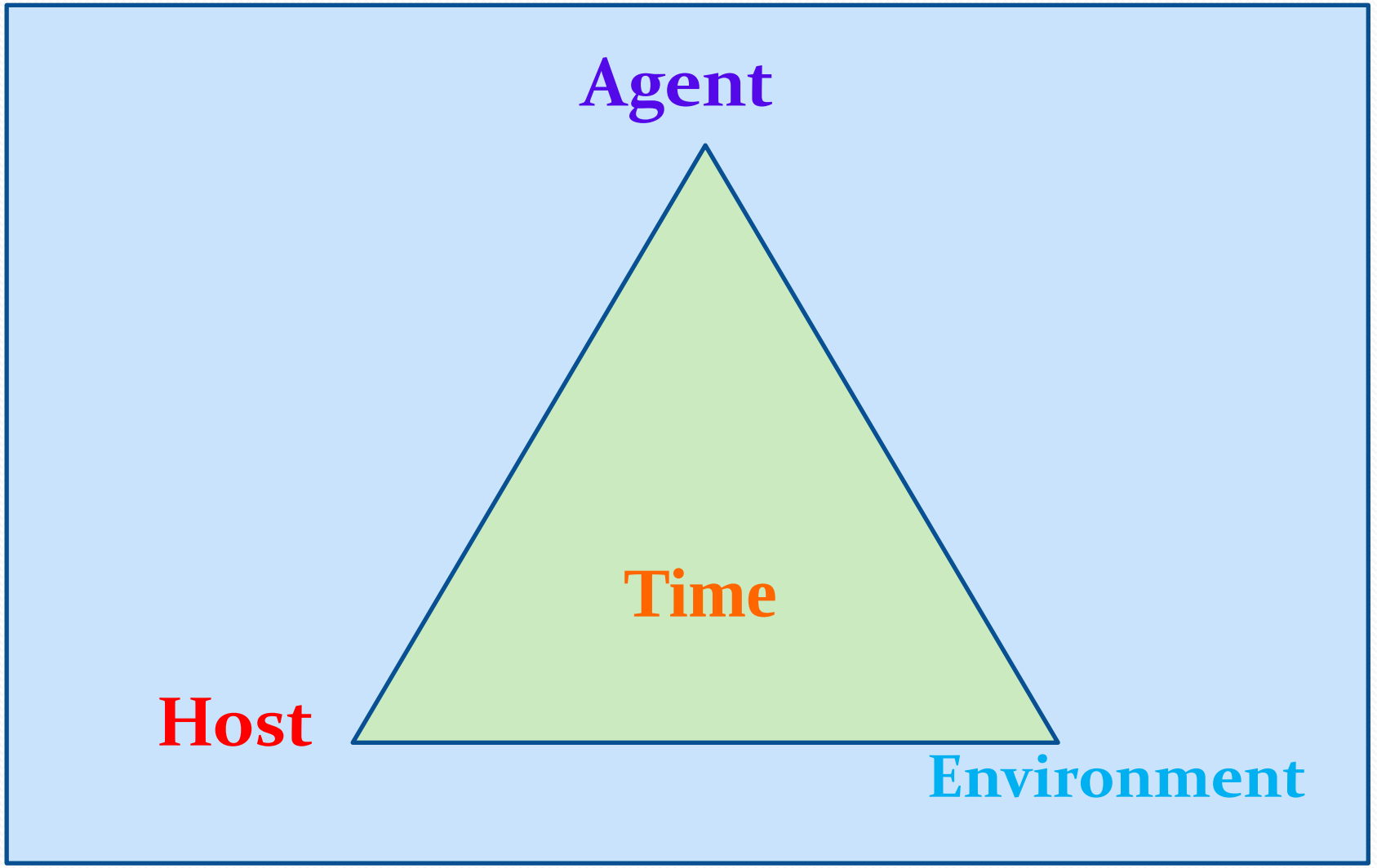
Time account for :

- incubation period,
- Life expectancy of the host or pathogen
- duration of the course of illness

Epidemiological Tetrad

Epidemiological Tetrad

- Agent
- **Host**
- **Environment**
- **Time**



Disease Occurrence

• Different diseases, in different communities, show different patterns of expected occurrence:

• Endemic: habitual or constant presence of a disease or pathogen within a given geographic area , measured by the prevalence rate.

•Hyperendemic: A disease or pathogen that is constantly present at a high incidence and/or prevalence rate and affects all age groups equally, or a persistently high level of occurrence, high prevalence rate, Malaria in Africa.

• Sporadic : an irregular pattern of occurrence, with occasional cases occurring at irregular intervals (prevalence is zero)

Epidemic: occurrence in a community or region of a group of illnesses of similar nature, clearly in excess of normal expectancy and derived from a common or from a propagated source.

- Public health officials often use the term outbreak, which means the same, because it is less provocative to the public.

- When an epidemic spreads over several countries or continents, affecting a large number of people, it is called a pandemic (worldwide epidemic).

The Theory of "Web of Causation"

• The "epidemiological triad theory" was very effectively used by Leavel and Clark in explaining the natural history of disease and levels of prevention for avoiding such departures from the state of health.

• But it could not explain the causation of non communicable diseases like IHD or road accidents.

Web of causation

- McMahon and Pugh forwarded the theory of "epidemiological web of causation", wherein the various factors (e.g. hypercholesterolemia, smoking, hypertension) are like an interacting web of a spider.

- Each factor has its own relative importance in causing the final departure from the state of health, as well as interacts with others, modifying the effect of each other.

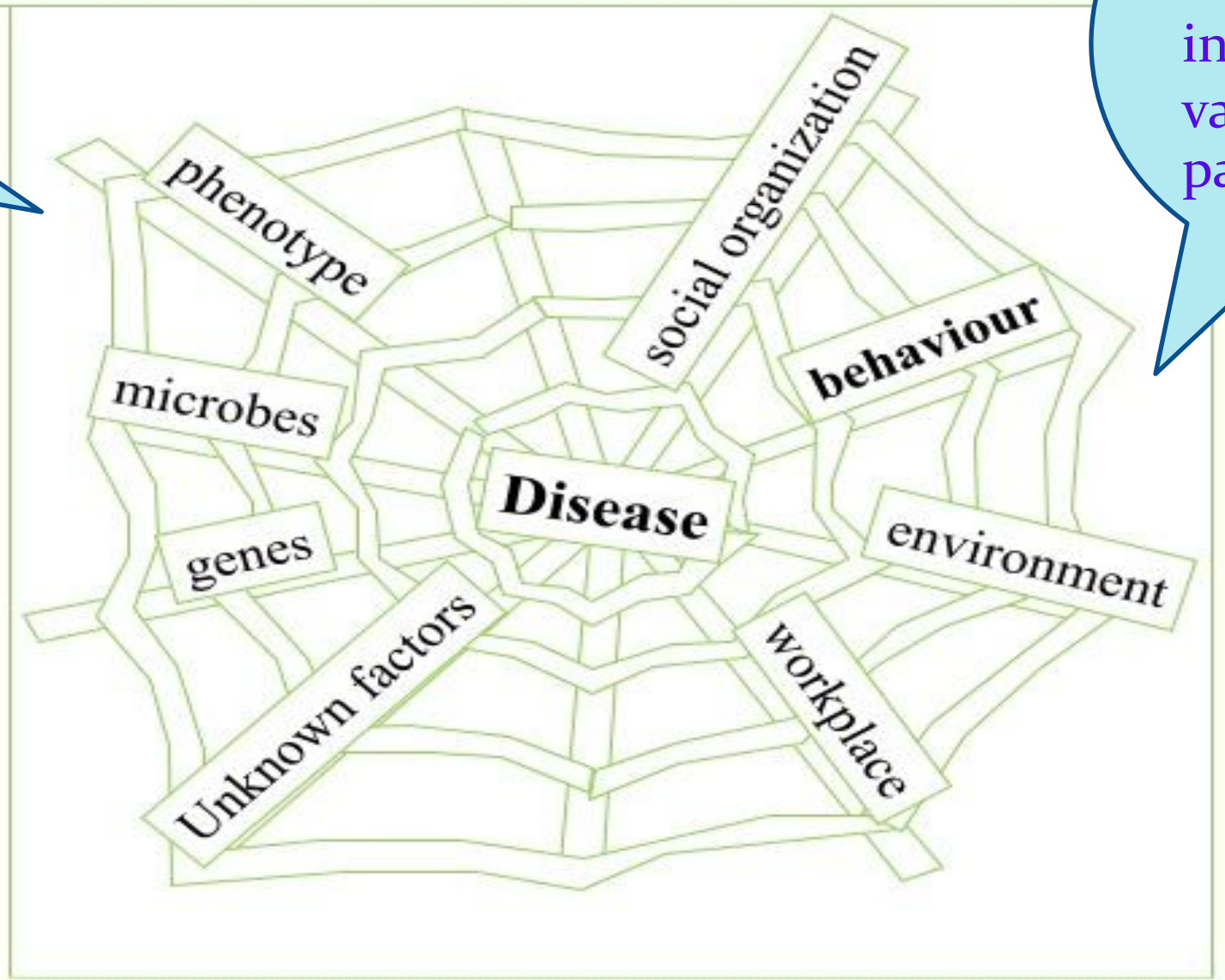
In summary:

- The epidemiologic triad is enhanced to understand communicable diseases.

- Web causation can be used for non- communicable diseases as well as communicable diseases..

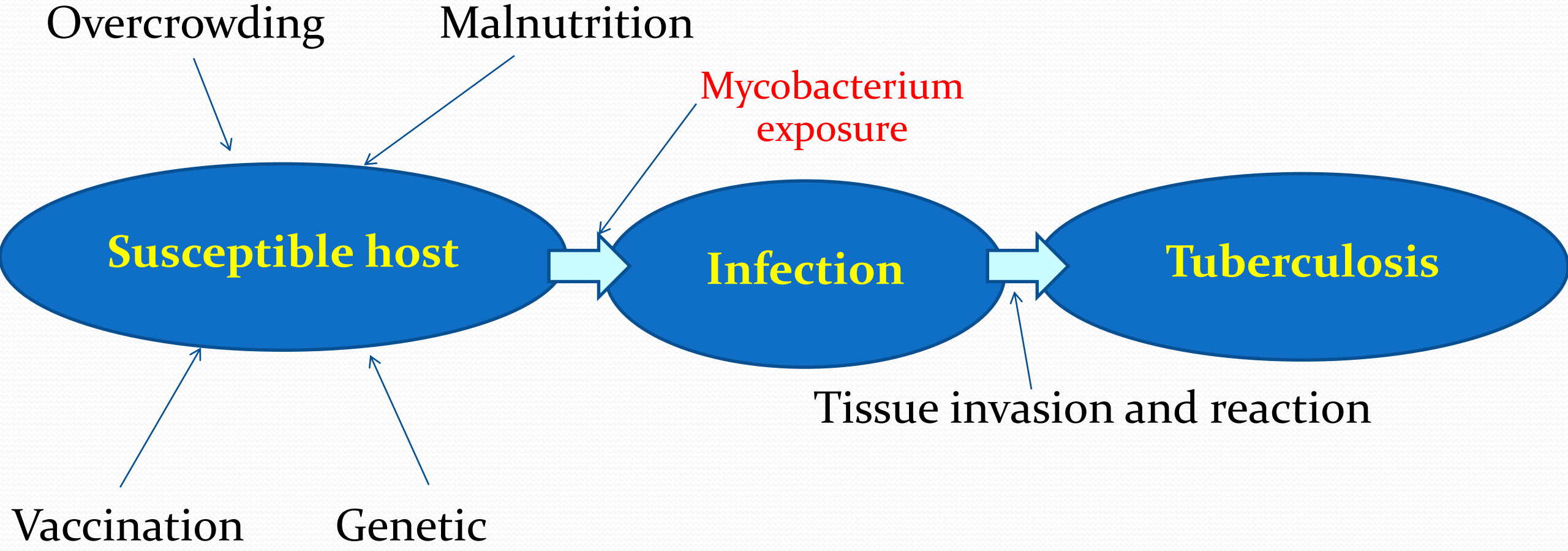
There is no single cause / multi-factorial causes

Web of Causation

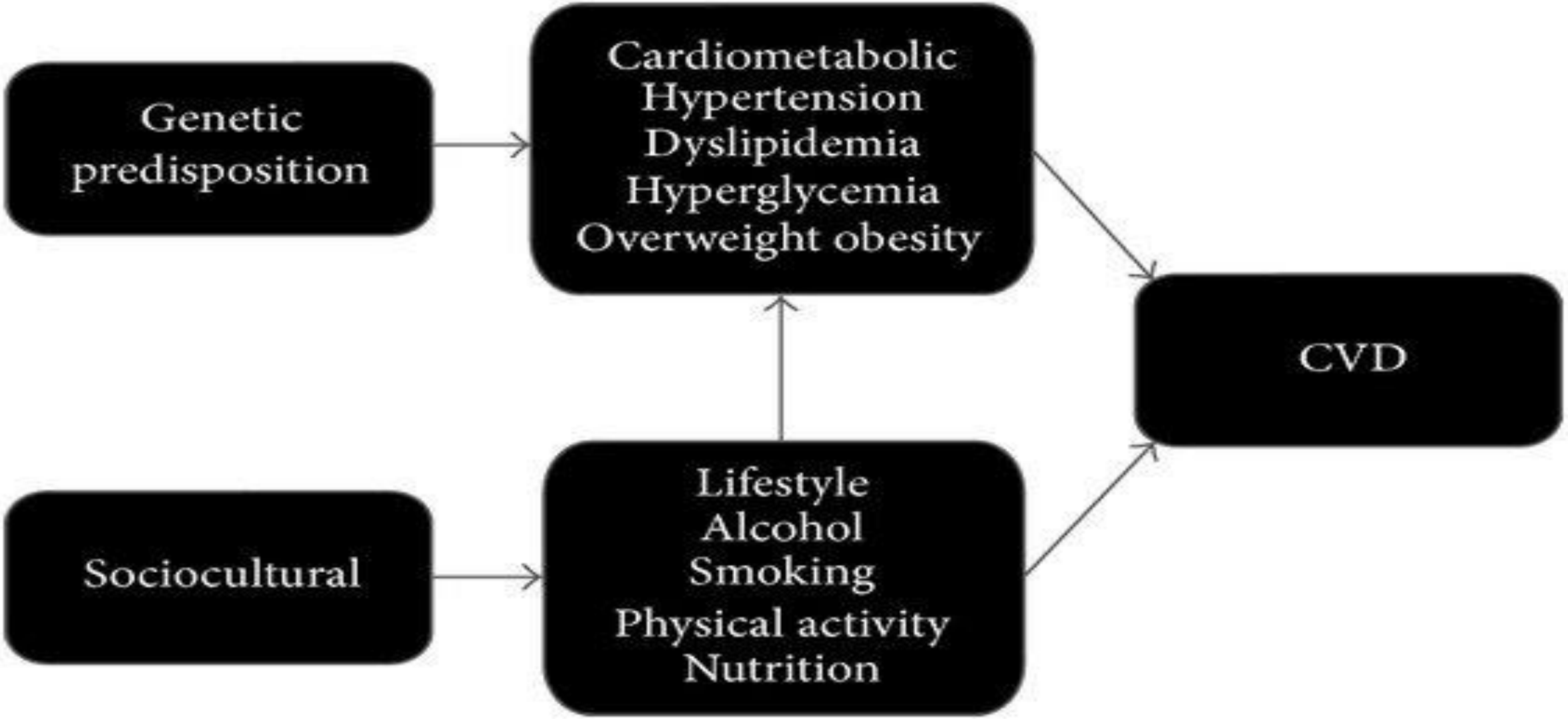


Causes of disease are interacting in various pathways

Example on Web of causation



Example on Web of causation CVD



Wheel theory

• As medical knowledge advanced, an additional aspect of interest that came into play is the comparative role of "genetic" and the "environmental" (i.e. extrinsic factors outside the host) factors in causation of disease.

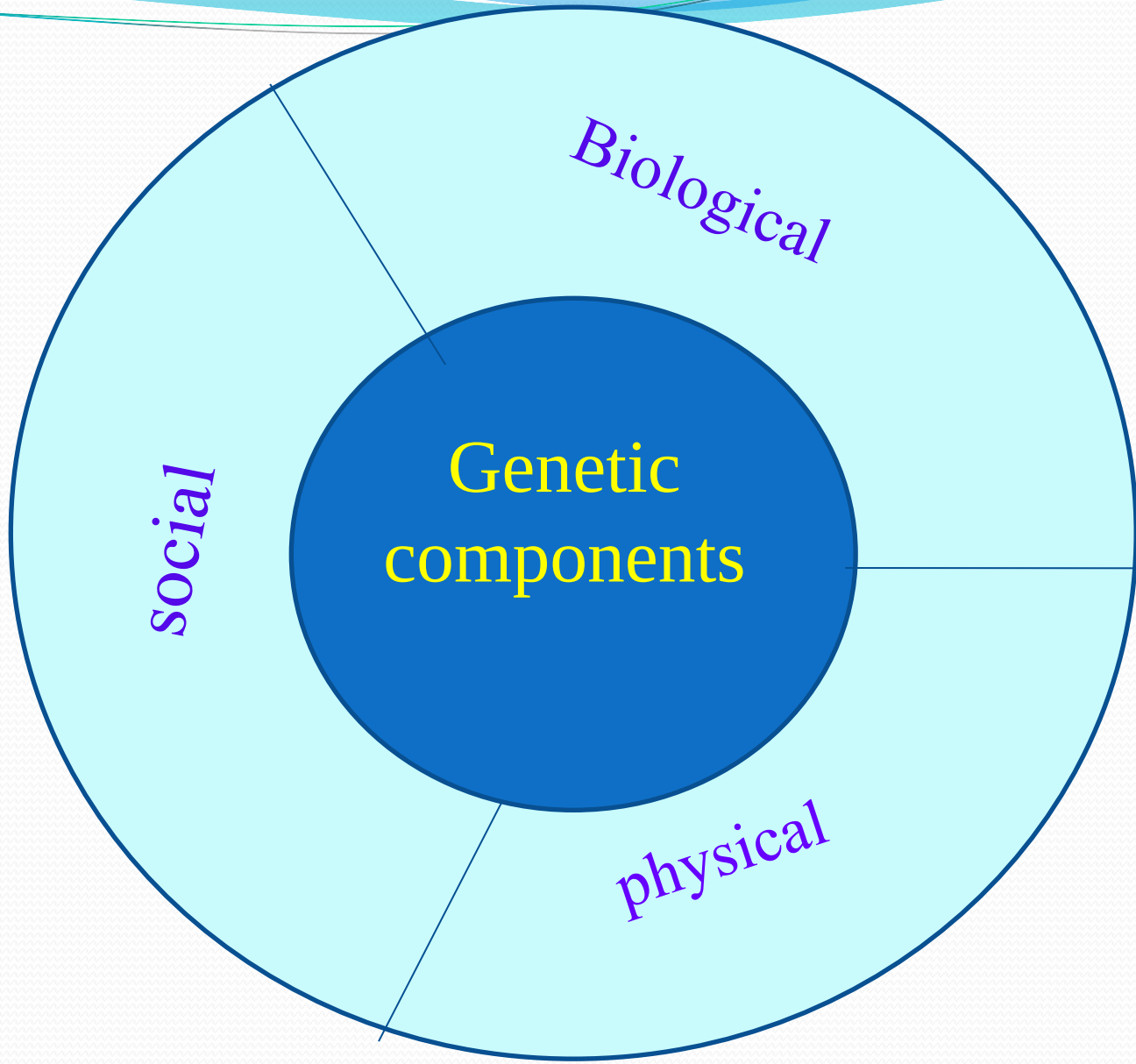
• The "triad" as well as the "web" theory does not adequately cover up this differential.

• To explain such relative contribution of genetic and environmental factors, the "wheel" theory has been postulated.

Wheel theory

• The theory visualizes human disease in the form of a wheel, which has a central hub representing the genetic components and the peripheral portion representing the environmental component.

• Like any wheel, the outer part (environmental component) has spokes (3 in this model) and the environmental component is thus divided into 3 sub components, representing the social, biological and physical components of the environment.



Necessary Vs Sufficient

Necessary

- The presence of this factor always result in disease.
- Example: Rabies virus for rabies

Sufficient

- is not a single factor, but a minimum set of factors and circumstances that, if present in a given individual, will produce the disease.
- Example: Mycobacterium TB for TB

Necessary Causes vs. Sufficient Causes

- If someone says that A (cause)causes B (disease):

- If A is necessary for B (necessary cause) that means you will never have B if you don't have A. In other words, if one thing is a *necessary* cause of another, then it means that the outcome *can never happen* without the cause. However, sometimes the cause occurs without the outcome.

- If A is sufficient for B (sufficient cause), that means that if you have A, you will ALWAYS have B. In other words, if something is a *sufficient* cause, then every time it happens the outcome will follow. The outcome *always follows* the cause. However, the outcome may occur without the cause.

- If A is *neither necessary nor sufficient* for B then sometimes when A happens B will happen. B can also happen without A. The cause sometimes leads to the outcome, and sometimes the outcome can happen without the cause.

- If A is *both sufficient and necessary* for B, B will never happen without A. Furthermore, B will ALWAYS happen after A. The cause always leads to the outcome, and the outcome never happens without the cause.

Examples

All four circumstances are types of causality that occur in the real world. Some examples are:

❖**Necessary but Not Sufficient:** Thus tubercle bacillus is a necessary, not a sufficient cause. This true for most the infectious causes.

❖**Sufficient but Not Necessary:** Decapitation is sufficient to cause death; however, people can die in many other ways. Therefore, decapitation is not necessary to cause death.

❖**Neither Necessary nor Sufficient:** Gonorrhea is neither necessary nor sufficient to cause pelvic inflammatory disease. A person can have gonorrhea without ever developing PID. They can also have PID without ever having been infected with gonorrhea.

❖**Both Necessary and Sufficient:** A gene mutation is both necessary and sufficient for the development of the disease. Everyone with the mutation will eventually develop the disease. No one without the mutation will ever have it.

Thank You