UNIVERSITY MEDICINE • EXERCISE SHEET

7.3 Adaptive responses: T and B cells

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

KEY WORDS co-stimulation

Objective

Apply the two-signal rule and compute clonal expansion.

1 Key knowledge and worked examples

■ **The gate**

Signal 1 alone → anergy/deletion; signal 1 + co-stimulation → clonal expansion ✓. CD4 helps, CD8 kills.

■ **Worked example: the arithmetic**

Doubling ~6-hourly: $2^{12} \approx 4000$ by day 3; ~$2^{20} \approx 10^6$ by day 5 ✓. Adjuvant = signal 2.

2 Practice

2.1 What happens to a T cell that gets signal 1 only? [3]

2.2 Name the co-stimulatory pair. [3]

2.3 Which T-cell subset helps B cells class-switch? [3]

3 Exam-style questions

3.1 A vaccine contains purified protein with adjuvant (fictional).

Explain why the adjuvant is necessary (signal 2 via PRR-activated dendritic cells). Predict the response without it. Explain how the two-signal rule prevents autoimmunity to quiet self antigens. [7]

3.2 A boy has recurrent pyogenic infections, high IgM, and absent IgG/IgA (fictional hyper-IgM).

Name the defective molecule (CD40L) and its direction (T→B). Explain BOTH infection patterns (no switching → no IgG; no macrophage activation → opportunists). State the inheritance and why. [7]

Solutions

2.1

- Anergy or deletion – tolerance.

2.2

- B7 (dendritic) – CD28 (T cell) ✓.

2.3

- CD4 (TH) via CD40L–CD40 contact ✓.

3.1

- Protein alone gives signal 1 without PRR-driven B7 – tolerance or a weak response.
- Without adjuvant: little/no antibody, possible anergy ✓.
- Quiet self-presentation never carries B7, so self-reactive clones are tolerised – autoimmunity needs danger to license them.

3.2

- CD40L (CD154) on T cells, missing – X-linked.
- No CD40 signal: B cells cannot switch (IgM piles) → pyogenic (encapsulated) infections; macrophages are not activated → opportunists (Pneumocystis, Cryptosporidium).
- X-linked recessive: mother carrier, half of sons affected ✓.