

Short Course on Immunology

Adaptive Immune System

Bhargavi Duvvuri

Ph.D IIIrd Year (Immunology)

bhargavi@yorku.ca

Supervisor

Dr. Gillian E Wu

Professor, School of Kinesiology and Health Sciences
York University, Toronto

Immune System

```
graph TD; A[Immune System] --> B[Innate Immunity]; A --> C[Adaptive Immunity];
```

Innate Immunity

(Present before infection)

Adaptive Immunity

(Develops in response to infection)

Adaptive Immunity

“Immunity that an organism develops and adapts to recognize, eliminate and remember specific pathogens (antigen)”

What is an antigen?

An antigen is any substance that elicits an immune response.

Innate vs. Adaptive Immunity

Attribute	Innate immunity	Adaptive immunity
Response time	Minutes/hours	Days
Specificity	Broad recognition: less-specific	Highly specific
Diversity	Limited number of germ line-encoded receptors	Highly diverse; Adaptive: G.O.D
Memory response	None	Present
Self/non-self discrimination	Perfect	Very good
Major cell types	Phagocytes, natural killer cells, dendritic cells	T cells, B cells, antigen-presenting cells (APC)

Source: Kuby Immunology, Sixth Edition

Players and their effector functions

Duality of Adaptive Immune System

```
graph TD; A[Duality of Adaptive Immune System] --> B[Humoral (Antibody-Mediated) Immunity]; A --> C[Cell Mediated Immunity];
```

Humoral (Antibody-Mediated) Immunity

(Extra cellular pathogens)

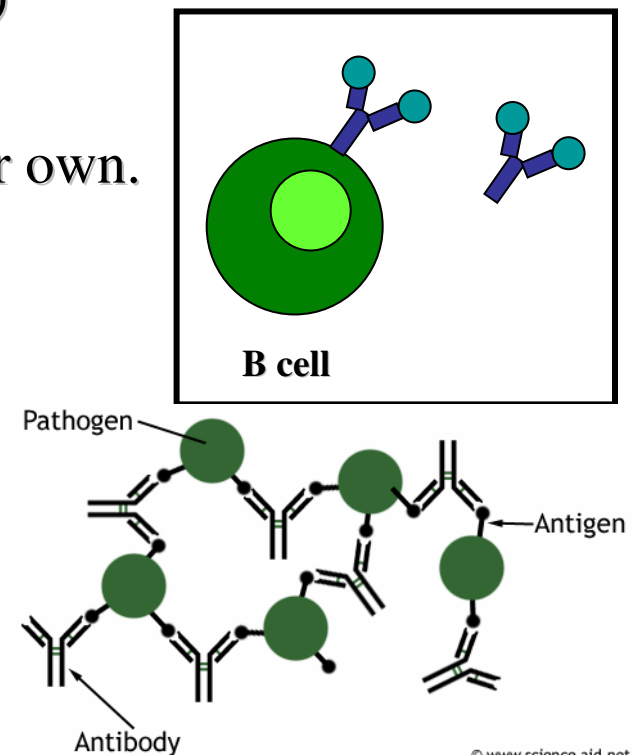
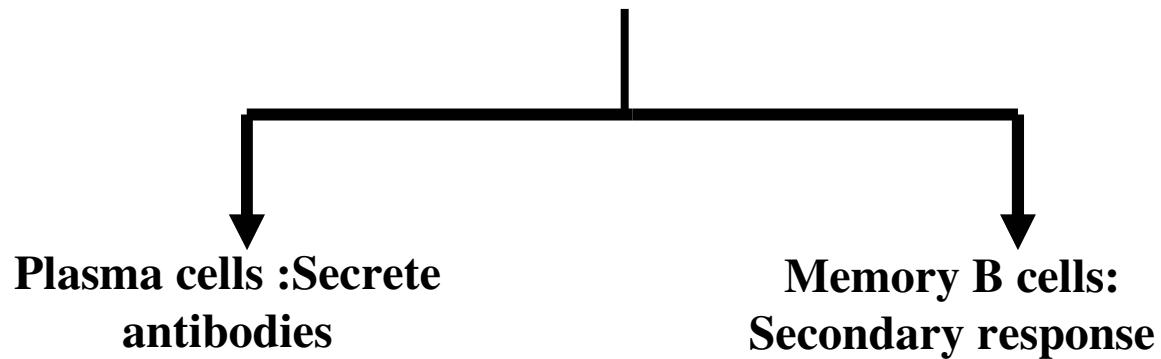
Cell Mediated Immunity

(Intra cellular pathogens)

Humoral (Antibody-Mediated) Immunity

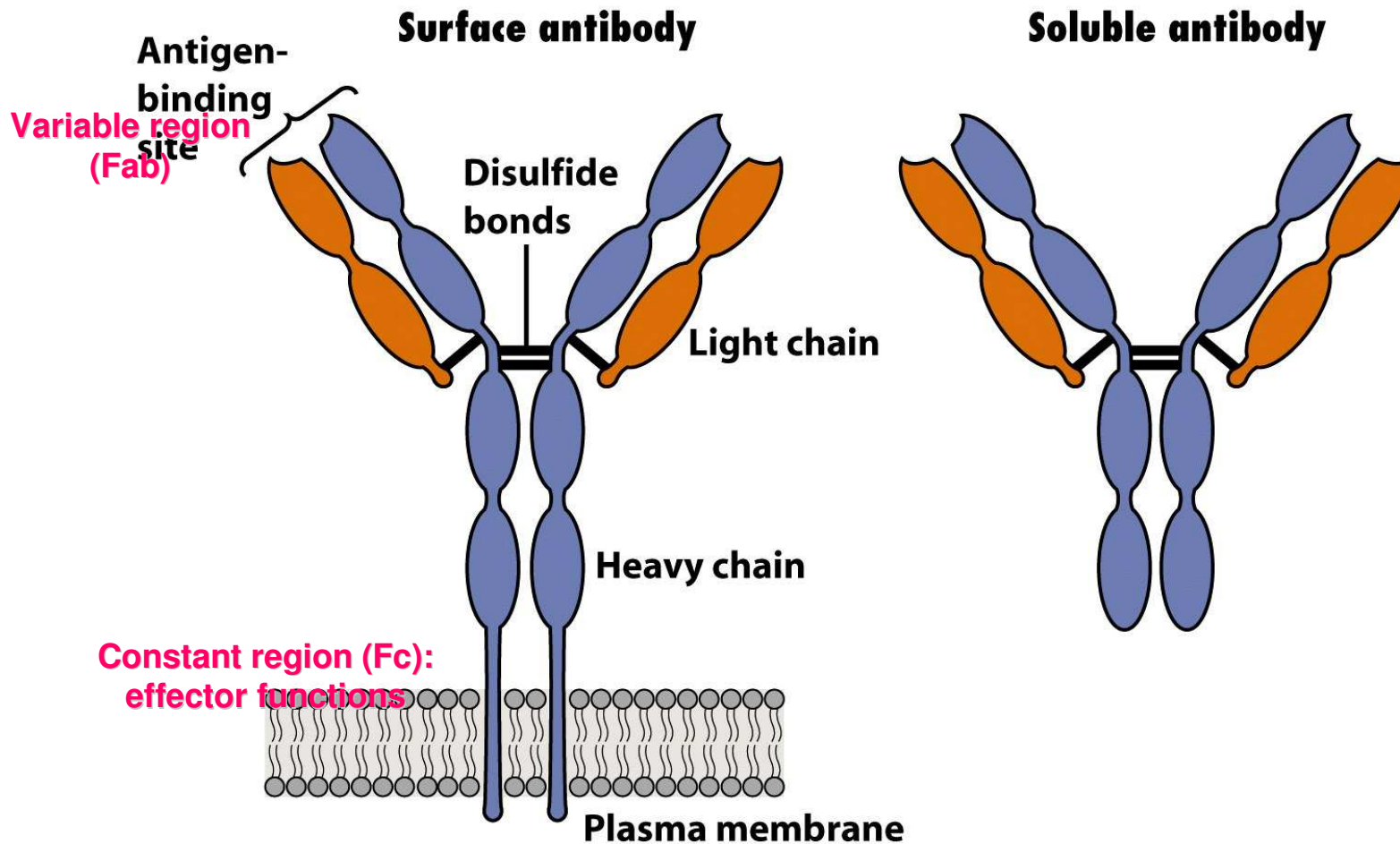
- § Involves production of antibodies against foreign antigens.
- § Antibodies (membrane bound and soluble) are produced by a subset of lymphocytes called B cells. (Bone marrow)
- § Antibodies can recognize free antigen on their own.

B cell differentiation (T cells help)



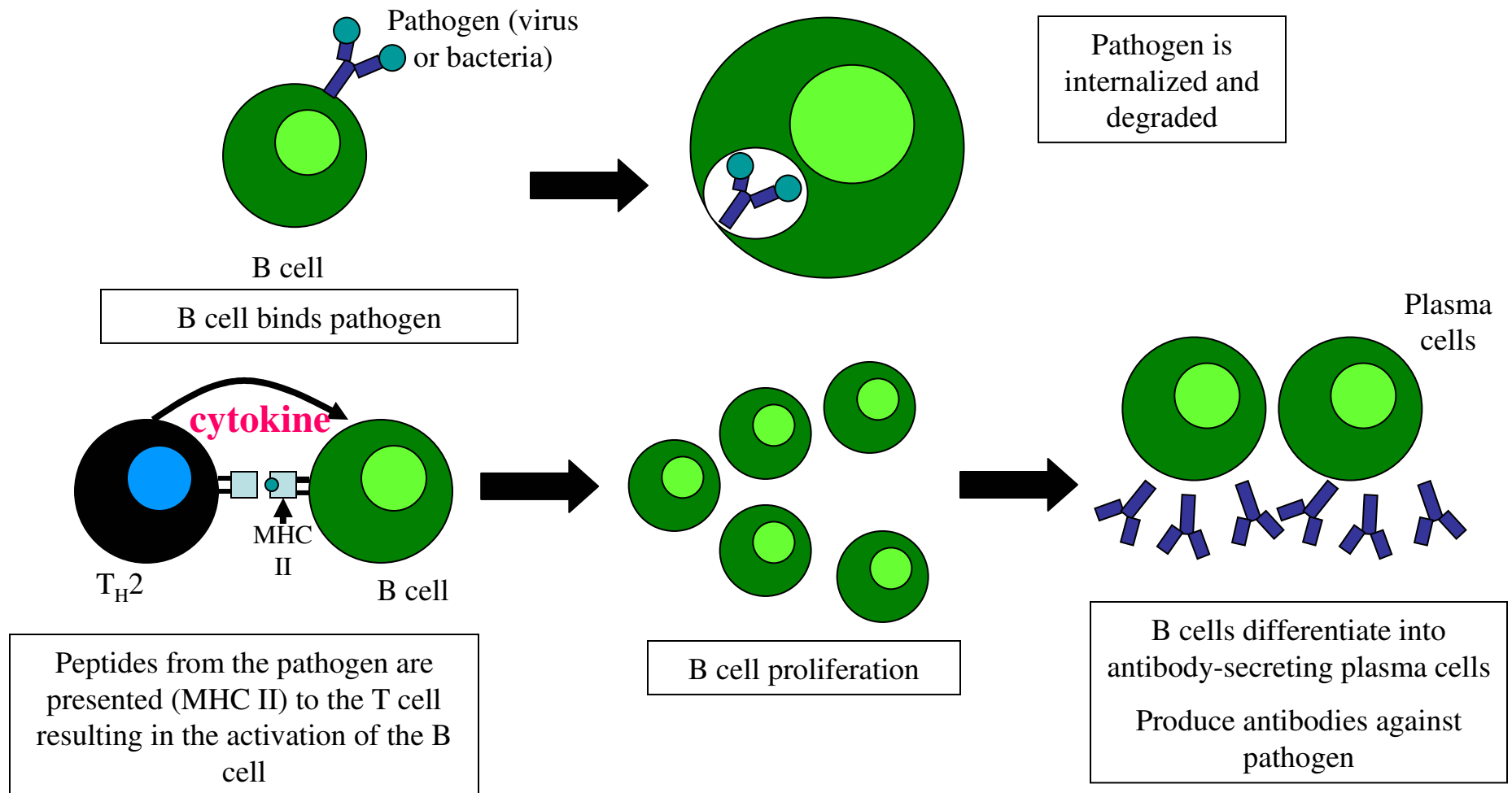
Detect and prevent the entry of extracellular pathogens

Antibody structure



Five classes of antibodies: IgG, IgA, IgM, IgD, and IgE. Each have a different function.

Production of antibodies



Cell Mediated Immunity

Involves specialized set of lymphocytes called T cells (Thymus) with membrane bound T cell receptor (TCR) .

Two main types:

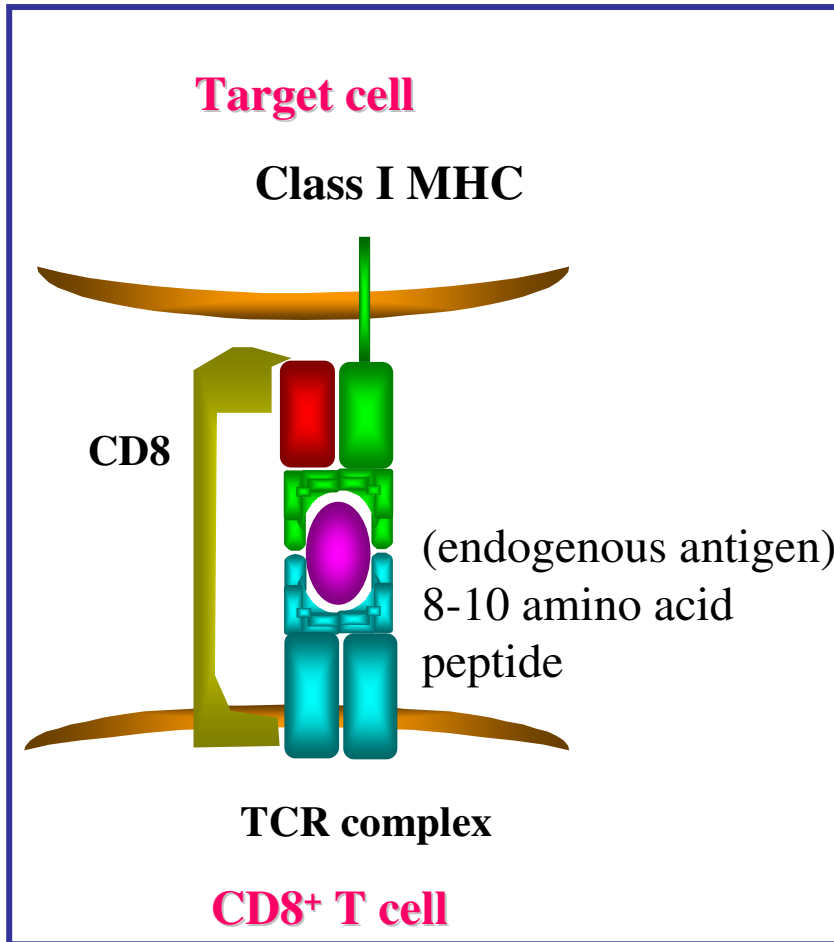
1. CD4+ (TH1 and TH2): Stimulate other immune cells.
2. CD8+ Cytotoxic T cells (T_C): Kill intracellularly-infected cells.

Recognition of processed Ag in the context of Major Histocompatibility complex (MHC)

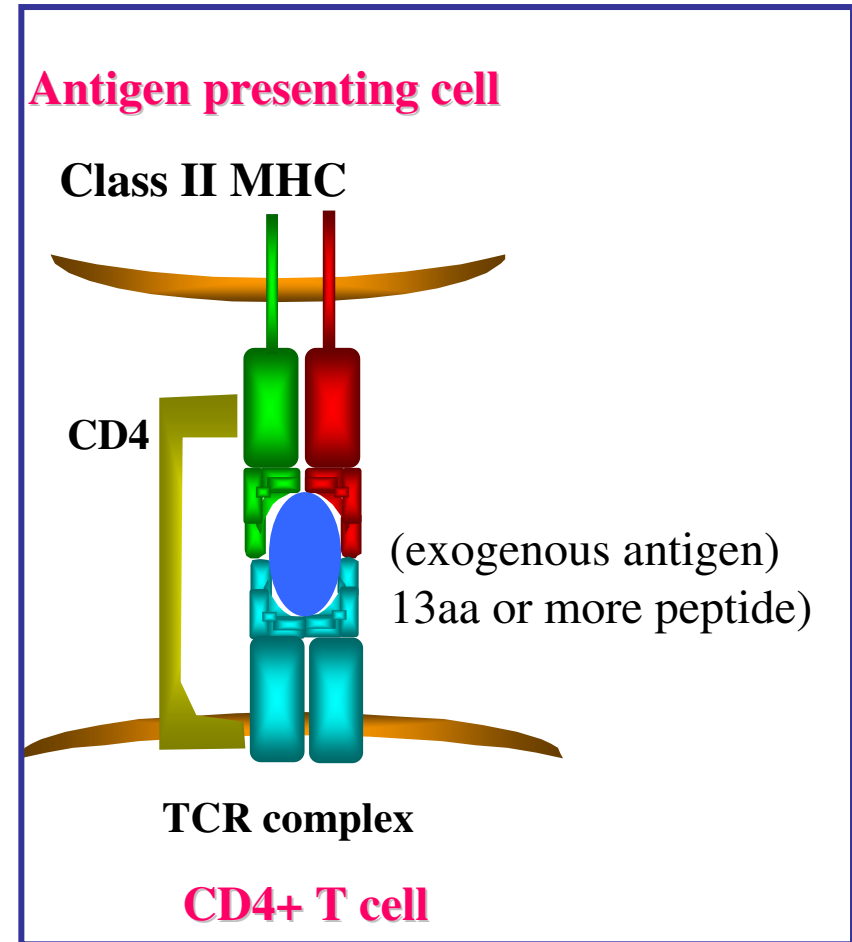
T cells detect presence of intracellular pathogens

And T cells, the cells that “help”, are the “**brains**” of the immune system.

Antigen Presentation to T cells: MHC Restriction



MHC I: on most of the cells



**MHC II: Dendritic cells, macrophages
and B cells**

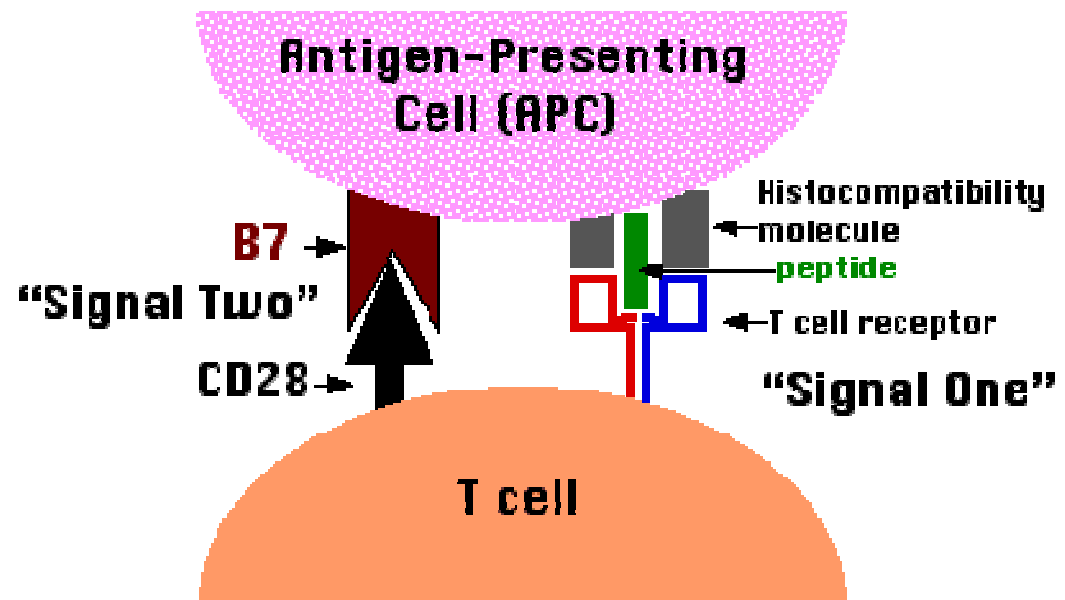
Cells that link the innate and adaptive immune systems: Antigen Presenting Cells (APCs)

1. Dendritic cells
2. Macrophages
3. B lymphocytes

§ Ag is internalized

§ Stimulates T-helper cells

§ they provide co-stimulatory signals



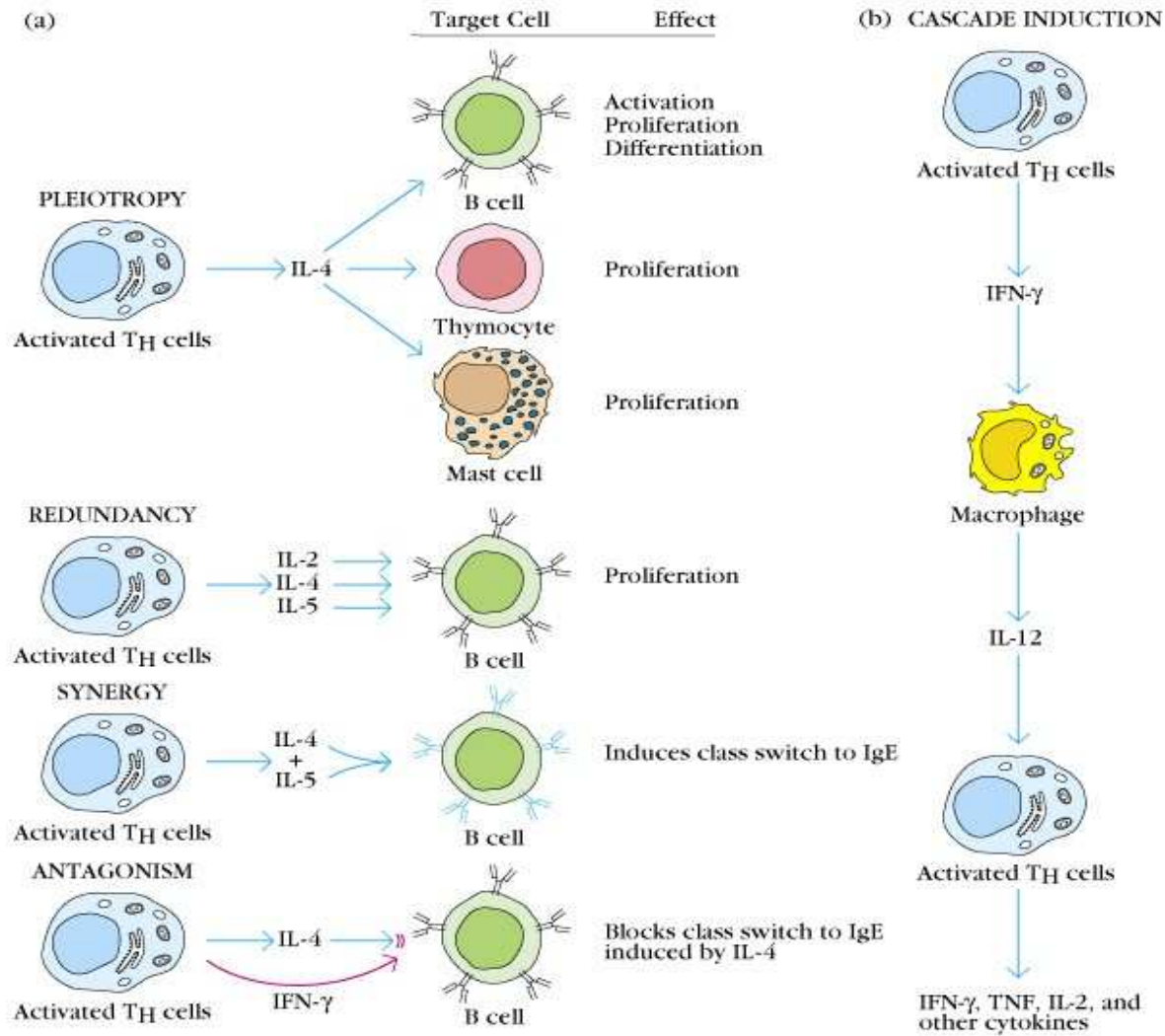
One method of the “co-stimulation” needed to activate T cells. If the T cell fails to receive “signal two”, it dies by apoptosis. (B7 comes in two forms: B7-1 [CD80] and B7-2 [CD86].)

Cytokines

- Cytokines are soluble protein factors that can activate many cells

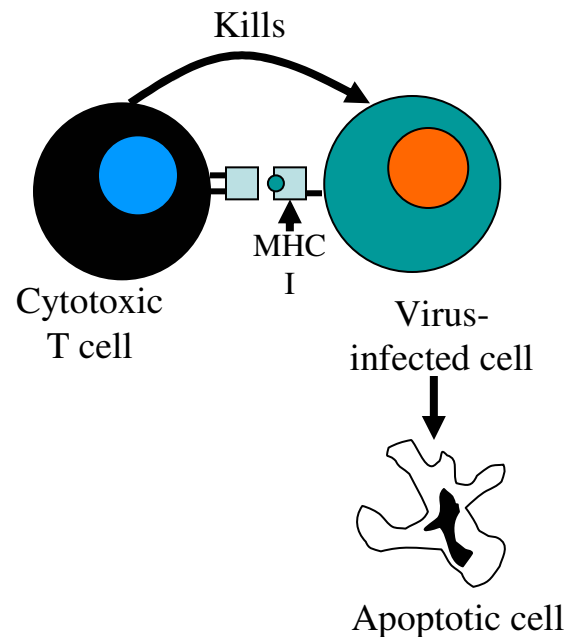
Ex. Cytokines secreted by T_H can affect B-cells, CTLs, $M\Phi$, NK: IL-4, IL-5 etc.

Cytokine functions

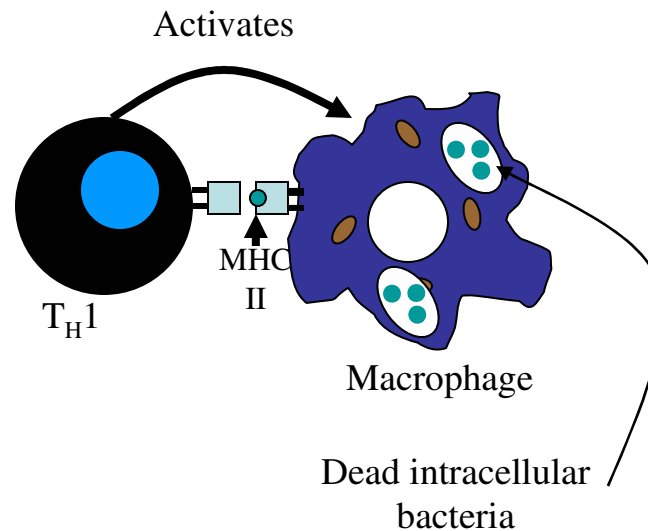


Antigen Recognition by T-cells

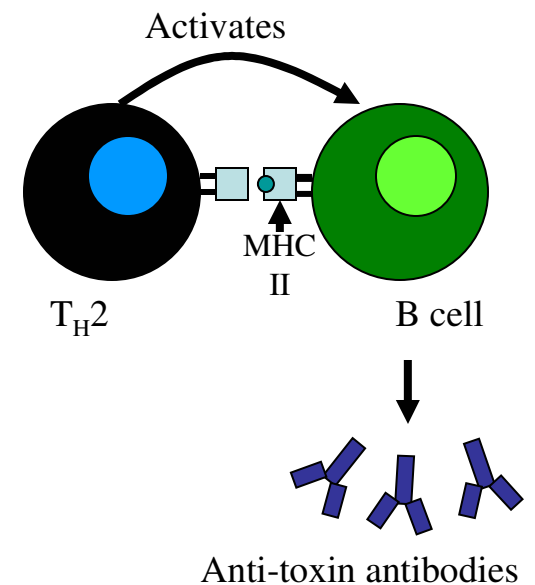
Cytotoxic T cells (CD8)
recognize antigen
presented by **MHC I** and
kills the cell



T_H1 cells (CD4)
recognize antigen
presented by **MHC II**
and activates
macrophages



T_H2 cells (CD4)
recognize antigen
presented by **MHC II**
and activates B cells



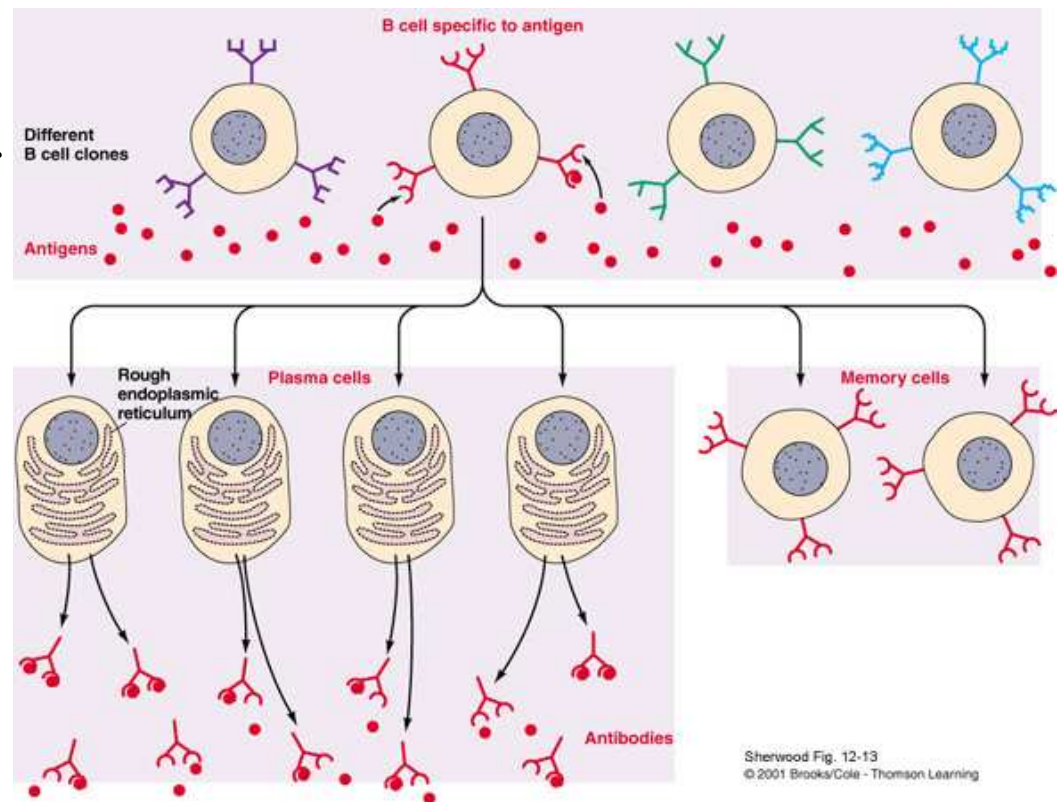
Characteristics of Adaptive Immune System

- **Antigenic Specificity**
- **Diversity**
- **Memory response**
- **Self/non-self discrimination**

Antigenic specificity

Is due to the CLONAL EXPANSION of only those lymphocytes with antigen specific receptors.

§ B lymphocytes – BCR/Antibody
§ T lymphocytes – T Cell Receptor



Each lymphocyte expresses only a **SINGLE SPECIFICITY RECEPTOR**

Diversity

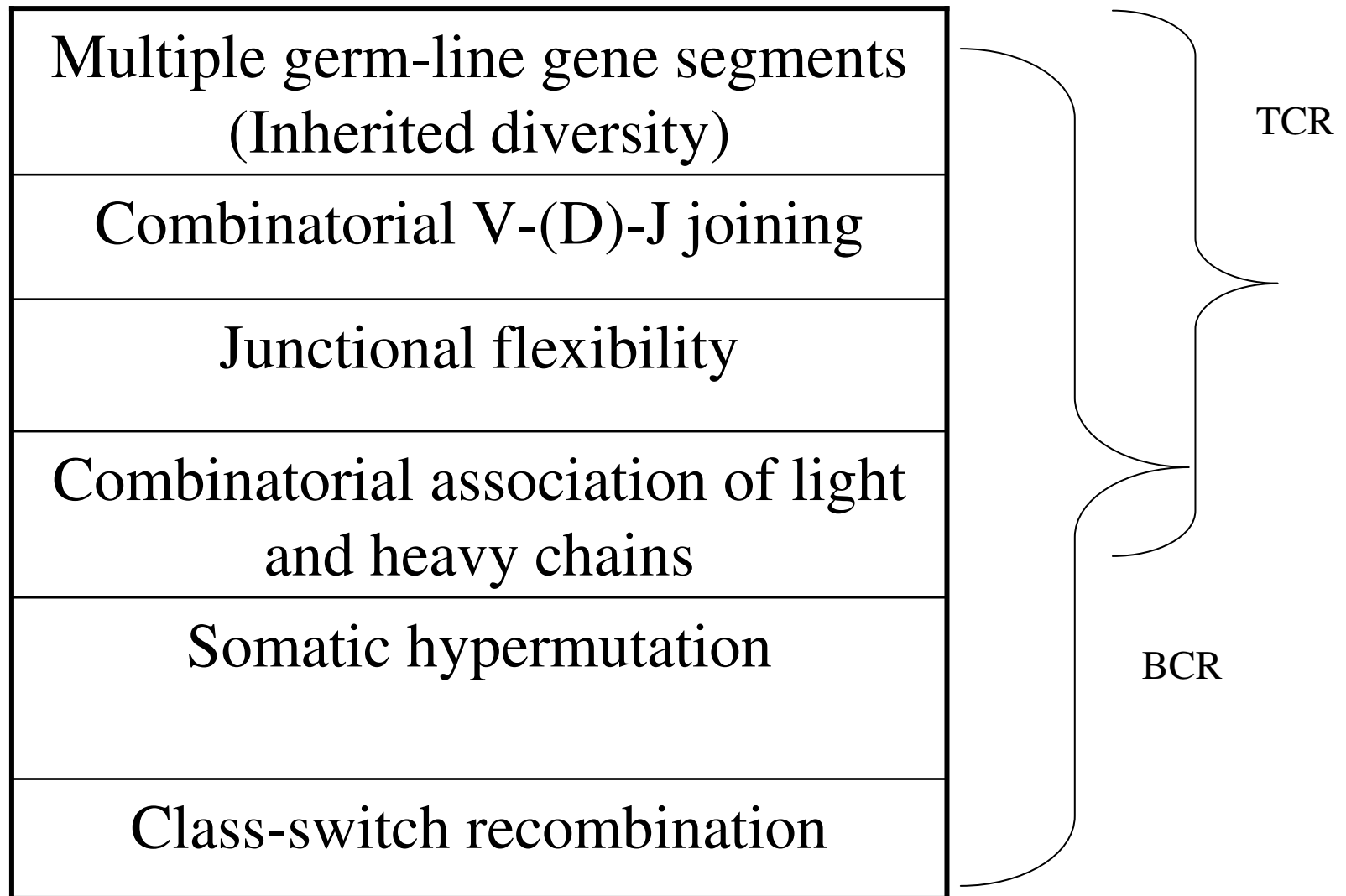
- § Human genome has ~30,000 protein encoding genes
- § Exposure to unlimited number of antigens
- § Humans have such a large immune repertoire. How?

by

G.O.D



Generation of Diversity (G.O.D): BCR and TCR



Combinatorial antibody diversity in humans

Multiple germ-line segments	Heavy chain	LIGHT CHAINS	
		κ	λ
ESTIMATED NUMBER OF SEGMENTS IN HUMANS*			
V	48	41	34
D	23	0	0
J	6	5	5
Combinatorial V-D-J and V-J joining (possible number of combinations)	$48 \times 23 \times 6 = 6624$	$41 \times 5 = 205$	$34 \times 5 = 170$
Possible combinatorial associations of heavy and light chains†	$6624 \times (205 + 170) = 2.48 \times 10^6$		+
<p>*These numbers have been determined from studies of single subjects; slight differences may be seen among different individuals. In the cases of both human and mouse, only the functional gene segments have been listed. The genome contains additional segments that are incapable of rearrangement or contain stop codons or both.</p> <p>†Because of the diversity contributed by junctional flexibility, P-region nucleotide addition, N-region nucleotide addition, and somatic mutation, the actual potential exceeds these estimates by several orders of magnitude.</p>			

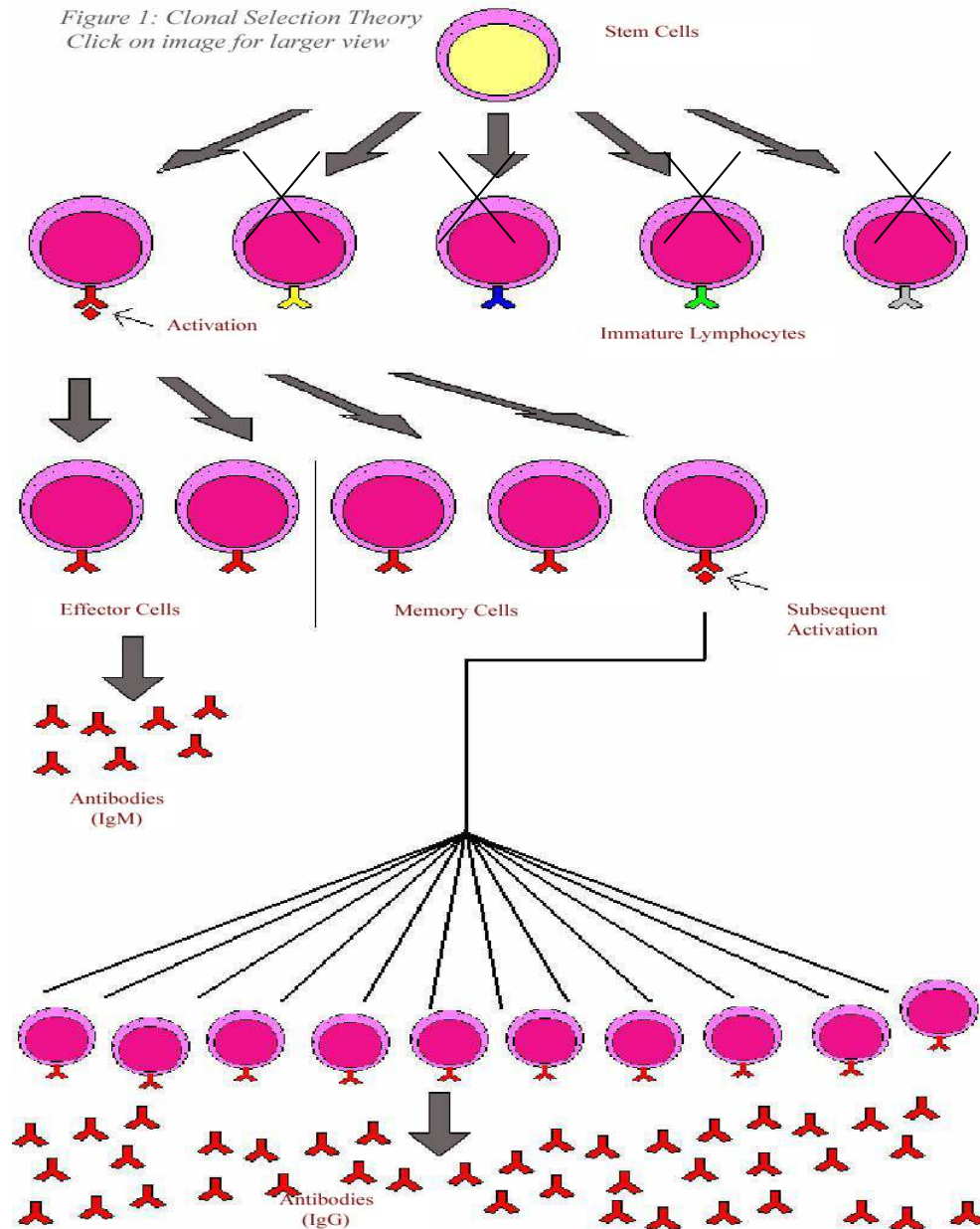
Table 5-2

Kuby IMMUNOLOGY, Sixth Edition

© 2007 W. H. Freeman and Company

The potential number of immune receptors is around $\sim 10^{12}$

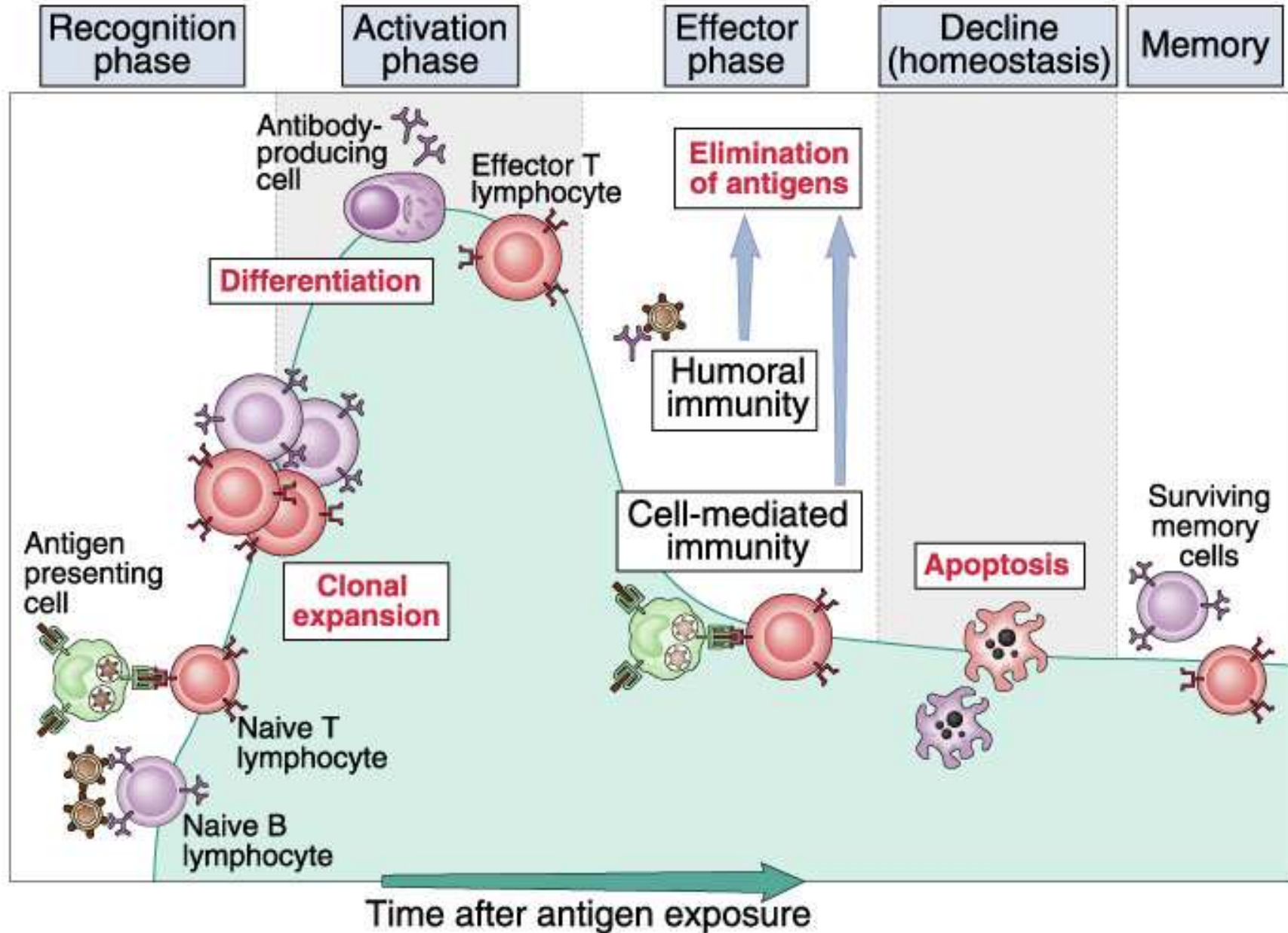
Self/non-self discrimination: The **Clonal selection**



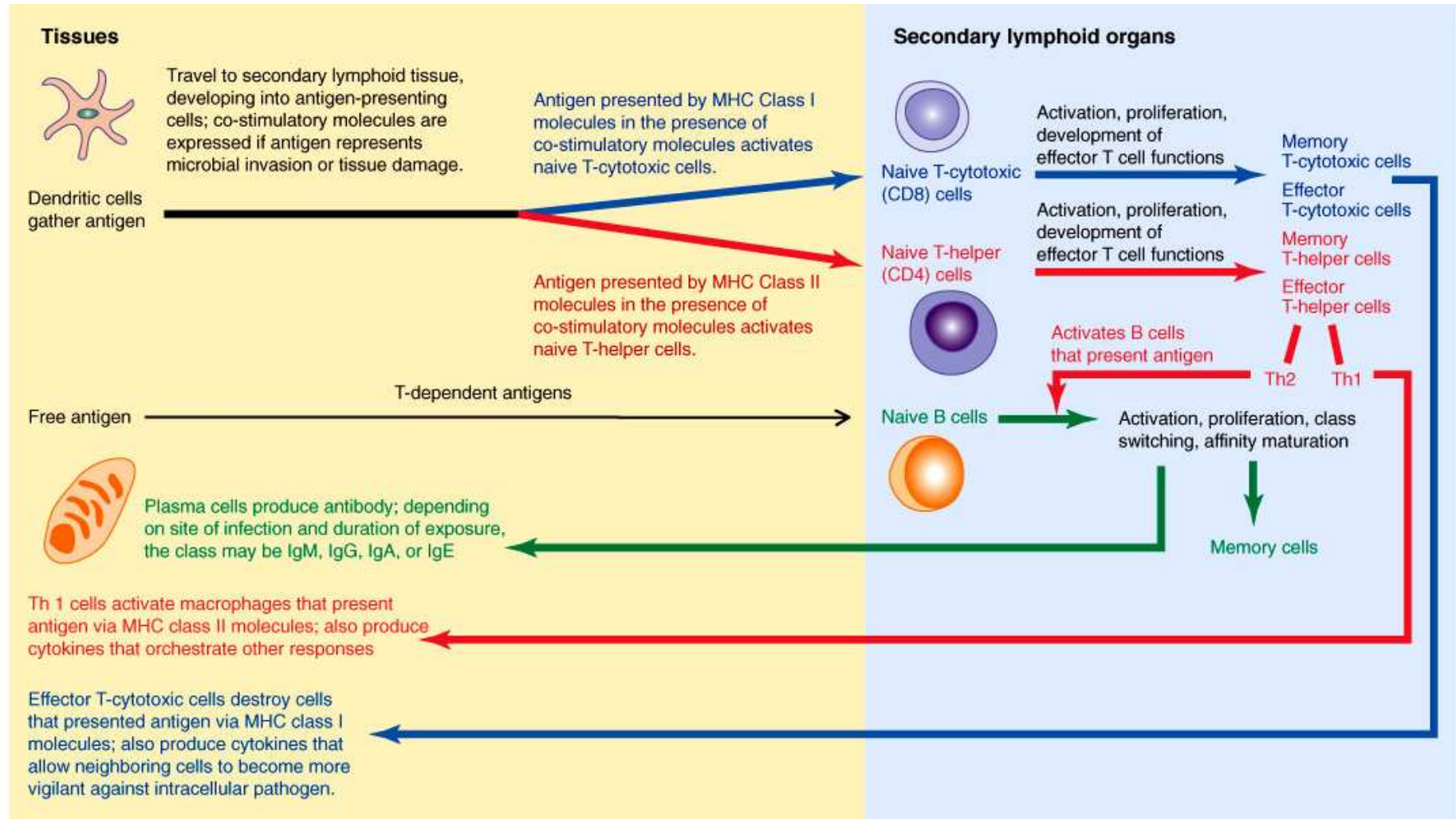
Immunologic memory

The attribute of the adaptive immune system mediated by MEMORY CELLS where by second encounter with same antigen results in heightened state of immune reactivity

Phases of adaptive immune responses.



Innate immunity and Adaptive immunity collaborate to protect the body



Adaptive Immune System

- **Antigenic Specificity**
- **Diversity**
- **Memory response**
- **Self/non-self discrimination**

Thank You