Collaborative Bio-Inspired Algorithms
Lecture 7: Immunology

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Outline

Classical View

Cognitive Immune System

Danger

Summary

What is the Immune System?

Classic View

a complex system of cellular and molecular components having the primary function of distinguishing self from not self and defense against foreign organisms or substances

Cognitive View

The immune system is a cognitive system whose primary role is to provide body maintenance [1]

Danger View

The immune system recognises dangerous agents and not non-self [5]

What is the Immune System?

- The purpose of the immune system is defence
- Innate and acquired immunity
  - Innate is the first line of defense. Germ line encoded (passed from parents) and is quite “static” (but not totally static)?
  - Adaptive (acquired). Somatic (cellular) and is acquired by the host over the life time. Very dynamic.
- These two interact and affect each other

Multiple Layers of the Immune System

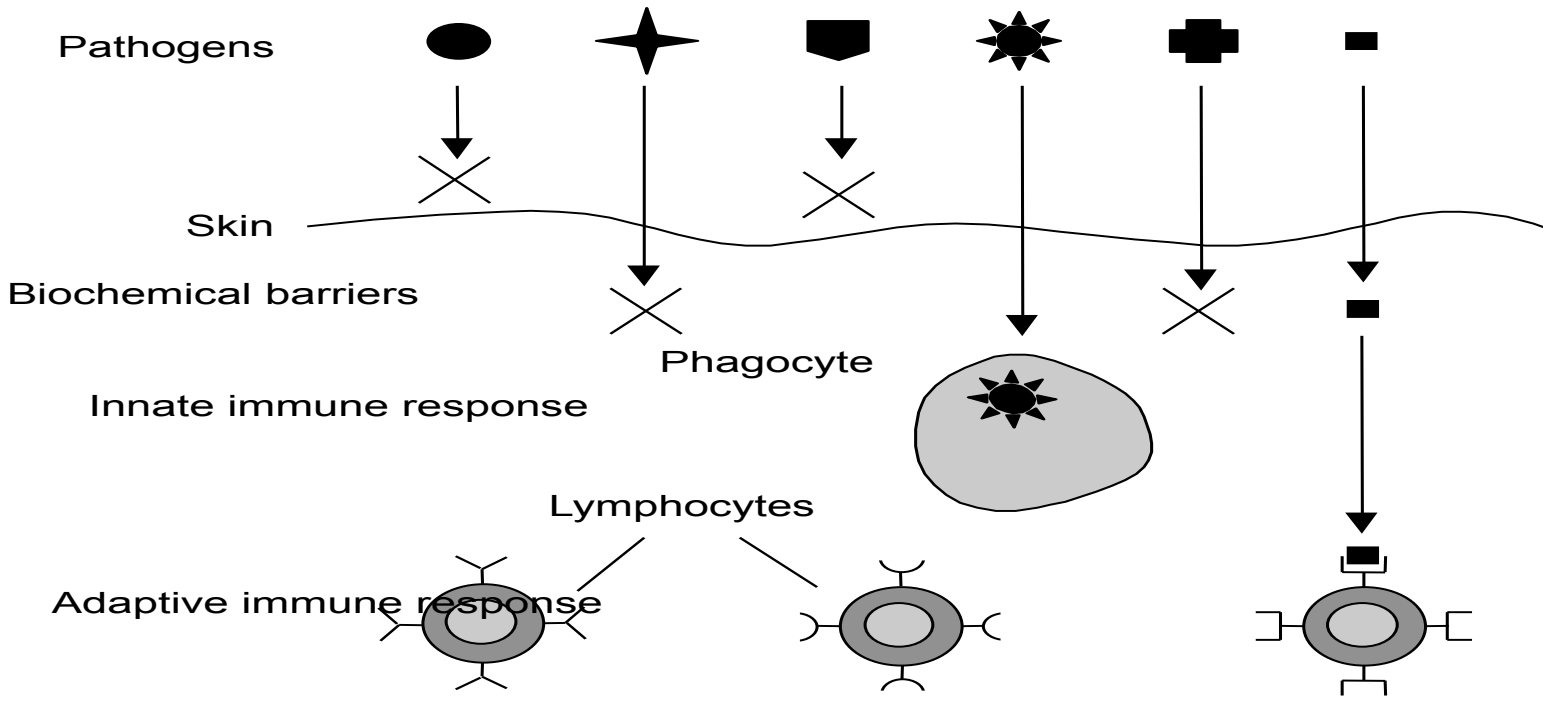


Figure: Many layers of the immune system: finding boundaries is not that helpful, after [2]

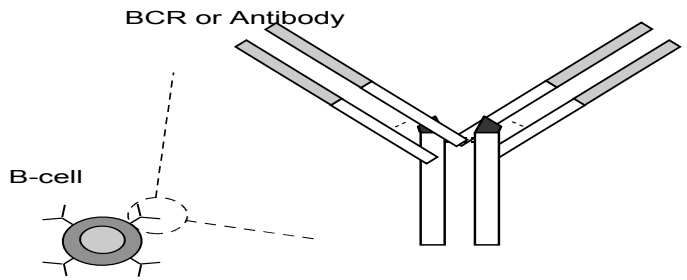
Innate Immune System

- May take days to remove an infection, if it fails, then the adaptive response may take over
- Germ-line encoded: specific detection.
  - Bind to common (known) things. This knowledge has been evolved and passed from generation to generation.
  - Evolution on the generational scale
- Other actors such as TLR's and dendritic cells are essential for recognition

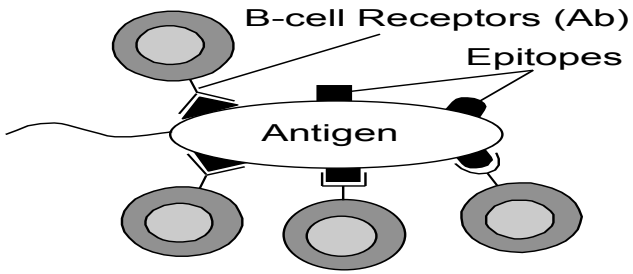
Adaptive Immune System

- Action occurs in the lymph node
- Main actors are *lymphocytes*
  - Carry antigen receptors that are specific to an antigen (one to one mapping)
  - They are produced in the bone marrow through random re-arrangement
  - Two main types: B and T Cells

B Cells

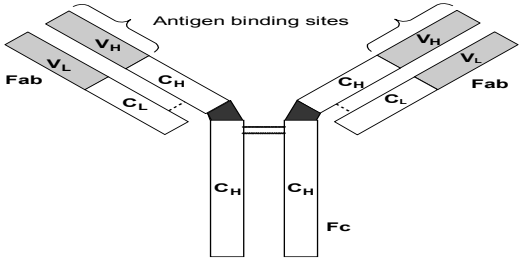


(a) B cells have receptors called antibodies. Recognition is based on the complimentary binding between sites, after [2]

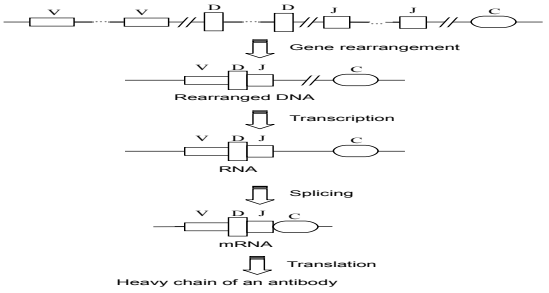


(b) Multiple binding sites are required, after [2]

Antibodies



(c) Many different sites on an antibody, after [2]



(d) Arrangement of genes, after [2]

Immune System Processes (basic!)

- Negative Selection
  - Censoring of T-cells in the thymus gland of T-cells that recognise self
  - *Defining normal system behavior*
- Clonal Selection
  - Proliferation and differentiation of cells when they have recognised something
  - *Generalise and learn*

Clonal Selection *Revisited*

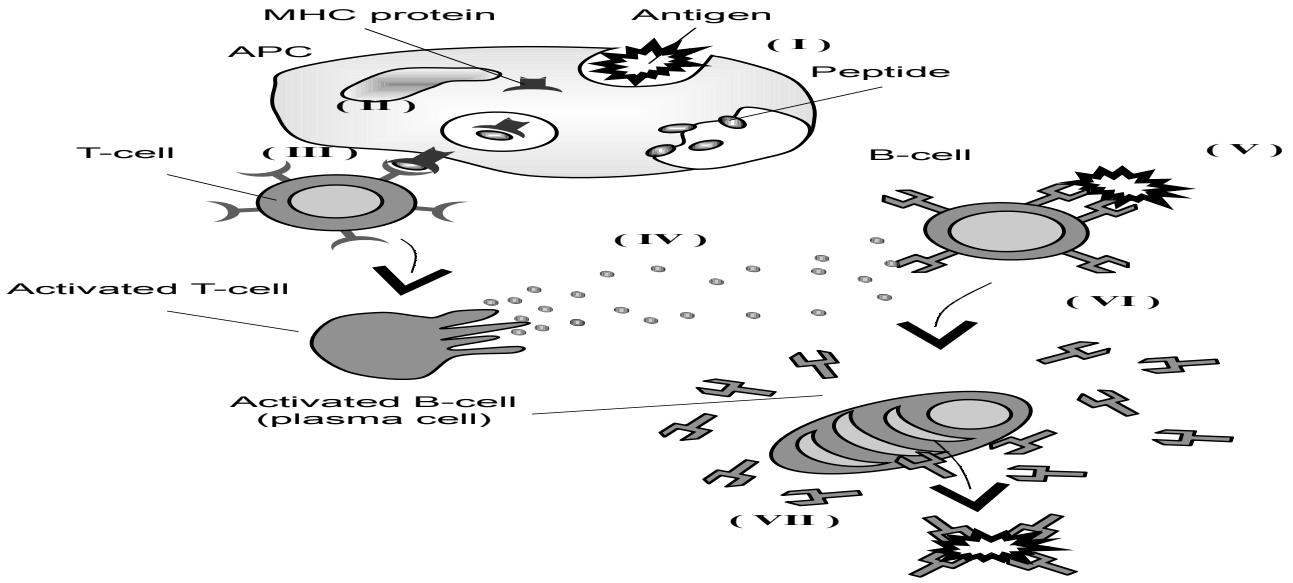


Figure: The clonal selection process of the adaptive immune system, integral to this is the ability to distinguish self from non-self, after [2]

Clonal Selection

- Each lymphocyte bears a single type of receptor with a unique specificity
- Interaction between a foreign molecule and a lymphocyte receptor capable of binding that molecule with high affinity leads to lymphocyte activation
- Effector cells derived from an activated lymphocyte bear receptors identical to those of parent cells
- Lymphocytes bearing self molecules are deleted at an early stage

Immune *Learning*

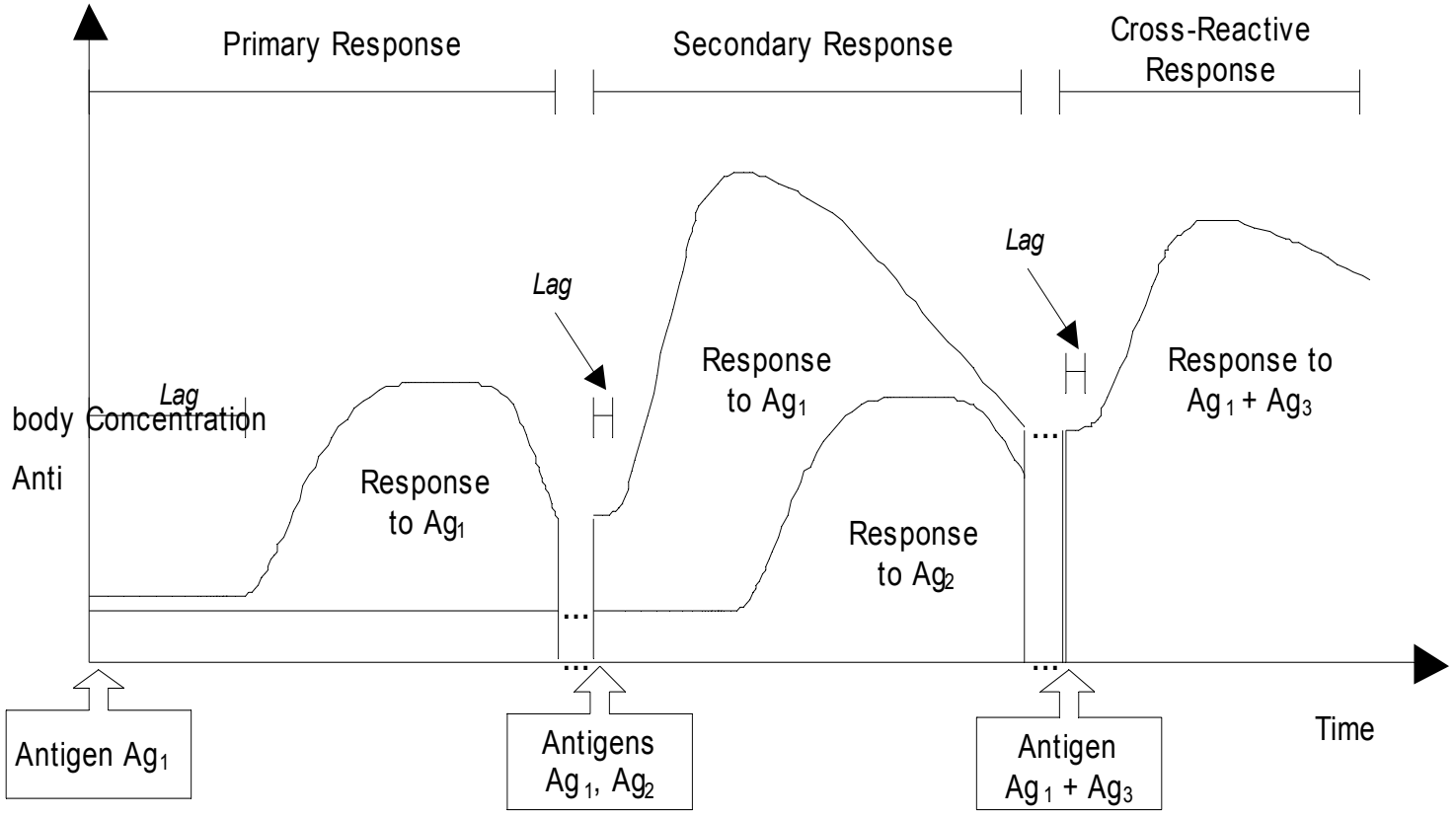


Figure: Various immune responses over time, after [2]

Cognitive Immune System I

Cohen's Immune System [1]

- Complex, reactive and adaptive system
- Carries out body maintenance
- Operates via cognitive strategy similar to brain

Cognitive Immune System II

- Inflammation
  - Range of processes e.g. cell growth, replication, death, movements and differentiation
  - Results in body maintenance
- Body Maintenance
  - Detect state of body tissues and elicit appropriate response to keep body *fit*
  - Defence against pathogen as a special case

Cognitive Immune System III (Co-Respondence)

- Immune cells respond to different aspects of target
- Immune cells respond to each other
- Immune dialogue through immune molecules
- Picture of target emerges from co-operation
- Immune agents form networks with positive and negative feedback.

Immune Networks

- Idiotypic network [3]
- B cells co-stimulate each other and treat each other a bit like antigens

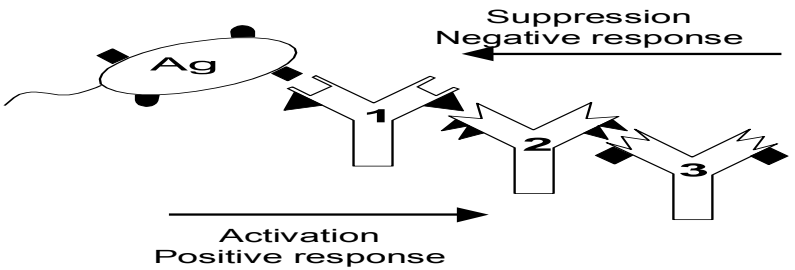
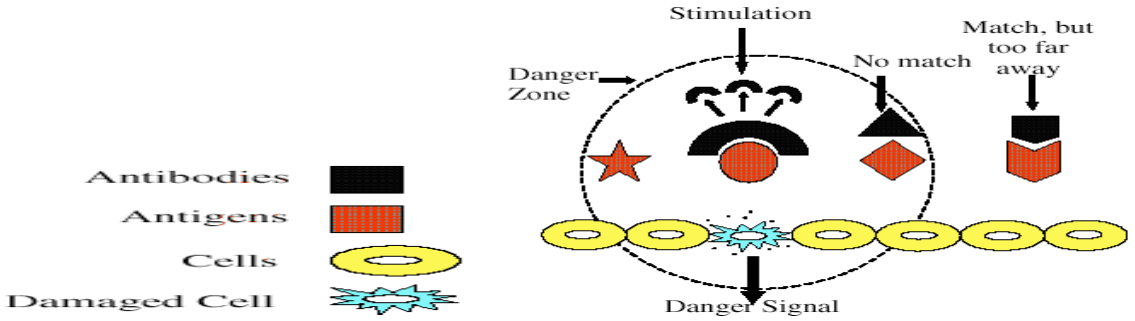


Figure: Active suppression and stimulation between B-cell receptors, gives rise to a complex network for memory, after [2]

Danger Theory

- it is not “non-self”, but “danger” that the IS recognises [5]
- dangerous invaders cause cell death or stress (necrosis)
- these cells generate “danger signal” molecules
  - unlike natural cell death (apoptosis)
- these stimulate an immune response local to the danger to identify the “culprit”



(a) The actors (b) Identifying the culprit

Figure: Basic principle of danger theory

Immunologists disagree!!

> “There is an obvious and dangerous potential for the immune system to kill its host; but it is equally obvious that the best minds in immunology are far from agreement on how the immune system manages to avoid this problem ”

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