Medical Microbiology and Infection

Curated preclinical study track (not a medical degree, no licensure claim; mechanism tasks and laboratory interpretation only, no treatment regimens). Original explanations and practice only, following the reviewed course handout.

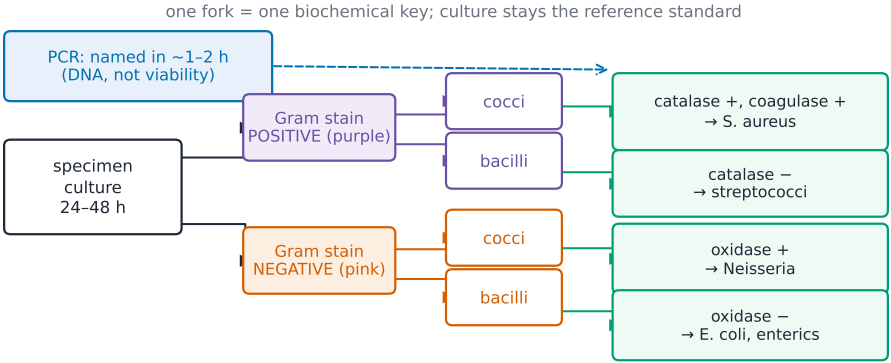
Organisms first, then the negotiation

- Units 8.1-8.4 name the attackers (classification, bacteria, viruses, fungi and parasites); 8.5-8.7 the interaction (transmission, drugs, prevention).
- Every number - doubling times, incubation periods, R_0 - is something you recompute.

Classification and the diagnostic laboratory: fork by fork

1. **Gram chemistry** Crystal violet-iodine trapped by thick **peptidoglycan** $\rightarrow$ purple; thin wall + outer membrane loses it $\rightarrow$ pink counterstain.
2. **Report walk** Gram-positive cocci in clusters; catalase + (not streptococci); coagulase + $\rightarrow$ Staphylococcus aureus.
3. **Fast lane PCR** names DNA in ~1-2 h (meningitis); culture 24-48 h proves viability and susceptibility.

The classification tree from specimen to named organism



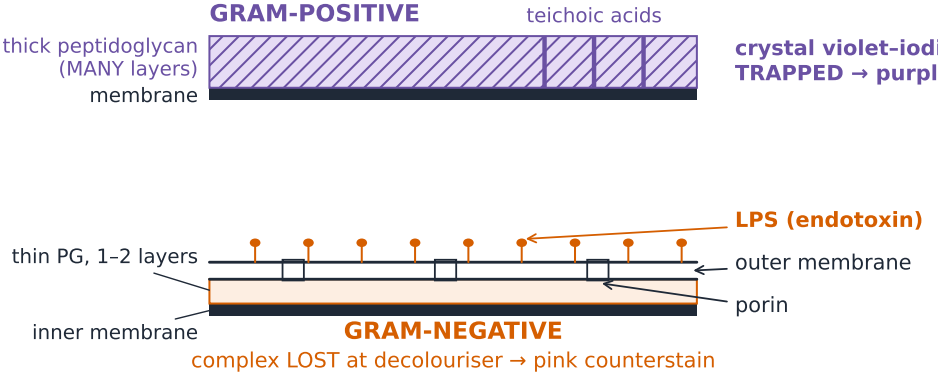
Gram stain first, then shape, then biochemistry; **PCR** is the fast lane.

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Bacteria: structure, growth and pathogenesis - the wall decides

1. **Walls** Gram-positive: many **peptidoglycan** layers + teichoic acids. Gram-negative: 1-2 layers + outer membrane with LPS (endotoxin) and porins.
2. **Growth** $N = N_0$ doubled (t ÷ g) times; a 20-minute doubler makes $2^{30} \approx 10^9$ cells in 10 h; a 20-hour doubler manages half a generation.
3. **Virulence Capsule** defeats phagocytosis (the clear halo on a pneumococcal stain); exotoxins are secreted proteins with named targets.

Gram-positive versus Gram-negative cell walls



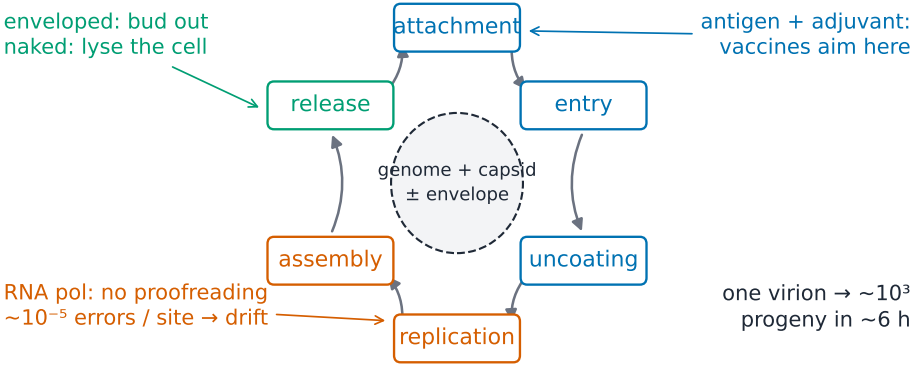
Thick **peptidoglycan** with teichoic acids versus thin peptidoglycan inside an LPS outer membrane.

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Viruses: six steps around one cell

1. **Cycle** Attachment $\rightarrow$ entry $\rightarrow$ uncoating $\rightarrow$ replication $\rightarrow$ assembly $\rightarrow$ release; enveloped viruses bud, naked viruses lyse.
2. **Burst** One virion $\rightarrow$ $\sim 10^{3}$ progeny in $\sim$6 h; two rounds $\rightarrow$ 10^{6}; a 1-2 day incubation is 4-8 rounds.
3. **Drift and shift** No proofreading $\rightarrow$ $\sim 10^{-5}$ errors per site $\rightarrow$ **antigenic drift** (yearly vaccines); 8 segments reassort $\rightarrow$ **antigenic shift** (pandemics).

The virus replication cycle



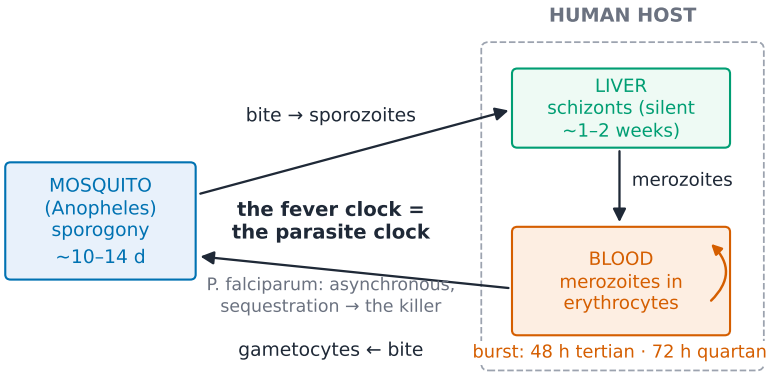
Attachment, entry, uncoating, replication, assembly, release - every antiviral target sits on it.

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Fungi and parasites: two hosts, one clock

1. **Dimorphism** Mould at 25 °C in the environment, yeast at 37 °C in tissue - the thermostat is the identity card.
2. **Malaria cycle Sporozoites** → liver schizonts → erythrocytic **merozoites** → **gametocytes** → next mosquito; synchronous bursting every 48 h (tertian) or 72 h (quartan).
3. **The exception** P. falciparum: asynchronous, sequestering - irregular fevers but the killer.

The malaria life cycle between mosquito and human



Liver stage, blood stage, gametocyte stage - each stage names a target.

Transmission: the chain and R_0

1. **Chain** Reservoir → exit → route (contact, droplet, airborne, vector, vehicle) → entry → susceptible host.
2. **R_0 clock** Measles ~12-18, SARS-CoV-2 ancestral ~2.5-3, influenza ~1.3; doubling time = SI × log 2 / log R_0 (flu ~5-8 d, measles ~2.5-3 d).
3. **Outbreak page one** 54/120 ill = 45% **attack rate**; stratify once by dish (85% vs 10%) and the vehicle is named.

The chain of infection with its transmission routes

carriers make reservoirs silent — sick patients are not the only source



break any ONE link → transmission stops

R_0 (secondary cases, fully susceptible population):

measles	**12–18**
SARS-CoV-2 (ancestral)	**2.5–3**
influenza	**1.3**

doubling $t_d \approx \mathrm{SI} \cdot \log 2 / \log R_0$

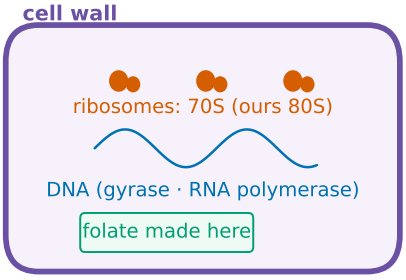
flu ~5–7 d · measles ~2.5–3 d

Five links; break any one and transmission ends.

Antimicrobials: four targets, resistance arithmetic

1. **Targets** Wall (β-lactams $\rightarrow$ penicillin-binding proteins), ribosome (30S/50S vs our 40S/60S), gyrase/RNA polymerase, folate (bacteria make it, we import it).
2. **Arithmetic** Resistance mutations 10^{-7}-10^{-9} per cell per generation; $\sim 10^{9}$ cells per mL overnight $\rightarrow$ mutants against any single drug; two hits multiply to 10^{-14}-10^{-18}.
3. **Report read** β-lactamase opens the ring (hydrolysis); PBP2a is the altered target - different mechanisms, different reports.

Drug targets on a bacterium



selective toxicity: a target we lack

wall	β-lactams → PBPs
ribosome	30S/50S; ours spared
DNA, RNA	gyrase, RNA pol.
folate	blocked; we import it

resistance: mutation (10^{-7}–10^{-9} per division) + plasmid transfer

Wall, ribosome, DNA enzymes, folate - four bacteria-specific targets on one cell.

Prevention: match the level to the physics

1. **Levels** Standard (every patient) + contact / droplet / airborne; droplets > 5 µm fall within ~1-2 m; ≤ 5 µm drift for hours.
2. **Ladder** Cleaning $\rightarrow$ disinfection (vegetative cells only) $\rightarrow$ **sterilisation** (steam 121-134 °C or chemical).
3. **Clocks** Staff flu vaccination 40% $\rightarrow$ 90% cuts the susceptible-staff fraction 60% $\rightarrow$ 10% (six-fold); a surgical-site cluster on days 5-7 dates the breach.

The precaution levels and their transmission routes

level	route physics	what you add	examples
airborne	≤ 5 µm, suspended for hours, rides air	respirator + neg.-pressure room	*measles, TB*
droplet	> 5 µm, falls within ~1–2 m of the source	surgical mask within 1–2 m	*influenza*
contact	hands, surfaces, fomites, wounds	gloves, gown, single room	*C. difficile, MRSA*

STANDARD PRECAUTIONS: every patient
hand hygiene · gloves if exposure expected



Standard for everyone; add the level that matches the route - contact, droplet or airborne.

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Check yourself

- Gram-positive stains purple because…? (Thick **peptidoglycan** traps the crystal violet-iodine complex.)
- A 20-minute doubler in 10 h gives…? (30 generations, $\sim 10^{9}$ cells.)
- Tertian fever periodicity is…? (48-hour synchronous erythrocytic bursting.)
- Two independent resistance mutations multiply to…? ($\sim 10^{-14}$-10^{-18}.)