Medical Immunology

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

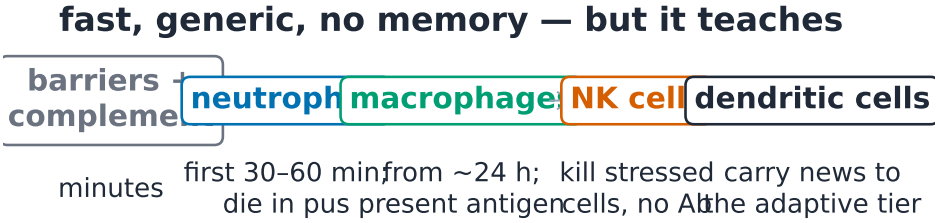
The defence network

- 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

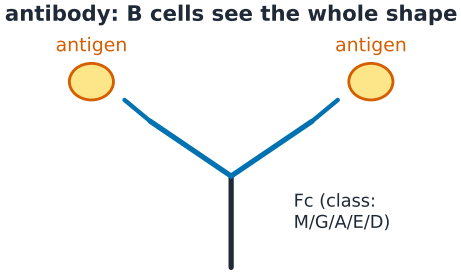


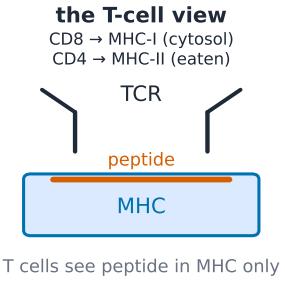
Each innate cell with its job and timeline.

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 $\rightarrow$ CD8); MHC-II (professionals, eaten $\rightarrow$ CD4).
3. **Diversity** V(D)J recombination + junctional diversity $\rightarrow$ over 10^{11} possible receptors; class switch + **affinity maturation** 10- to 1000-fold.

Antigen recognition - figure



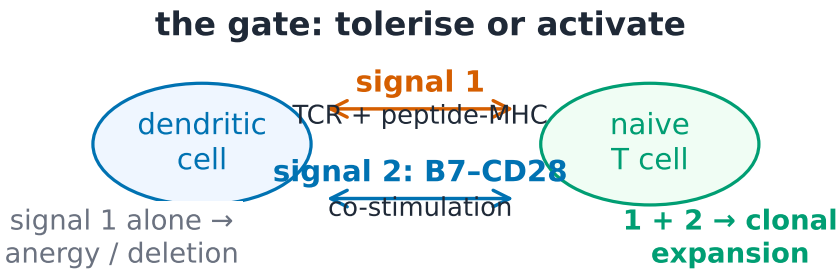


Antibody binding antigen beside MHC-peptide-TCR.

Adaptive responses: the gate and the arithmetic

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

Adaptive responses - figure

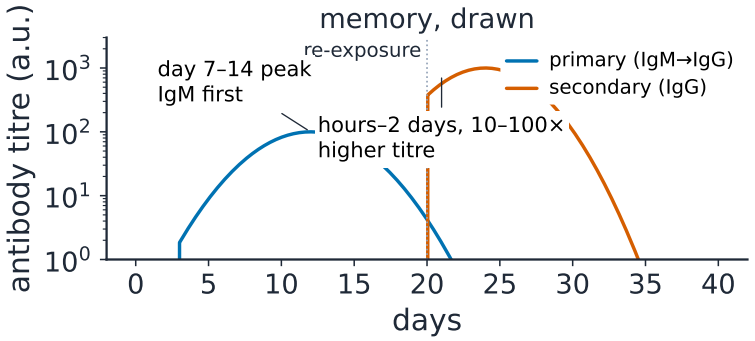


Signal 1 + **co-stimulation**: tolerise or activate.

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

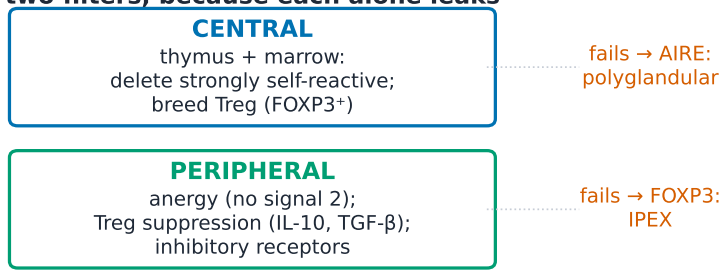
I — immediate	IgE + mast cells	minutes	anaphylaxis
II — cytotoxic	IgG on cells	hours	haemolysis
III — complexes	immune complex deposit	days	serum sickness
IV — delayed	T cells	48–72 h	contact dermatitis

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



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.)