

Medical Immunology

Curated preclinical study track (not a medical degree, no licensure claim). Original explanations and practice only, following the reviewed course handout.

The defence network

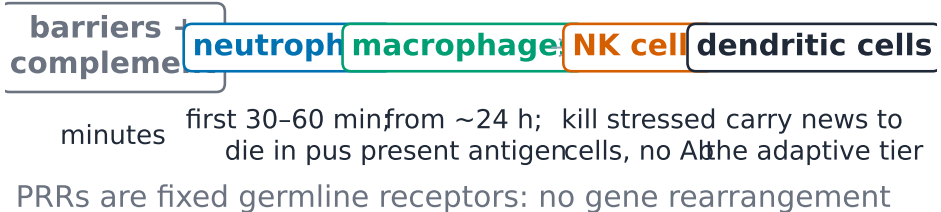
- Innate first, recognition and activation next, memory, then the four failure modes (allergy, autoimmunity, deficiency, rejection).
- Mechanism predicts lesion: every defect traced to the cell or signal that failed.

Innate immunity: the fast tier

- 1 **Map** Barriers → **complement** → neutrophils (30–60 min, die in pus) → macrophages (~24 h, present) → NK → dendritic cells (the courier).
- 2 **Receptors** PRRs are fixed germline receptors: fast, generic, no memory - but dendritic **co-stimulation** teaches the adaptive tier.
- 3 **Numbers** Neutrophils 50–70% of white cells; marrow reserve $\sim 10^{11}$ sustaining $\sim 10^9$ /min; febrile neutropenia ($< 0.5 \times 10^9$ /L) is an emergency.

Innate immunity - figure

fast, generic, no memory — but it teaches



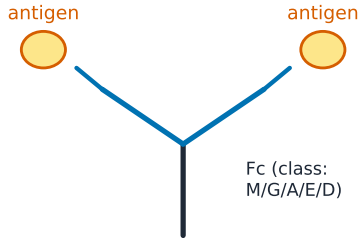
Each innate cell with its job and timeline.

Antigen recognition: two chemistries

- 1 **Antibody** Ig (M first, G memory/transfer, A mucosa, E allergy) binds FREE antigen, whole shape; Fc region sets the class job.
- 2 **TCR + MHC** T cells see ONLY peptide in MHC: MHC-I (all cells, cytosol → CD8); MHC-II (professionals, eaten → CD4).
- 3 **Diversity** V(D)J recombination + junctional diversity → over 10^{11} possible receptors; class switch + **affinity maturation** 10- to 1000-fold.

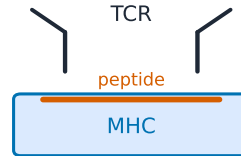
Antigen recognition - figure

antibody: B cells see the whole shape



the T-cell view

CD8 → MHC-I (cytosol)
CD4 → MHC-II (eaten)



T cells see peptide in MHC only

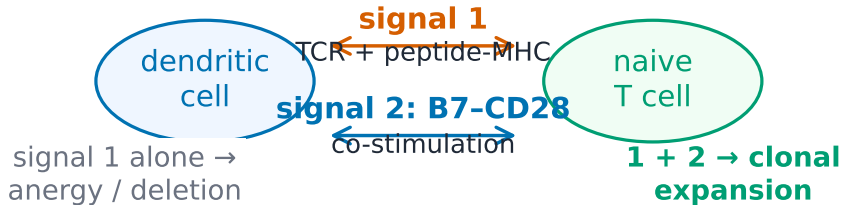
Antibody binding antigen beside MHC-peptide-TCR.

Adaptive responses: the gate and the arithmetic

- 1 Division** CD4 helps (macrophages, B switching via CD40L); CD8 kills (granules, Fas); B → plasma (thousands of Ig/second) + memory.
- 2 Gate** Signal 1 alone → anergy/deletion; signal 1 + **co-stimulation** (B7–CD28) → clonal expansion - the tolerance/activation decision.
- 3 Arithmetic** One naive cell doubling ~6-hourly: $2^{12} \approx 4000$ by day 3, $\sim 10^6$ by day 5; CD8 >1000-fold of the specific pool.

Adaptive responses - figure

the gate: tolerise or activate

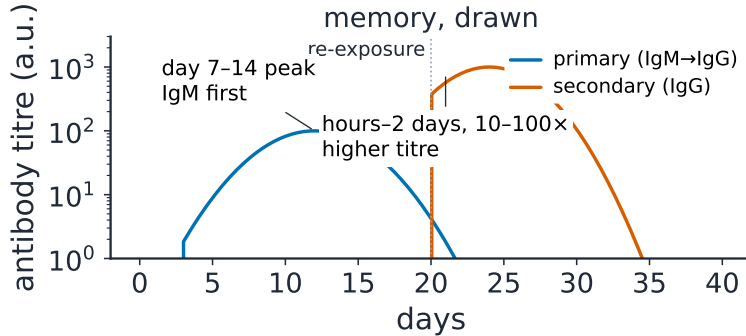


Signal 1 + **co-stimulation**: tolerise or activate.

Immunological memory: the curve

- 1 **Primary** Lag 4–7 d, IgM→IgG, peak day 7–14, modest titre.
- 2 **Secondary** Hours–2 d, IgG at once, 10–100× higher, higher affinity: memory cells wait at higher frequency, pre-matured.
- 3 **Herd** Threshold $1 - 1/R_0$: measles (R_0 12–18) → 92–95%; influenza (1.3) → ~25% - one equation sets policy.

Immunological memory - figure



Primary vs secondary **antibody** curves (log scale).

Hypersensitivity: four clocks

- 1 **I** IgE + mast cells, minutes: allergy, anaphylaxis - adrenaline IM is the decision.
- 2 **II/III** IgG on cells (hours: transfusion, haemolysis); immune complexes (days: serum sickness, nephritis).
- 3 **IV** T cells, 48–72 h: contact dermatitis, TB skin test - antihistamines useless, steroids work.

Hypersensitivity - figure

the clock names the mechanism

I — immediate	IgE + mast cells	minutes	anaphylaxis
II — cytotoxic	IgG on cells	hours	haemolysis
III — complexes	immune complex deposit	days	serum sickness
IV — delayed	T cells	48-72 h	contact dermatitis

Four types compared with clocks and examples.

Autoimmunity: two filters

- 1 **Central** Thymus/marrow delete strongly self-reactive cells and breed Treg (FOXP3⁺) - AIRE failure names polyglandular disease.
- 2 **Peripheral** Anergy (no signal 2), Treg suppression (IL-10/TGF- β) - FOXP3 failure names IPEX.
- 3 **Balance** Twin concordance 30–50% (T1D): HLA loads, environment and chance pull; mimicry (rheumatic fever) turns anti-strep onto the heart.

Autoimmunity - figure

two filters, because each alone leaks

CENTRAL

thymus + marrow:
delete strongly self-reactive;
breed Treg (FOXP3⁺)

fails → AIRE:
polyglandular

PERIPHERAL

anergy (no signal 2);
Treg suppression (IL-10, TGF- β);
inhibitory receptors

fails → FOXP3:
IPEX

Central and peripheral checkpoints with failure genes.

Immunodeficiency: the organism names the arm

- 1 Map** Neutrophils → abscesses/catalase-positive/fungi; C5-9 → Neisseria; T cells (SCID, HIV) → opportunists; B cells (XLA) → encapsulated, from ~6 months.
- 2 Clocks** Onset age localises: T defects from birth; B defects when maternal IgG wanes; **neutrophil** defects neonatal abscesses.
- 3 Transplant** Hyperacute = **antibody** (minutes), acute = T cells (days), chronic = scarring (months); immunosuppressives turn 7.3 signals down (calcineurin → IL-2).

Immunodeficiency - figure

the organism names the failed arm

neutrophil defect

abscesses; catalase+ bacteria, fungi

complement C5-9

Neisseria meningitis

T-cell defect (SCID, HIV)

Pneumocystis, Candida, viruses, mycobacteria

B-cell defect (XLA)

encapsulated bacteria, from ~6 months
rejection clock: antibody (min) → T cells (days) → scarring (months)

Defect-to-infection map plus the rejection clock.

Check yourself

- First cells at a breach? (Neutrophils, 30–60 min.)
- T cells see antigen only as —? (Peptide in MHC.)
- Herd threshold for measles? (~92–95 %.)
- The day-3 eczematous reaction type? (IV - T cells.)