¶ 1.1

$$\Delta \text{Infection} = f(\text{Microbial Invasion}) - f(\text{Host Stability})$$

THE BIOLOGICAL CONTEST AT THE SURFACE



The Microbe's Imperative:

- Get in → Stay in → Multiply.

(Objective: Survive in a rich environment).

The Host's Imperative:

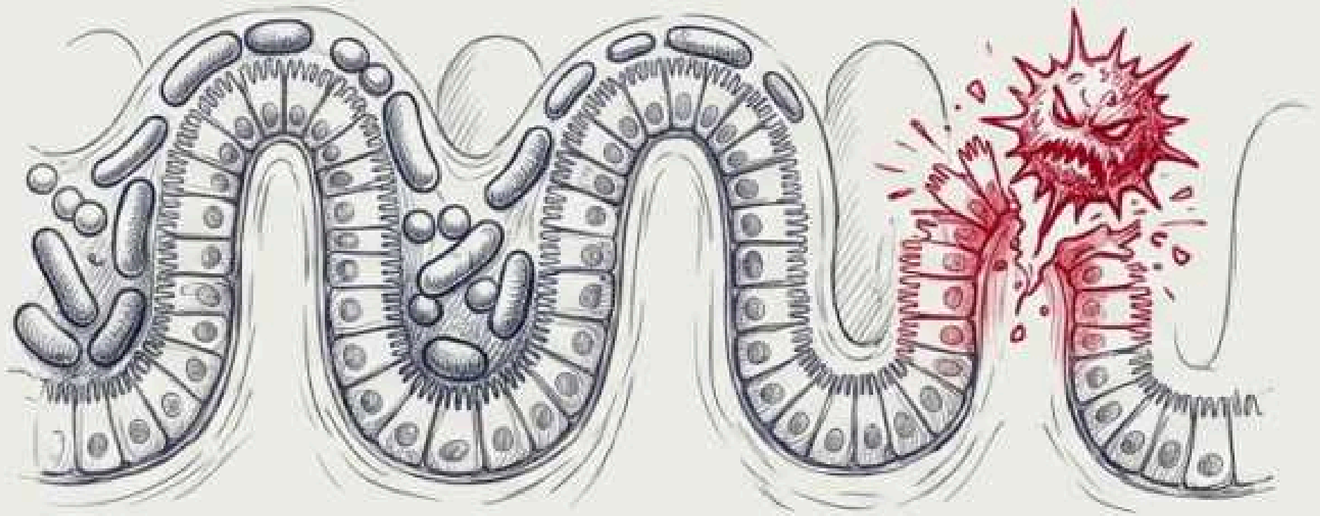
Maintain interior stability
→ Clear unwelcome guests.

The word "war" is a metaphor. Infections are not planned battles; microbes are not generals.

$M_{total} = M_{microbiota} \cup M_{pathogen}$

¶ 1.2

MOST MICROBES DO NOT CAUSE DISEASE



THE MICROBIOTA		PATHOGENS	
Role:	Passengers & helpful partners.	Role:	Capable of causing disease.
Location:	Skin, mouth, gut communities.	Context:	Often cause disease only when the host is weakened or if they reach abnormal, sterile sites.
Function:	Assisting with digestion; occupying space to block dangerous organisms. (High volume, low threat).		

↳ Takeaway: The body is not under constant siege; it is a complex, managed ecosystem.

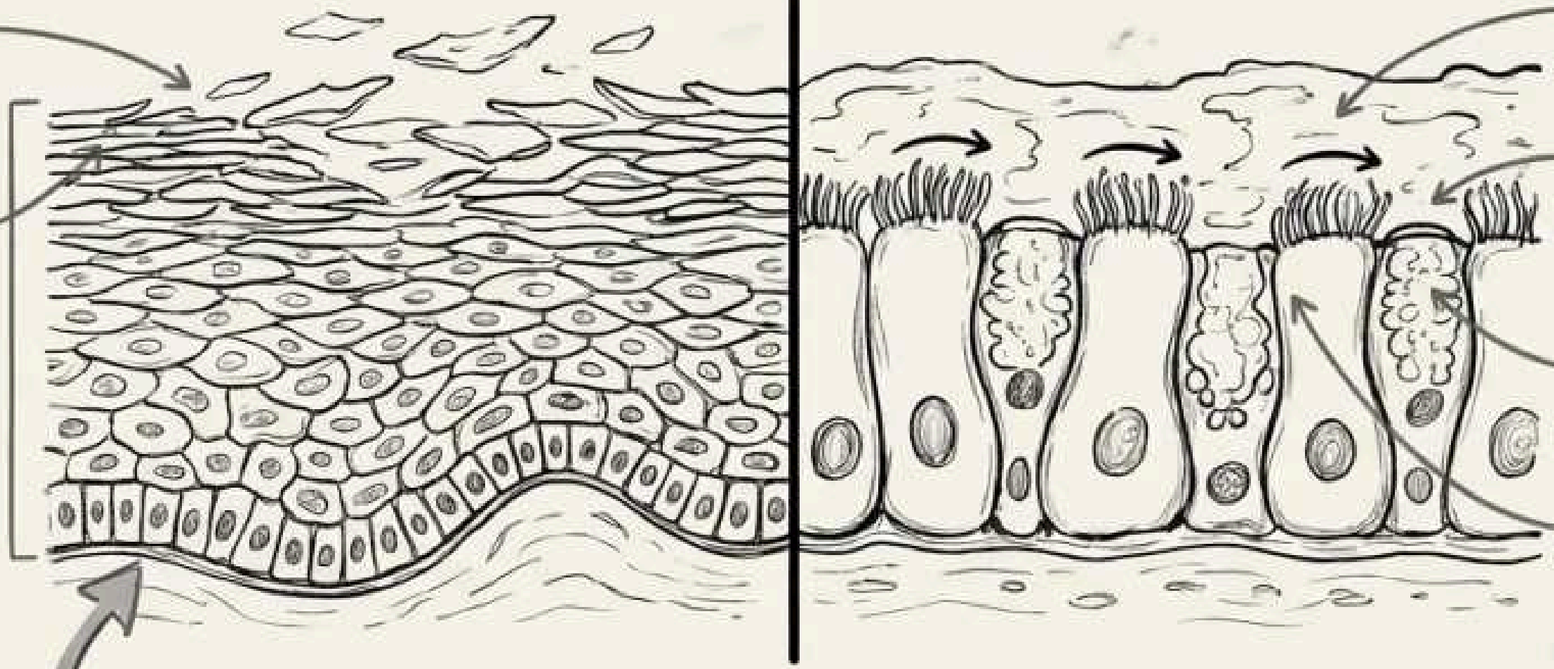
THE FIRST DEFENSES: PHYSICAL AND CHEMICAL BARRIERS

SKIN – THE DRY WALL

- Dry, slightly acidic
- Constantly shedding outer layer
- Result: A poor home for most microbes

MUCOSA – THE WET WALL

- Wetter, more vulnerable
- Active sweeps: Mucus, moving cilia, stomach acid
- Flushing: Urine/tears
- Antibacterial secretions (saliva)

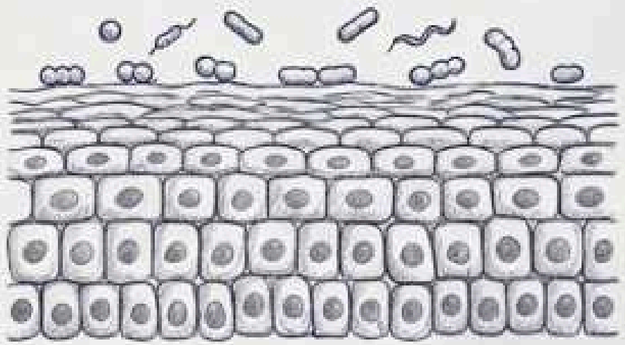


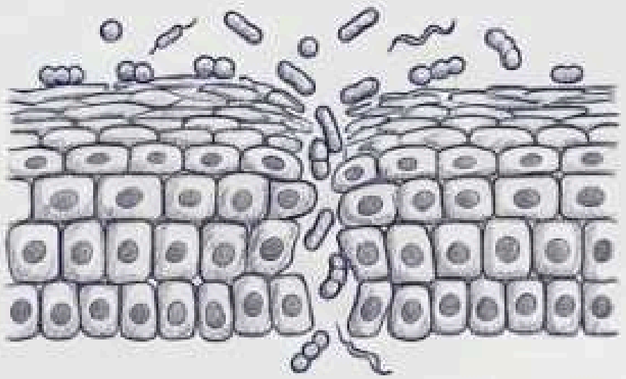
Resistance to infection is largely microbes failing to bypass these ordinary barriers. Breaches (wounds, burns, surgical incisions, tubes) instantly create a route inside.

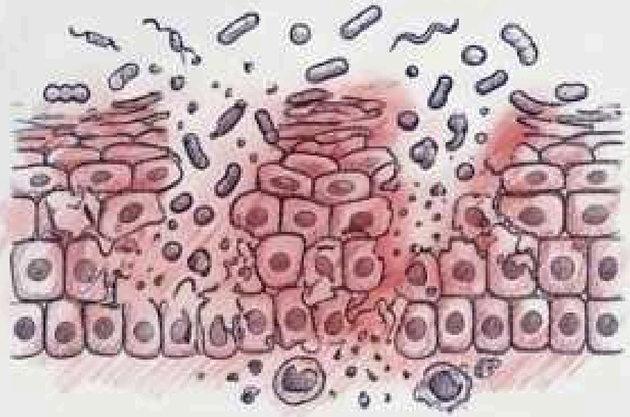
¶ 1.4

Colonisation ≠ Infection ≠ Disease

THE STAGES OF MICROBIAL ESTABLISHMENT







STAGE 1: COLONISATION

Microbe lives on a surface or in a site (e.g., nose/skin carriage). No illness is produced by itself.

STAGE 2: INFECTION

Microbe establishes itself via invasion or multiplication beyond mere surface carriage.

STAGE 3: DISEASE

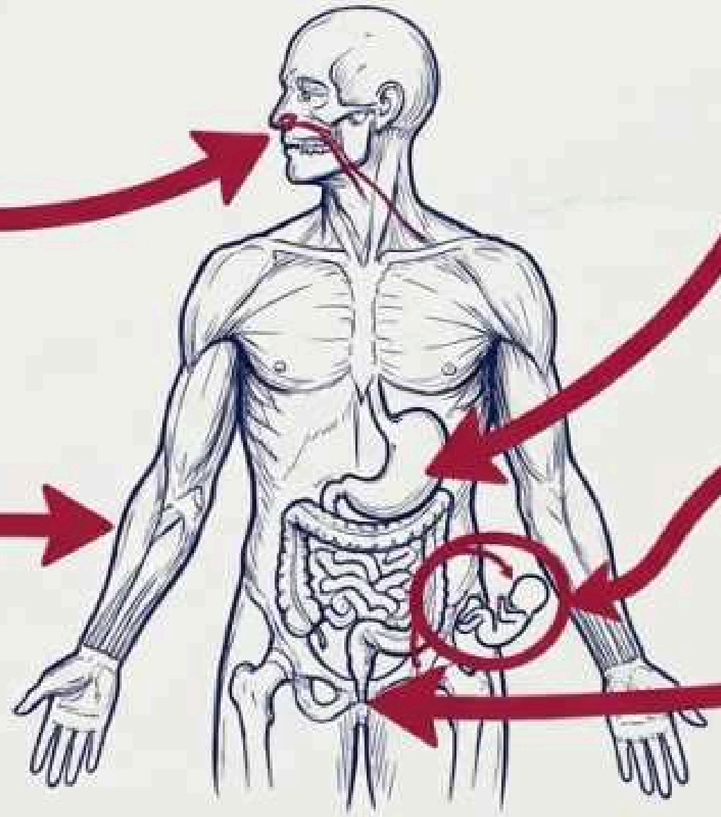
Illness follows, characterized by clinical symptoms and physical tissue damage.

INSIGHT: A single laboratory report name does not tell the whole story. The exact same organism can colonise Person A, mildly infect Person B, and cause severe disease in Person C.

$$\sum \text{Entry Points} = \begin{cases} \text{Inhalation} \\ \text{Ingestion} \\ \text{Trauma} \\ \text{Maternal} \end{cases}$$

¶ 1.5

Pathogenesis Begins at Normal Surfaces



Airways: Inhaling airborne particles.

Skin: Requires a physical break or breach to enter.

Gut: Swallowing contaminated food or water.

Vertical Transmission: Mother passing to child (pregnancy, birth, or breastfeeding).

Urinary/Genital Tracts: Direct contact at mucosal surfaces.

Takeaway: Microbes rarely use exotic devices to enter the body; they exploit ordinary biological openings.

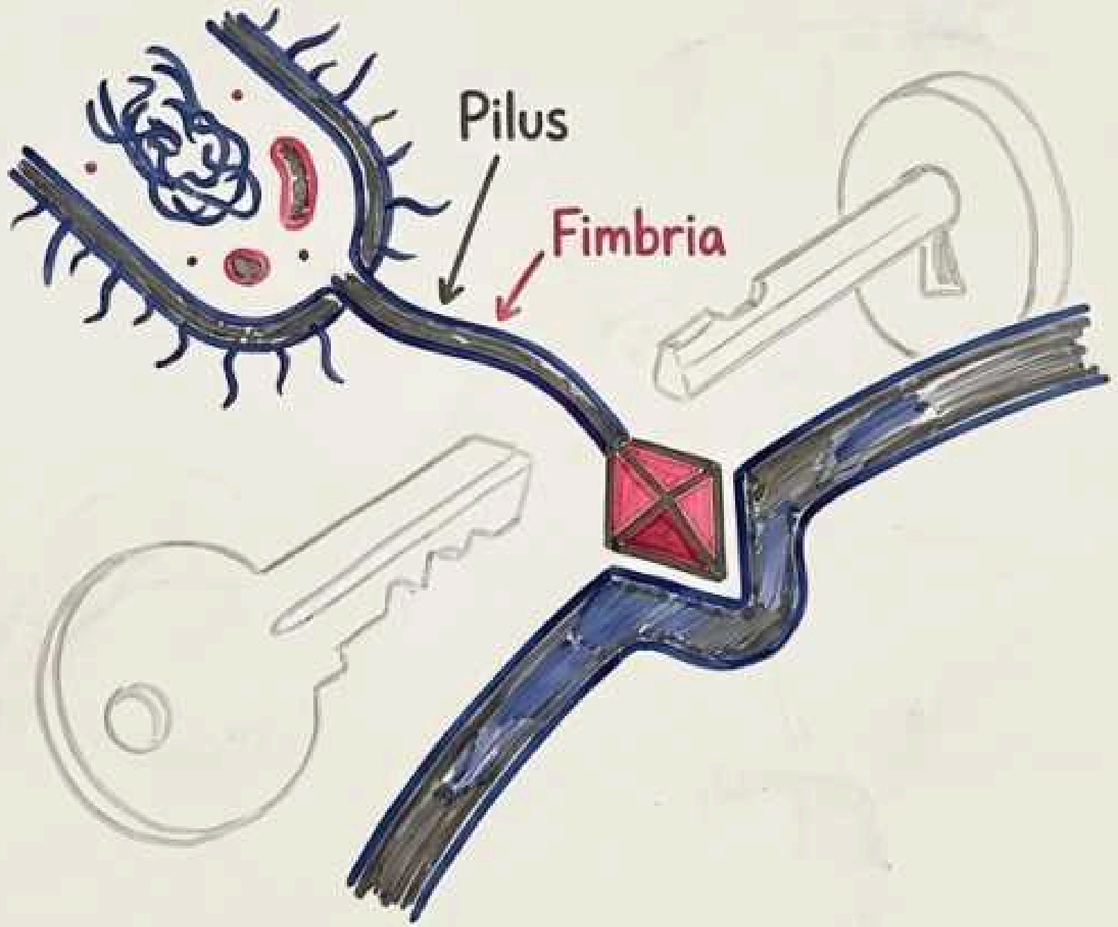
[Ligand] + [Receptor] ⇌ [Ligand-Receptor Complex]

¶ 1.6

Attachment (Adhesion): The First Active Step

The Problem:

- Host surfaces are actively swept by mucus, urine, and gut movement.
- Unattached organisms are simply carried away.



The Solution:

- Microbes utilize surface molecules (pili, fimbriae, or viral surface proteins).
- These fit specific host cell sugars or proteins exactly like a "poorly cut key finding one lock that it can enter."

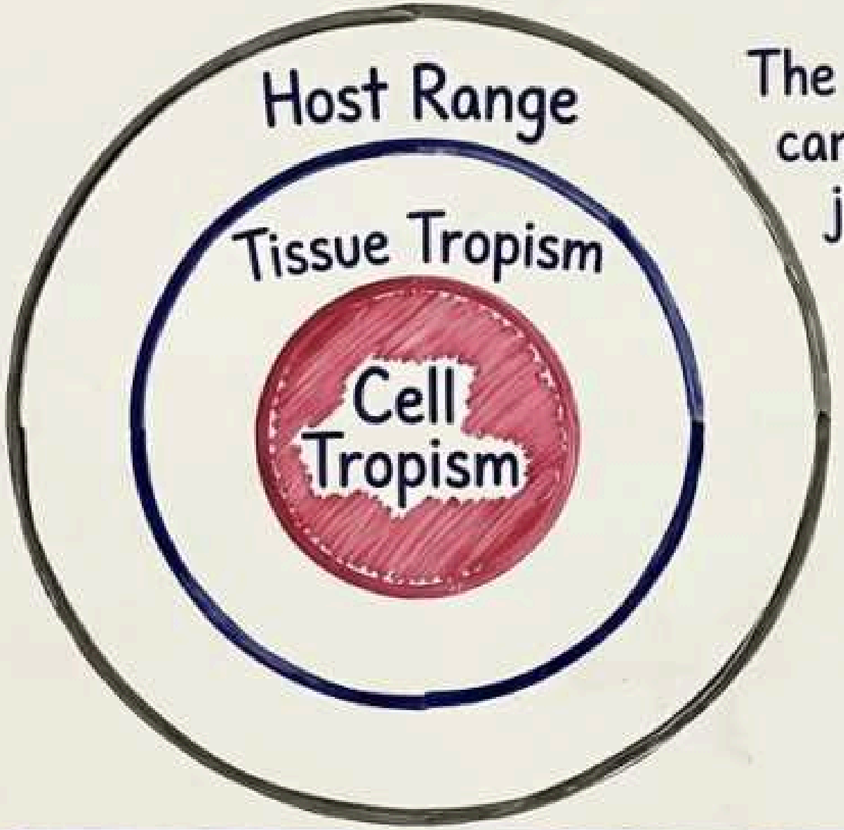
Impact: This precise molecular fit dictates exactly which organ an organism will ultimately settle in.

$$P(\text{Infection}) = f(\text{Receptor Match}) \times f(\text{Host Species})$$

¶ 1.7

Tropism: Preference for the Target

Definition: The biological preference of a microbe for particular tissues, cells, or host species.



The specific set of species a microbe can infect. Includes Zoonosis: diseases jumping between animals and people.

Organ preference (e.g., throat linings vs. bladder linings).

Specific cellular receptor constraints (e.g., a virus entering one kind of human cell but unable to enter another).

Conclusion: "Pathogen" is not a uniform class. A microbe's success is entirely context-dependent.

$$R_{disease} \propto \frac{\text{Microbial Load}}{\text{Host Immunity} - \text{Barrier Breaches}}$$

¶ 1.8

Broken Barriers & The Weakened Host

Risk Multipliers



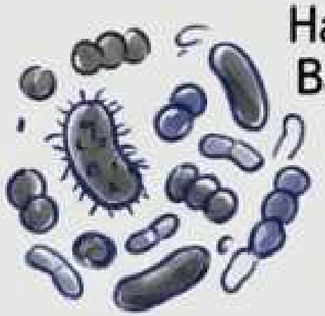
Physical Breaches:
Severe burns, medical devices crossing the skin.

Systemic Weakness:
Advanced diabetes, immunosuppressive drugs or diseases.



Age Extremes:
Very young infants (developing immunity), frail older adults (waning immunity).

The Opportunists:
Organisms that are harmless to a healthy neighbor, but cause illness when the host's defenses are compromised.



Harmless Bacteria

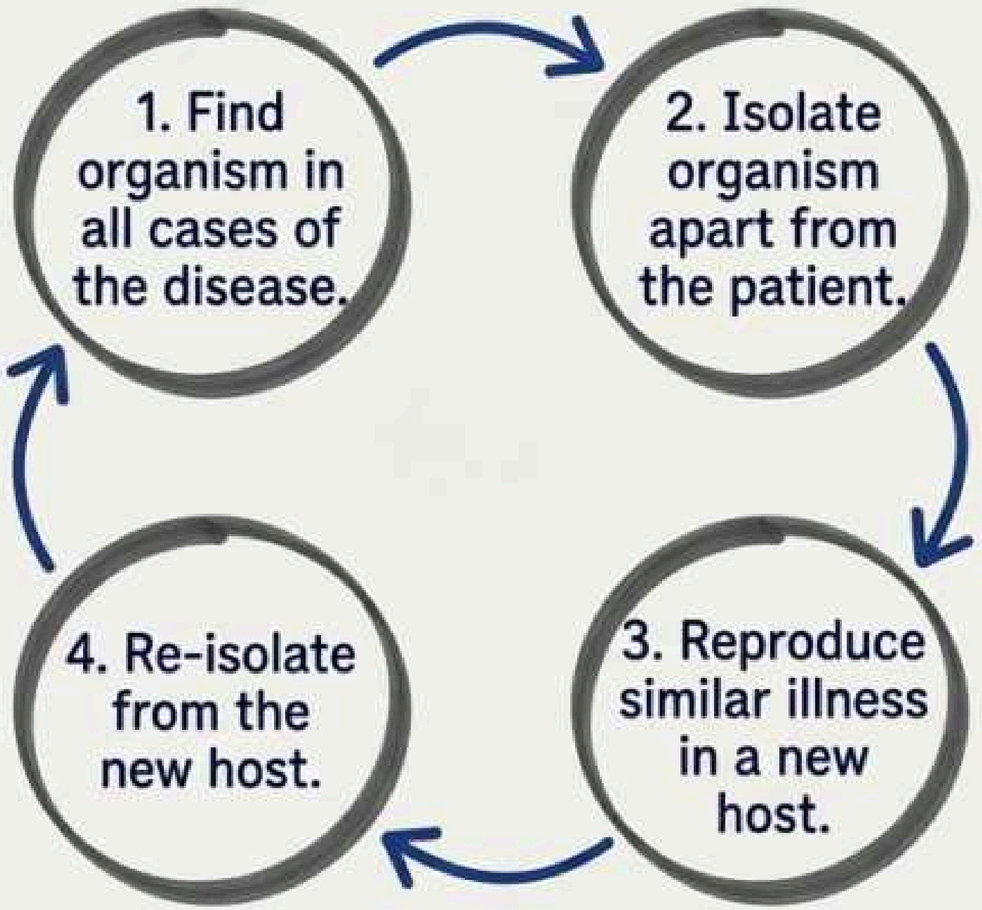
Takeaway: Pathogenesis is a dynamic relationship, not a fixed property of a name on a list.

A → B → C → A'

Proving Causation: Koch's Postulates

¶ 1.9

The Classic Test (Late 19th Century)



The Limitations

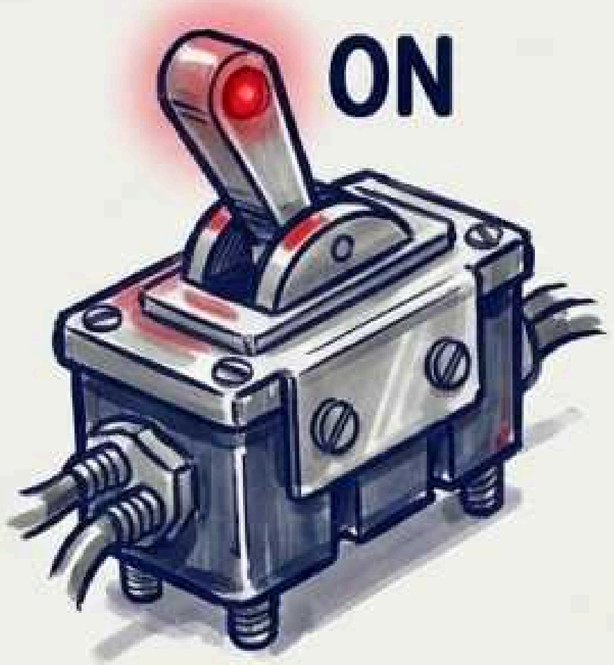
- [X] Asymptomatic carriers: Host has pathogen but no illness.
- [X] Unculturable microbes: Viruses and certain bacteria cannot be grown via traditional methods.
- [X] Polymicrobial diseases: Illness caused by multiple organisms working together.
- [X] Opportunists: Dangerous only in weakened hosts, breaking Postulate 3.

Measuring the Threat: Pathogenicity vs. Virulence

¶ 1.10

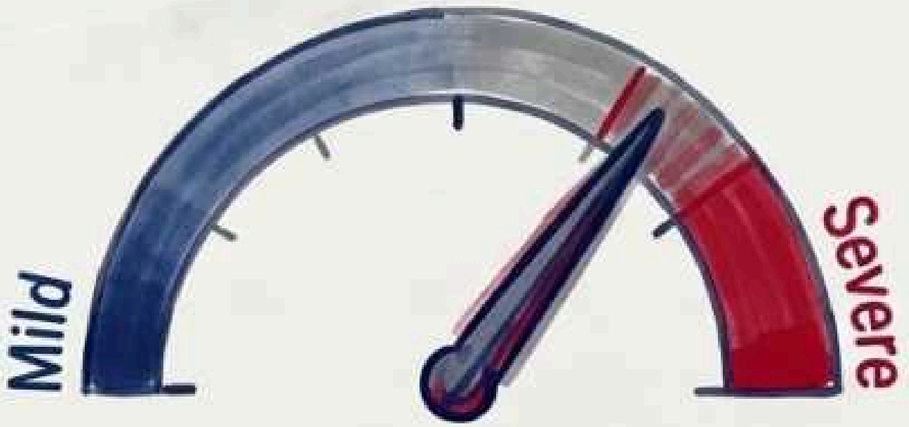
Pathogenicity (The Switch)

$$P \in \{0,1\}$$



$$V = \int (\text{severity})\, d(\text{host, dose, route})$$

Virulence (The Dial)



The degree of that ability; the relative severity of illness produced in a given kind of host.

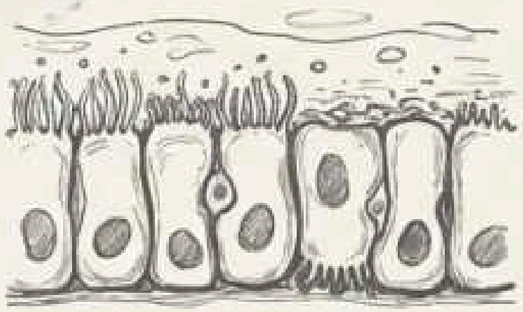
- Variables of Severity (Not a static score):
  - Inoculation dose
  - Route of entry
  - Host's age and immune status

Warning: Do not misuse these terms to rank organisms as static "weapons."

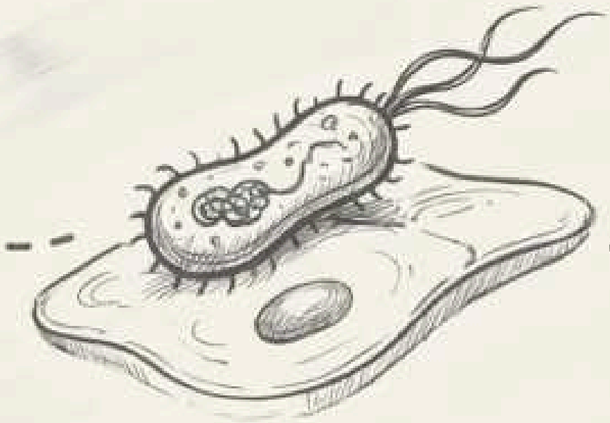
∑ Lecture 1 = Surfaces + Tropism + Barriers

¶ 1.11

Lecture 1 Synthesis & The Next Frontier



The biological contest begins at ordinary body surfaces.



Colonisation does not automatically equal disease.



Attachment, tropism, and barrier integrity dictate the outcomes.

Further Reading:

- Grokipedia (Pathogens, Infection)
- William H. McNeill's Plagues and Peoples

Next Up: Lecture 2

Beyond the Foothold. General mechanisms of clinical injury, focusing on bacterial toxins and host inflammation.