

Peter Parham

# **The Immune System**

**Second Edition**

## **Chapter 3**

Antigen Recognition  
by T Lymphocytes

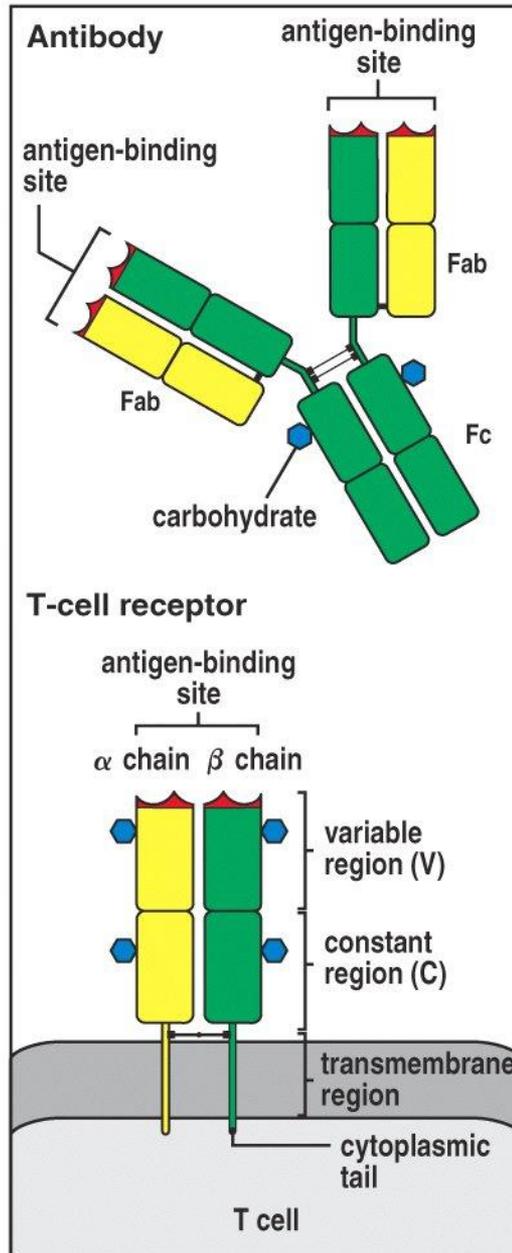


Figure 3-1 The Immune System, 2/e (© Garland Science 2005)

# Antibody

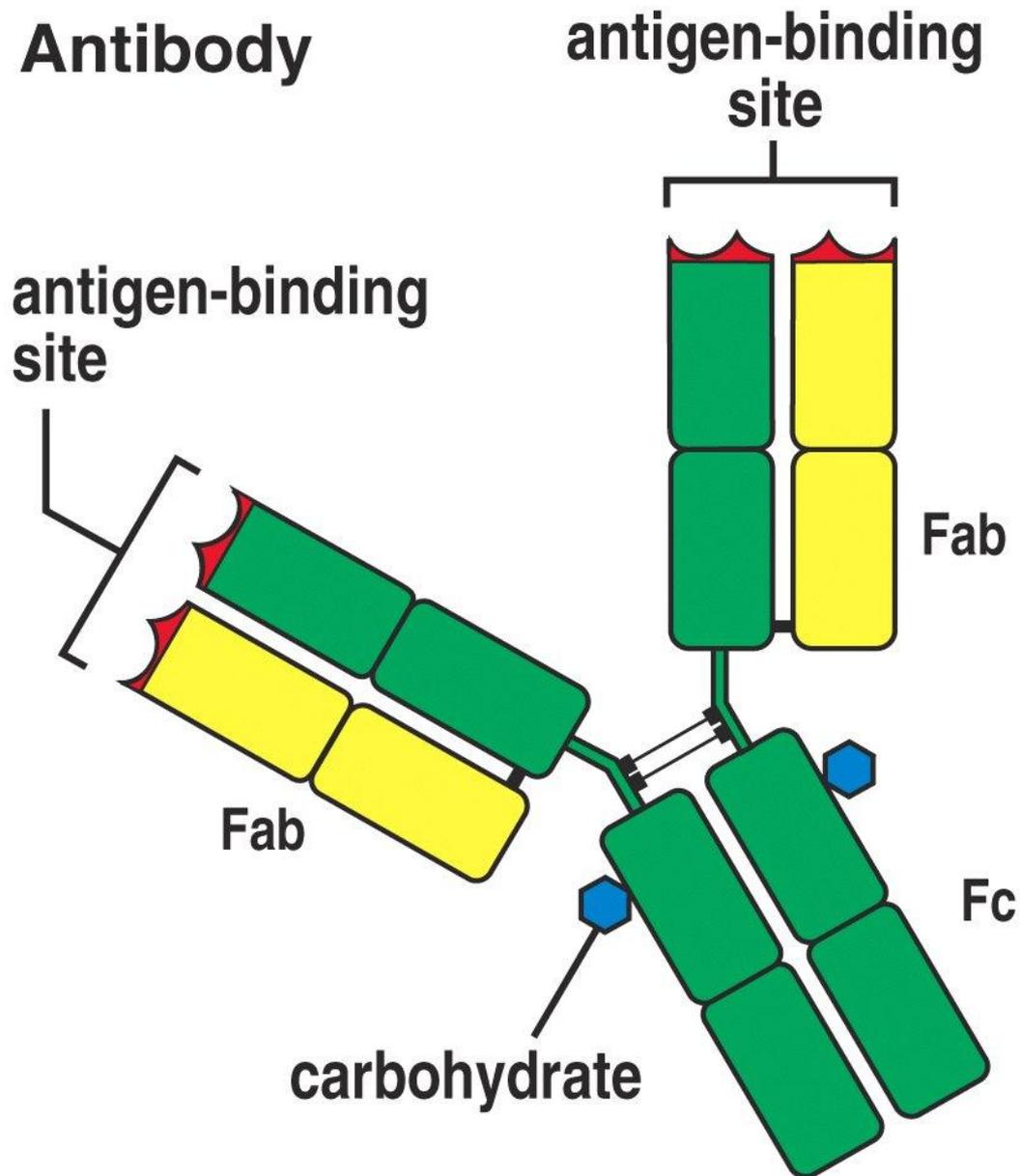


Figure 3-1 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

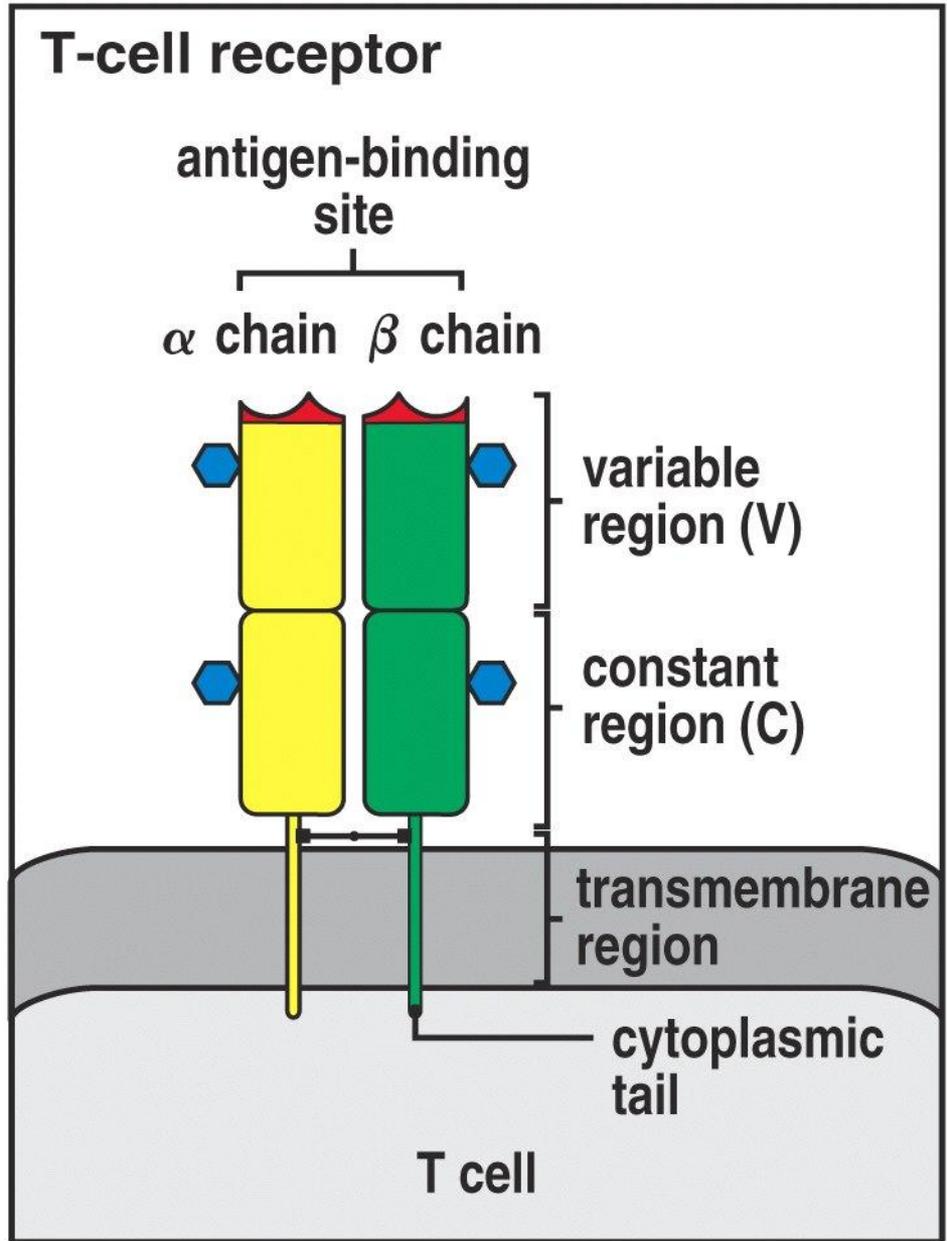


Figure 3-1 part 2 of 2 The Immune System, 2/e (© Garland Science 2005)

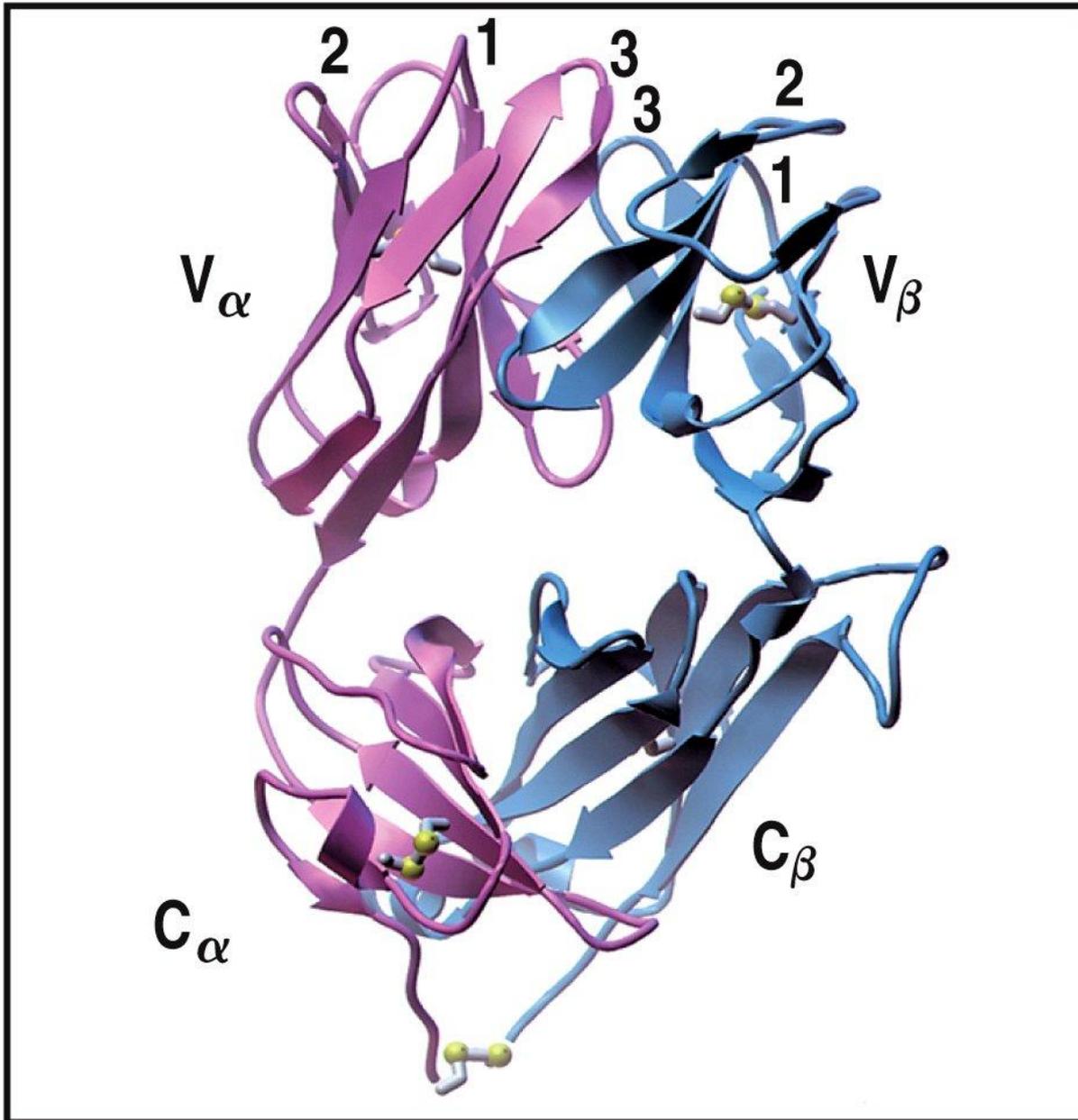


Figure 3-2 The Immune System, 2/e (© Garland Science 2005)

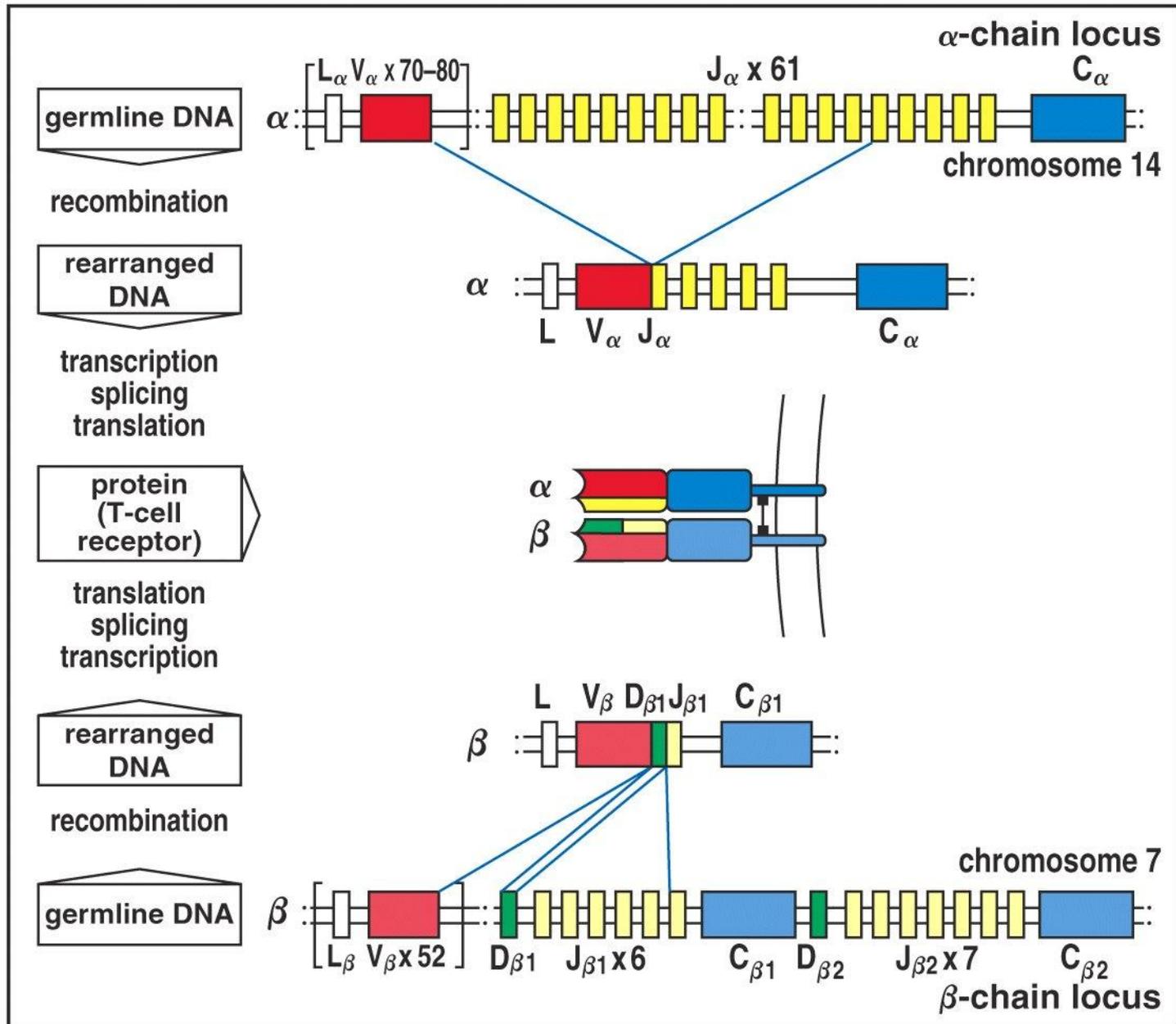


Figure 3-3 The Immune System, 2/e (© Garland Science 2005)

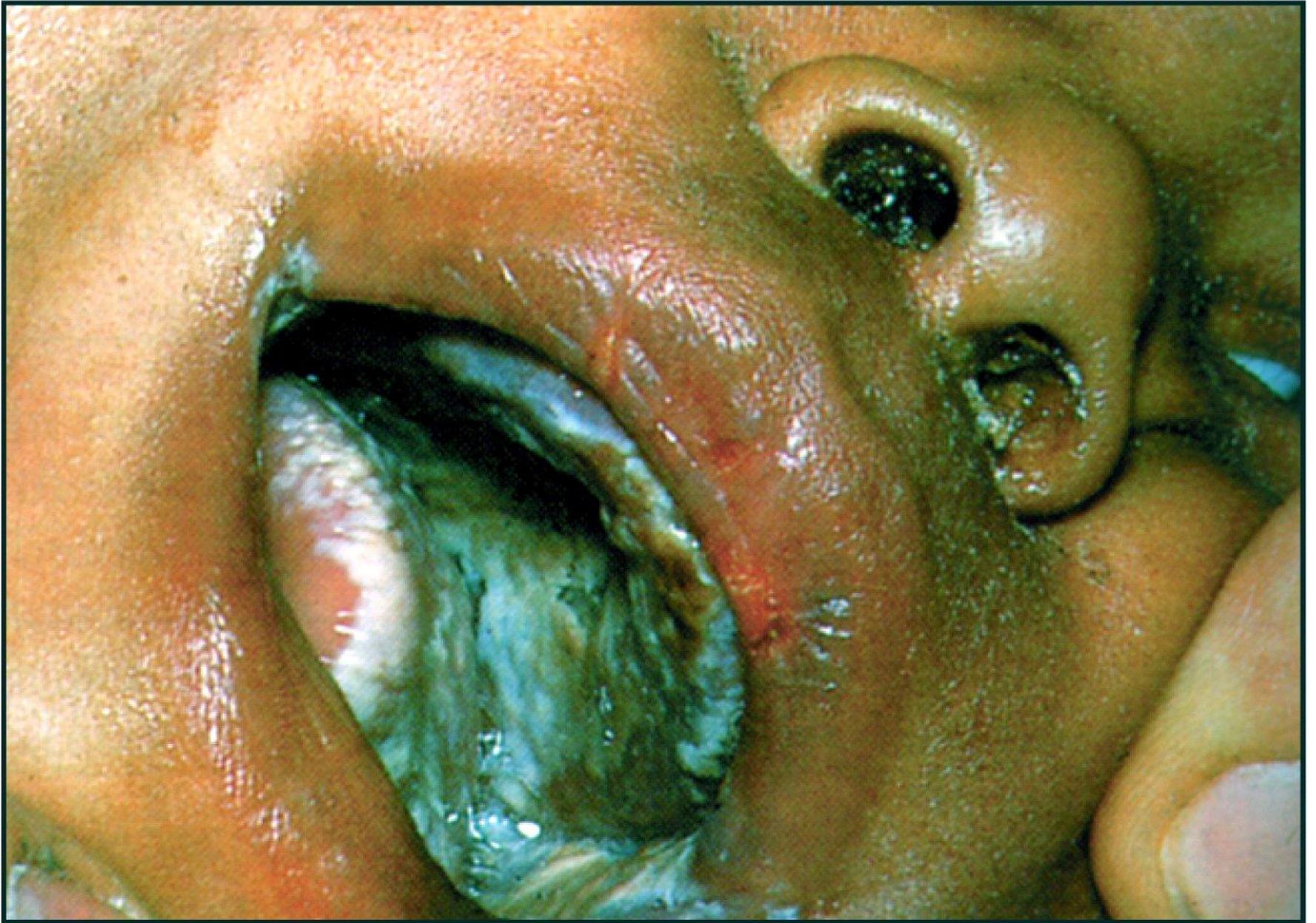


Figure 3-4 The Immune System, 2/e (© Garland Science 2005)



Figure 3-5 The Immune System, 2/e (© Garland Science 2005)

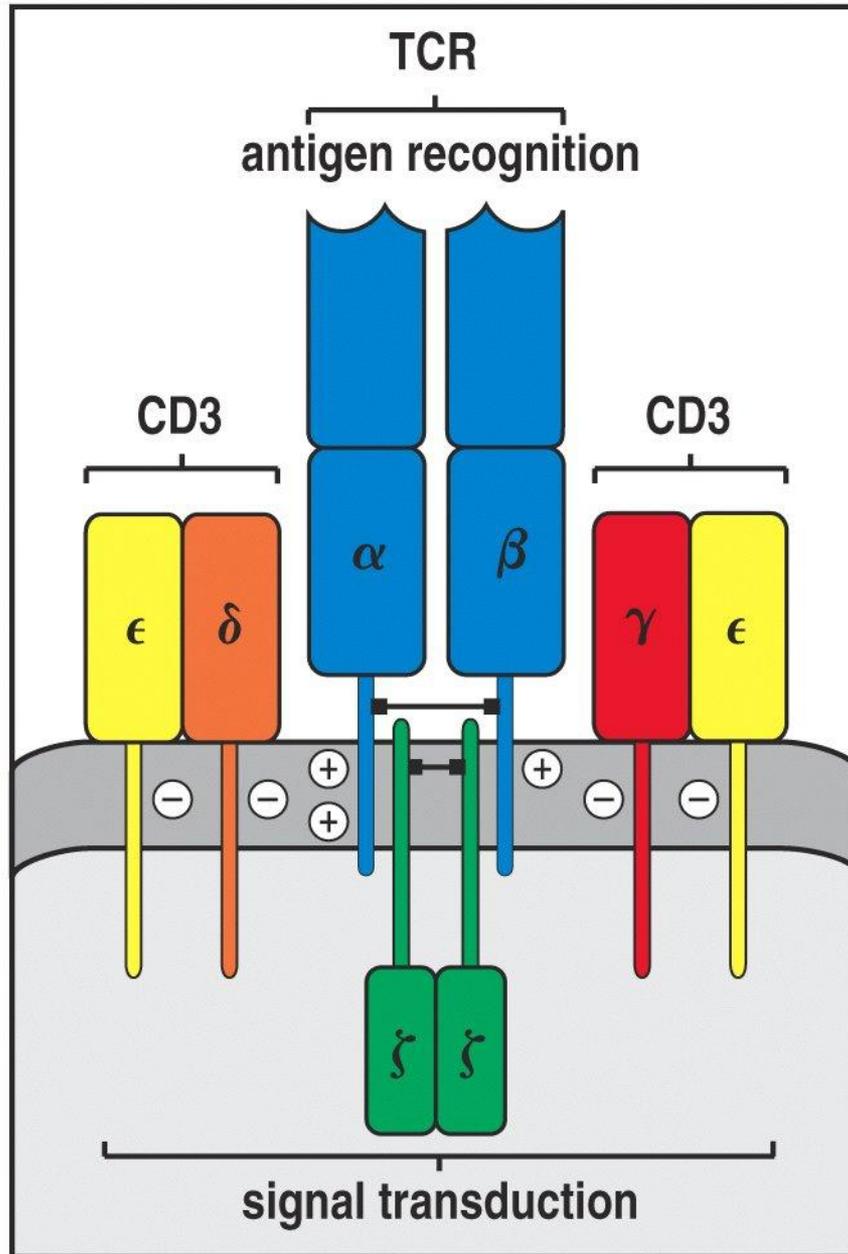


Figure 3-6 The Immune System, 2/e (© Garland Science 2005)

## Two classes of T-cell receptor

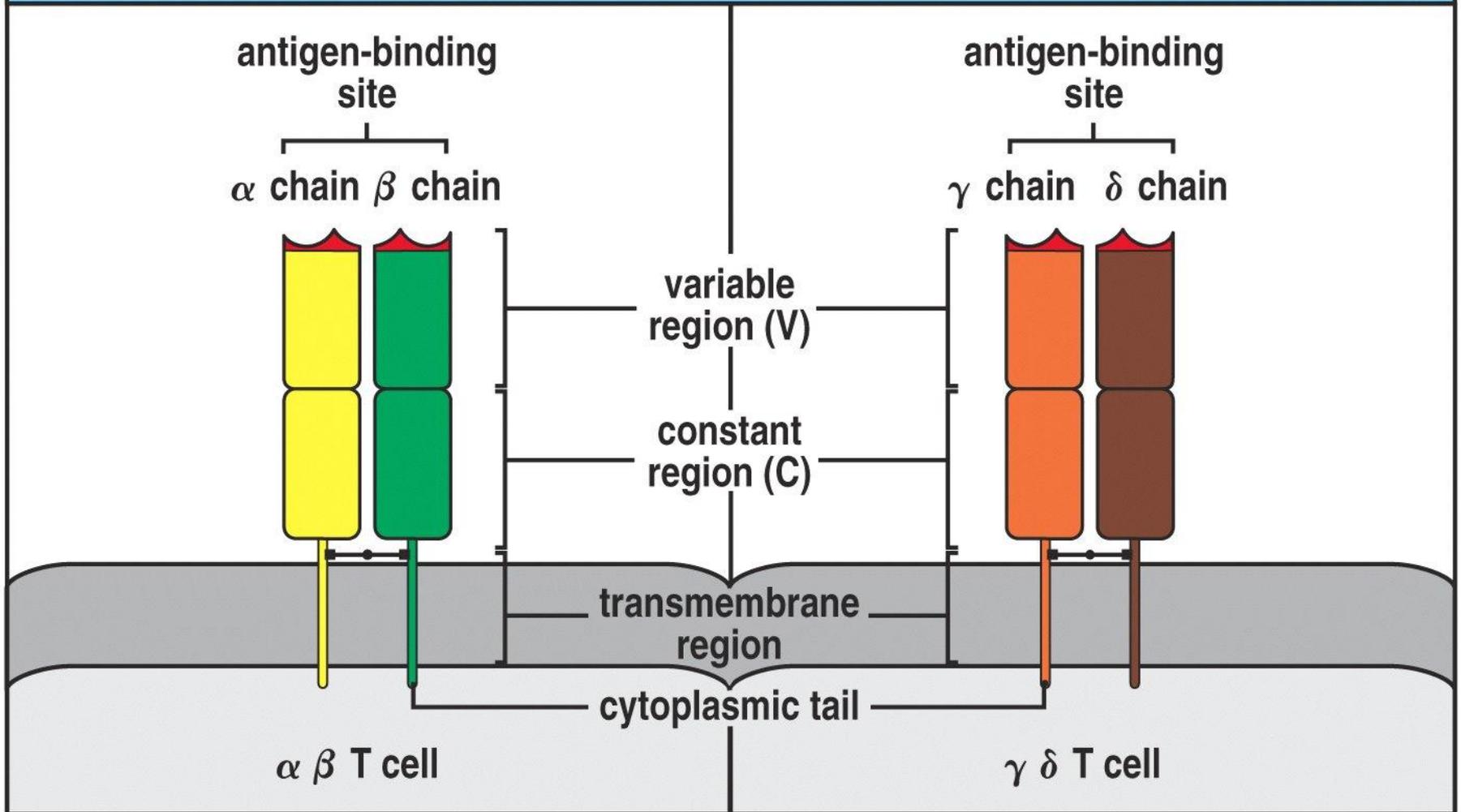
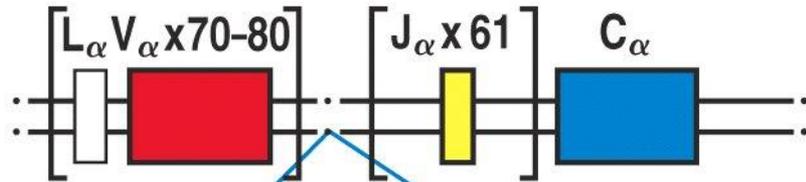


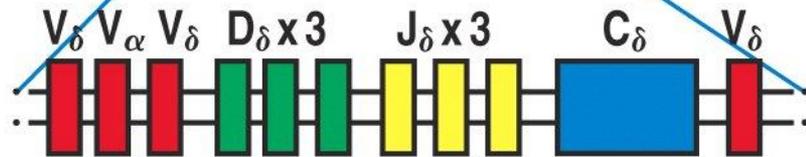
Figure 3-7 The Immune System, 2/e (© Garland Science 2005)

chromosome 14

$\alpha$ -chain locus



$\delta$ -chain locus



chromosome 7

$\gamma$ -chain locus

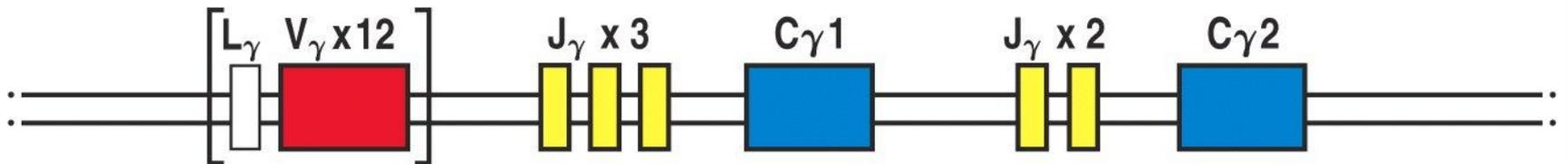
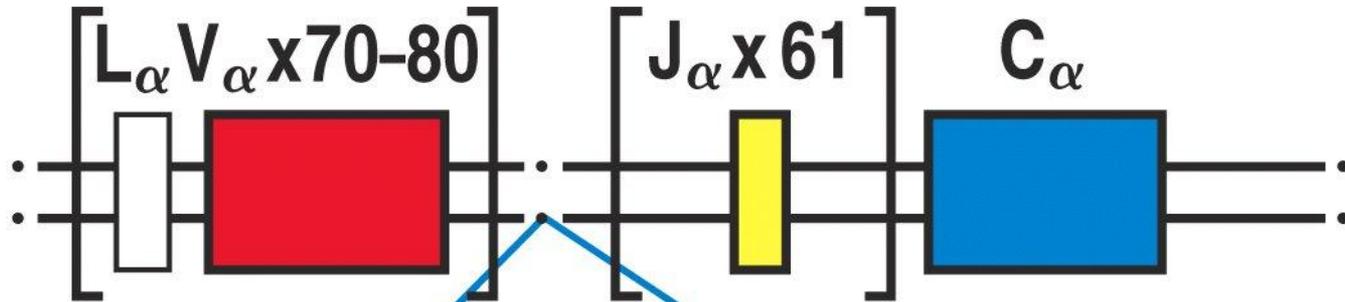


Figure 3-8 The Immune System, 2/e (© Garland Science 2005)

**chromosome 14**  
 **$\alpha$ -chain locus**



**$\delta$ -chain locus**

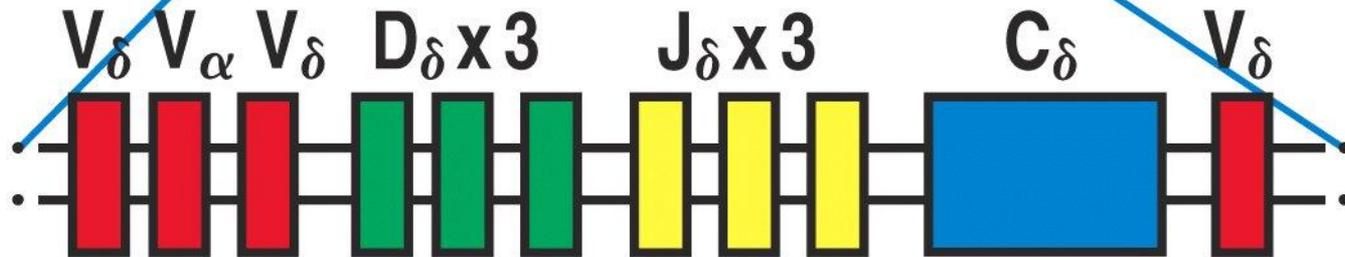


Figure 3-8 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

chromosome 7

$\gamma$ -chain locus

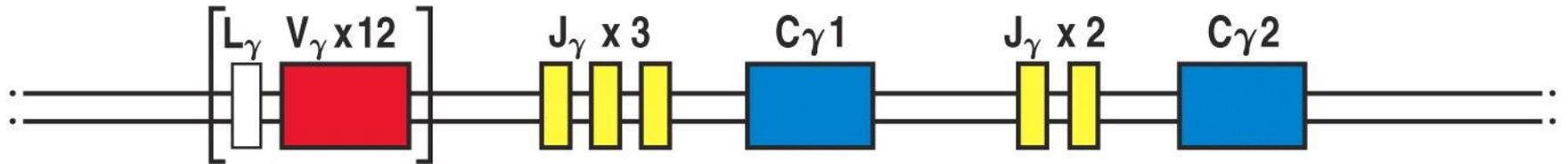


Figure 3-8 part 2 of 2 The Immune System, 2/e (© Garland Science 2005)

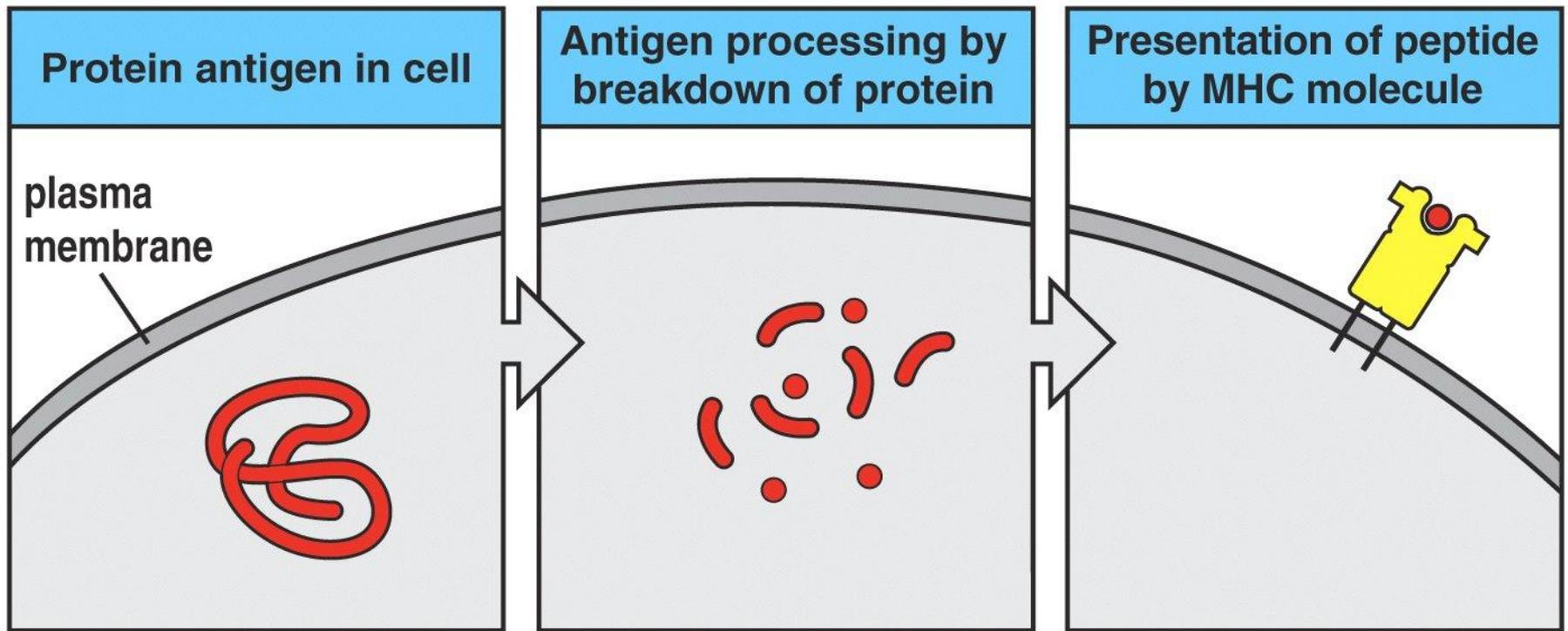


Figure 3-9 The Immune System, 2/e (© Garland Science 2005)

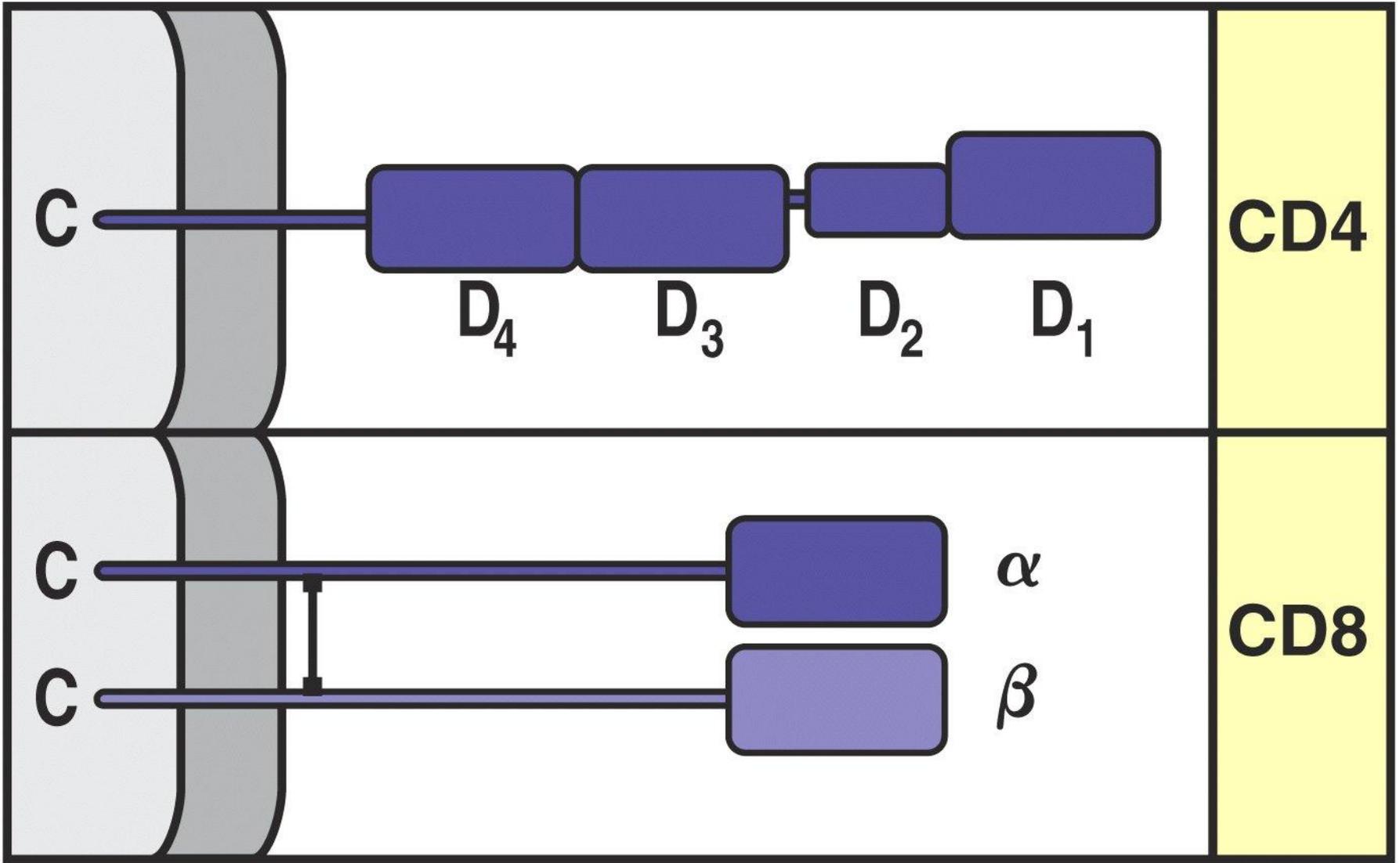


Figure 3-10 The Immune System, 2/e (© Garland Science 2005)

## T cells function by making contact with other cells and inducing them to change

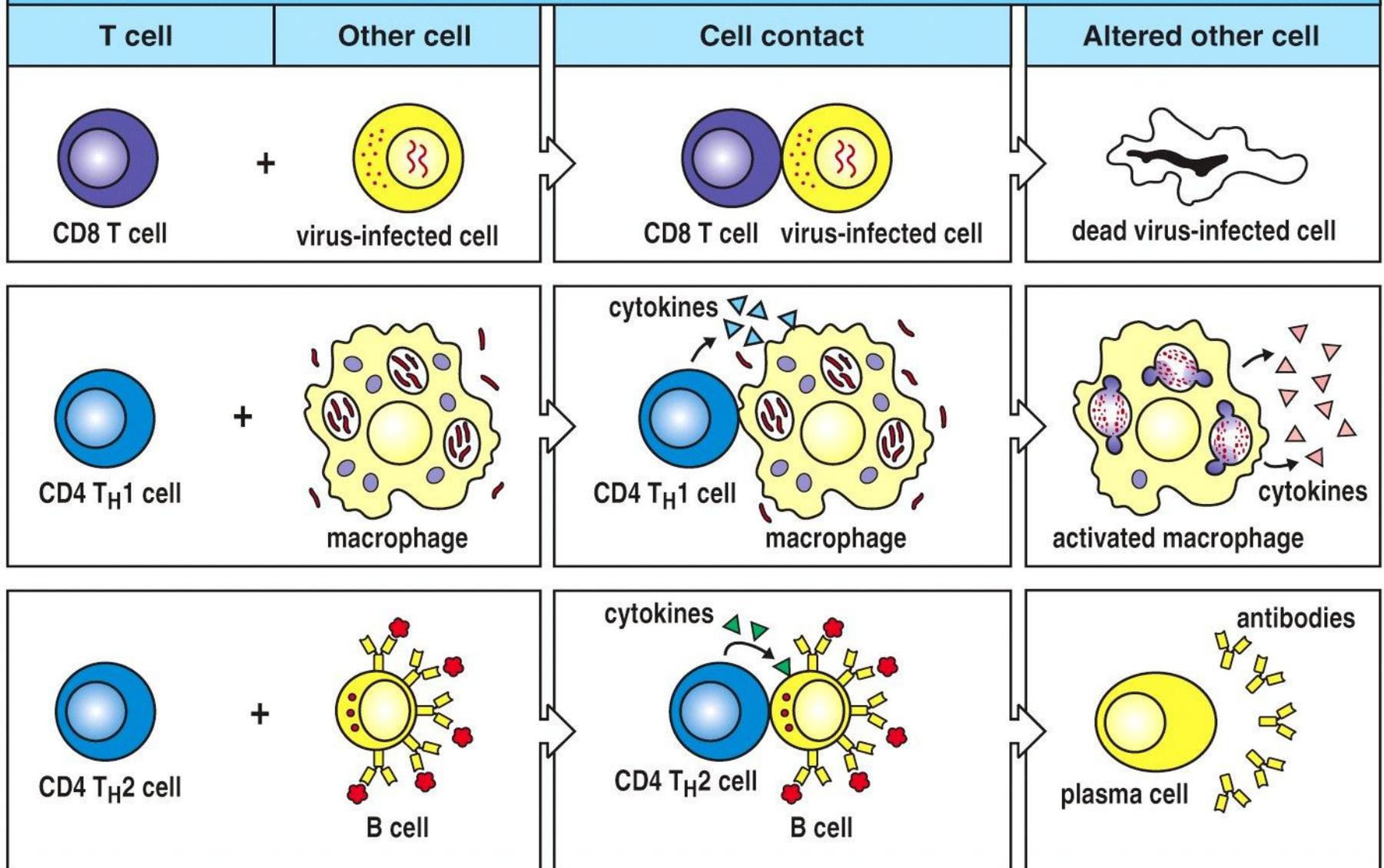


Figure 3-11 The Immune System, 2/e (© Garland Science 2005)

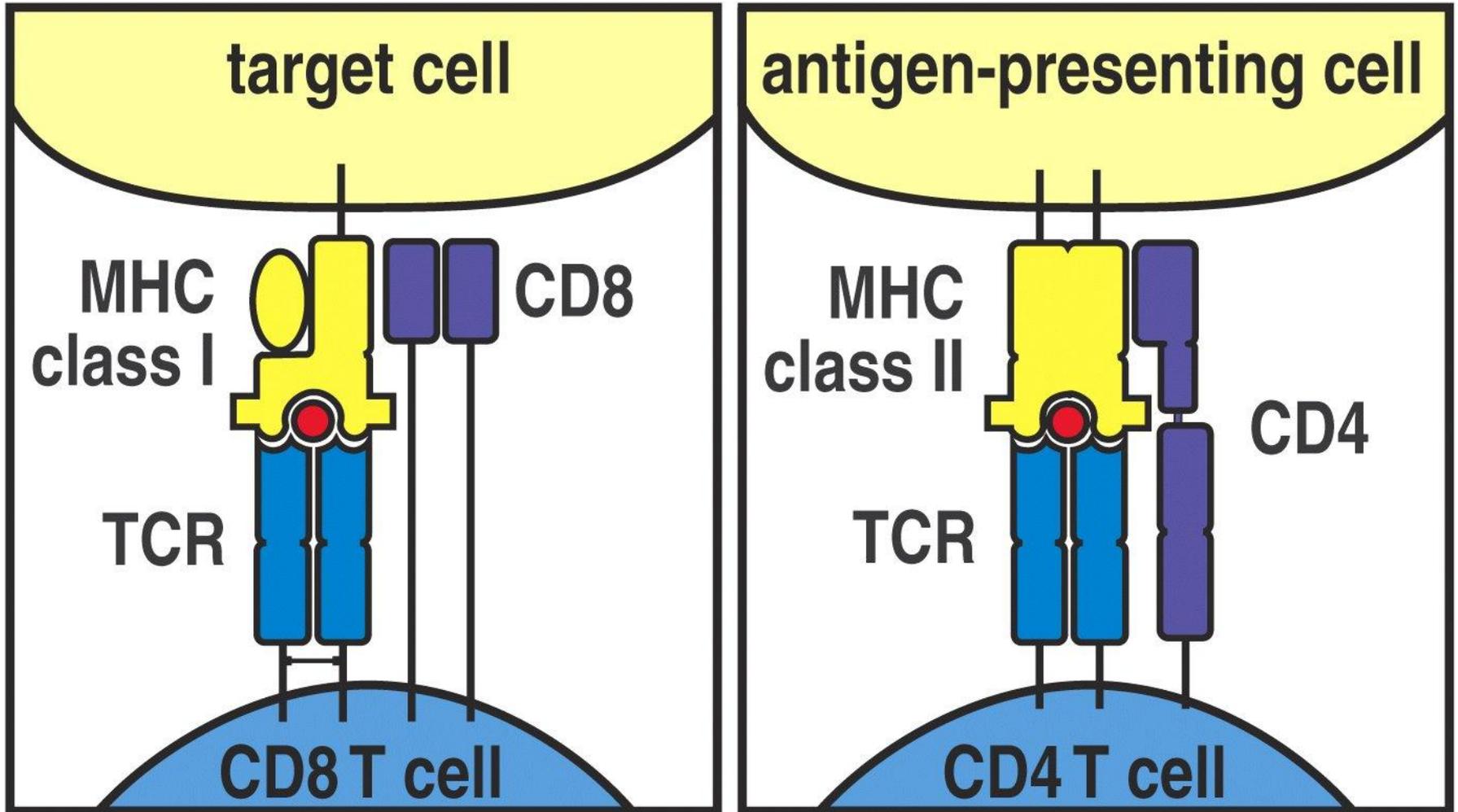


Figure 3-12 The Immune System, 2/e (© Garland Science 2005)

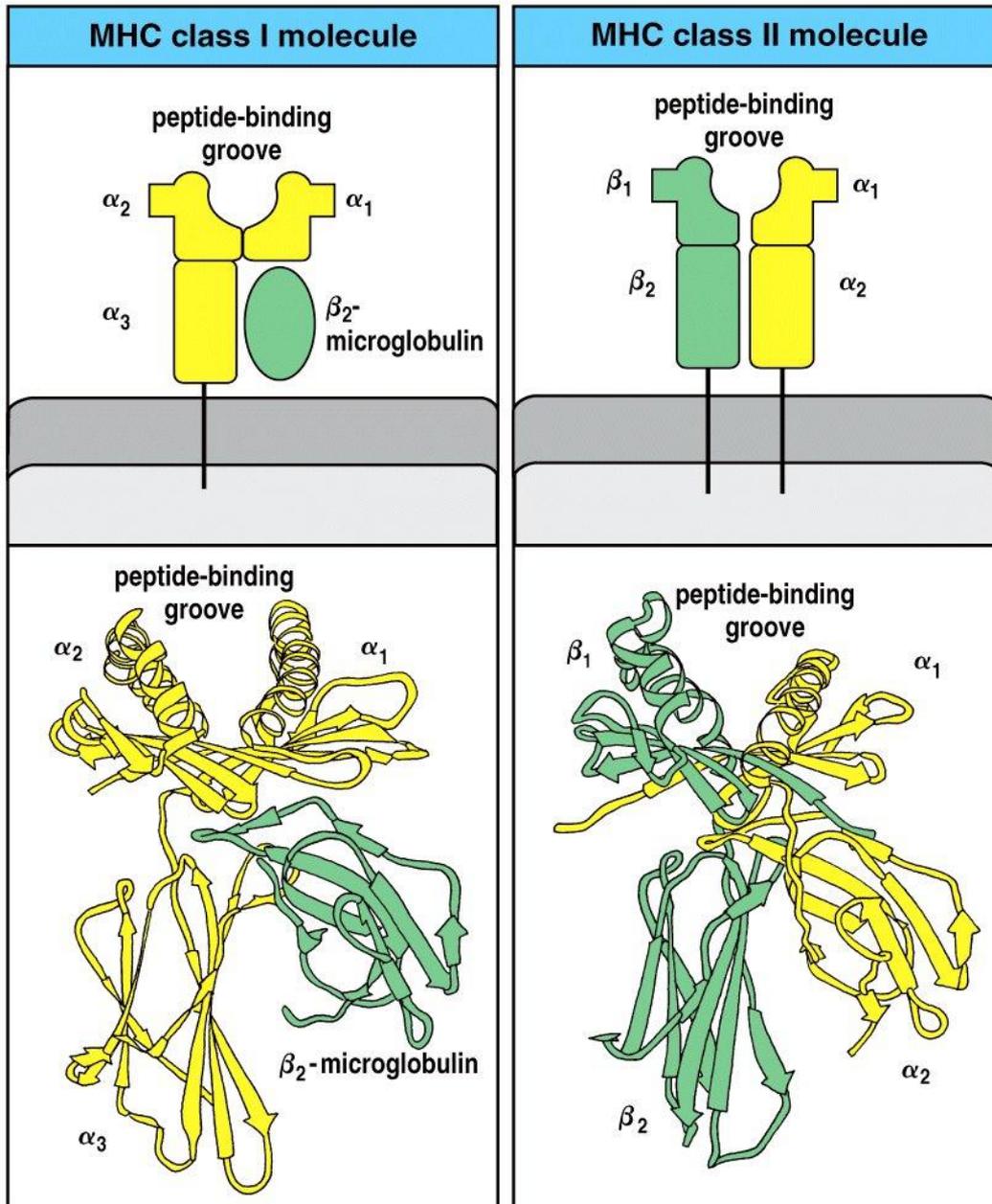
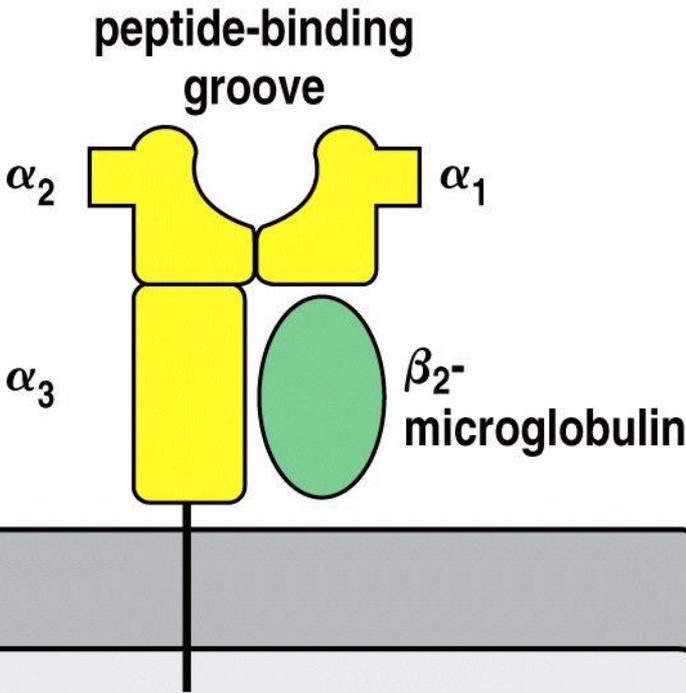


Figure 3-13 The Immune System, 2/e (© Garland Science 2005)

### MHC class I molecule



### MHC class II molecule

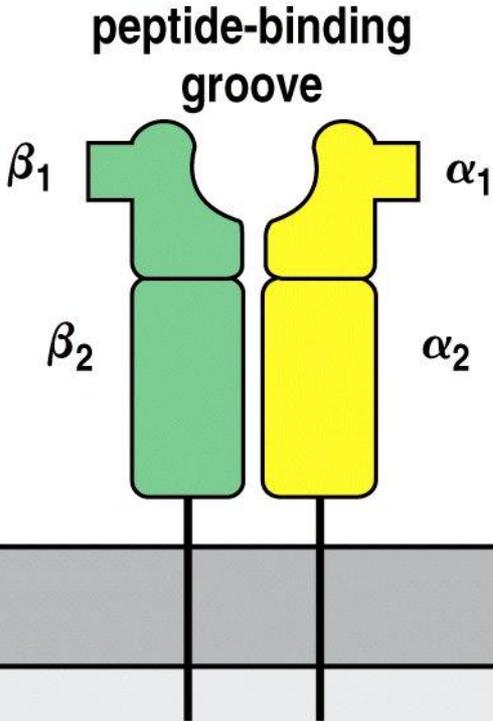
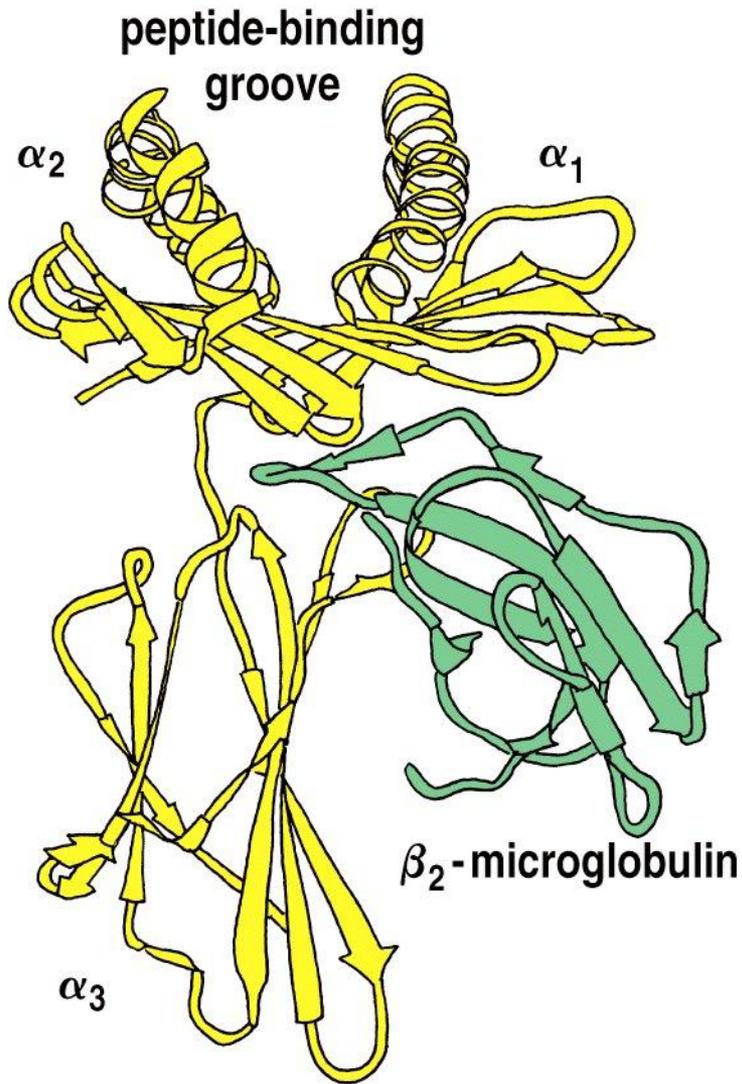
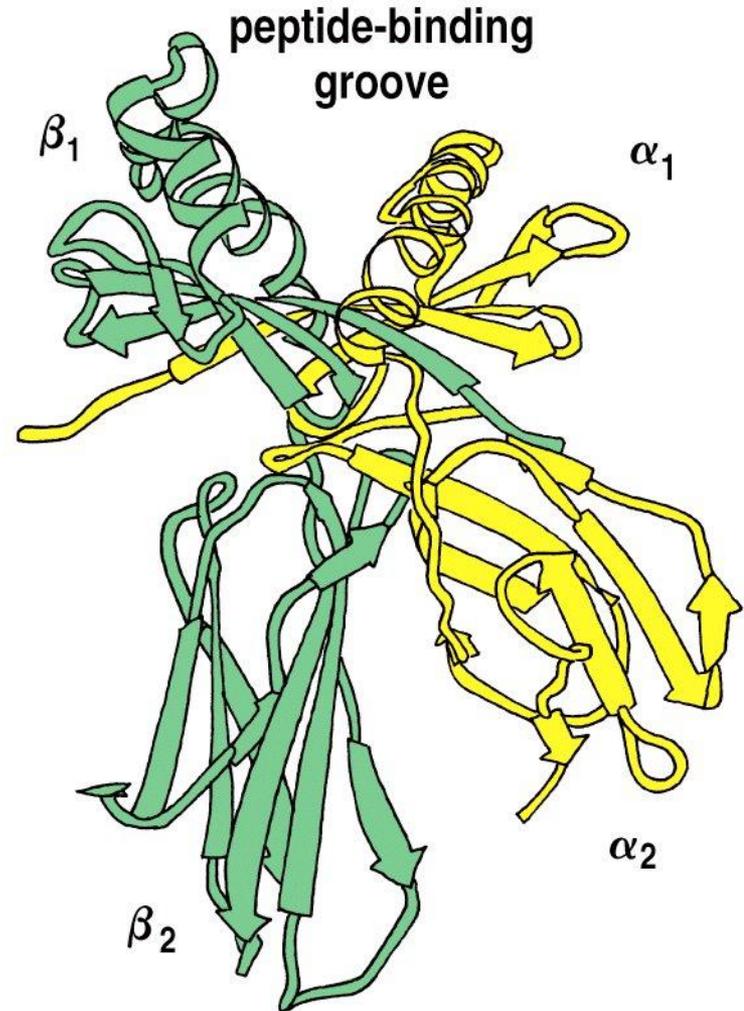


Figure 3-13 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

## MHC class I molecule



## MHC class II molecule



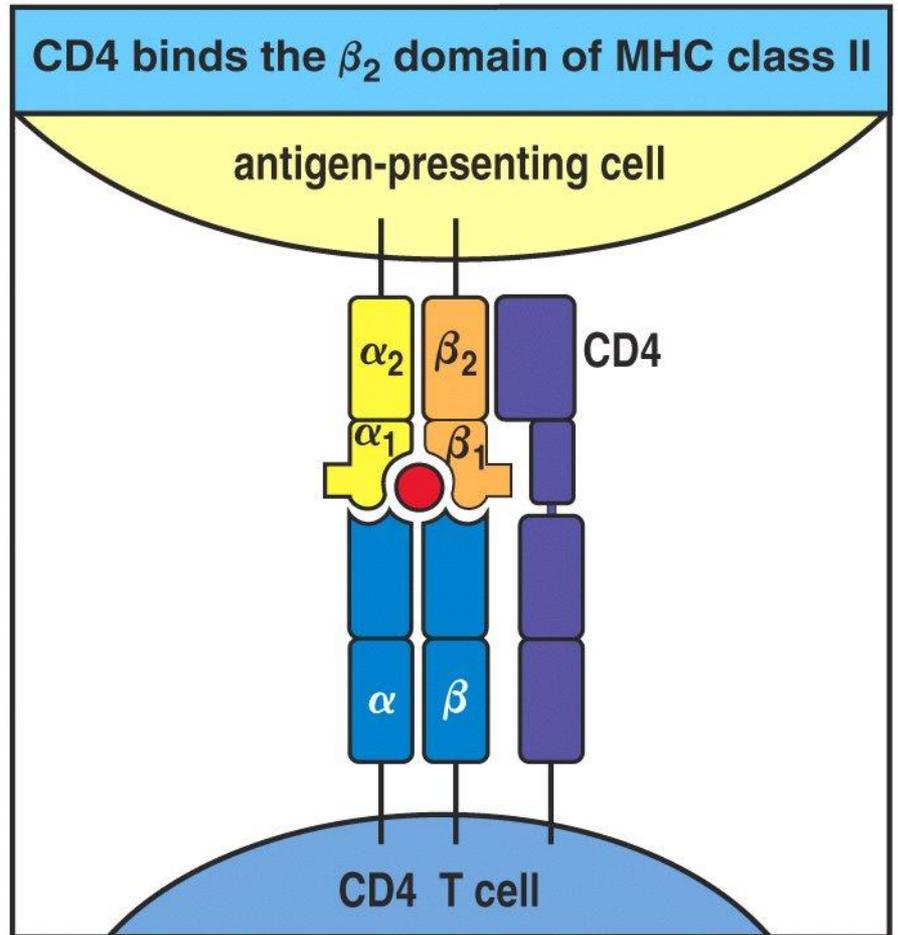
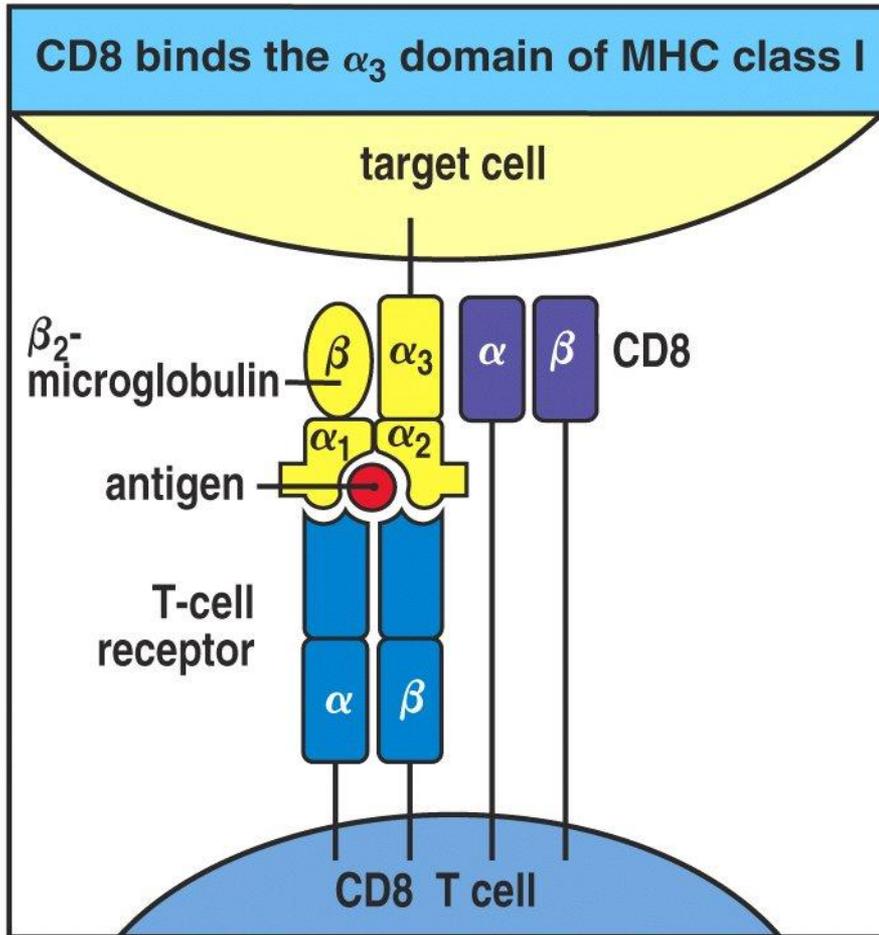
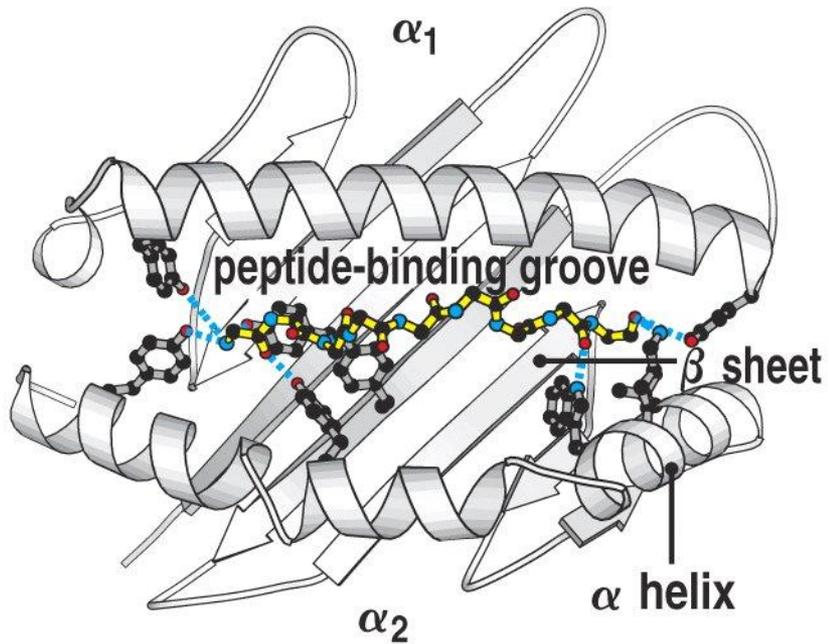


Figure 3-14 The Immune System, 2/e (© Garland Science 2005)

## MHC class I



## MHC class II

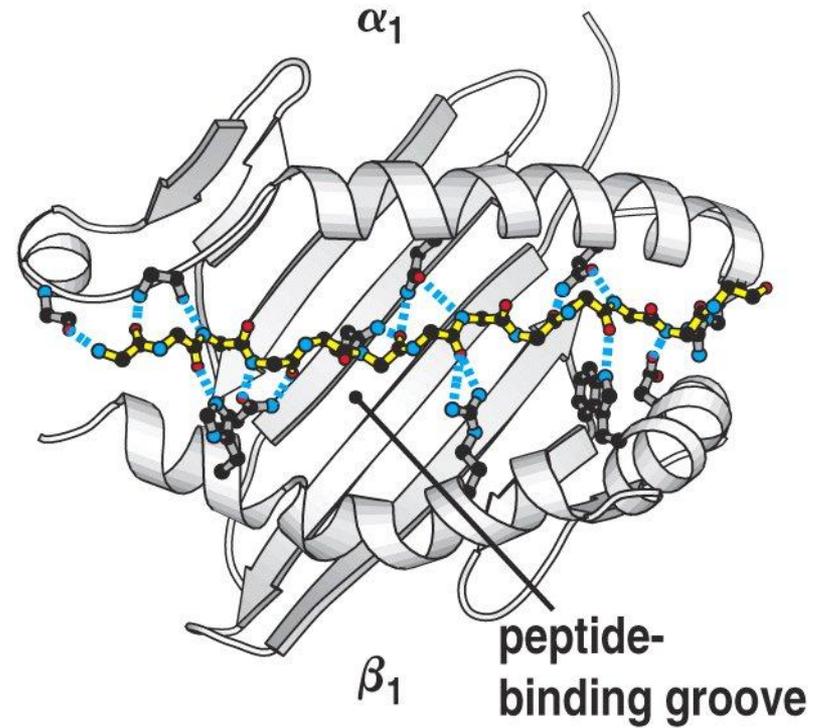


Figure 3-15 The Immune System, 2/e (© Garland Science 2005)

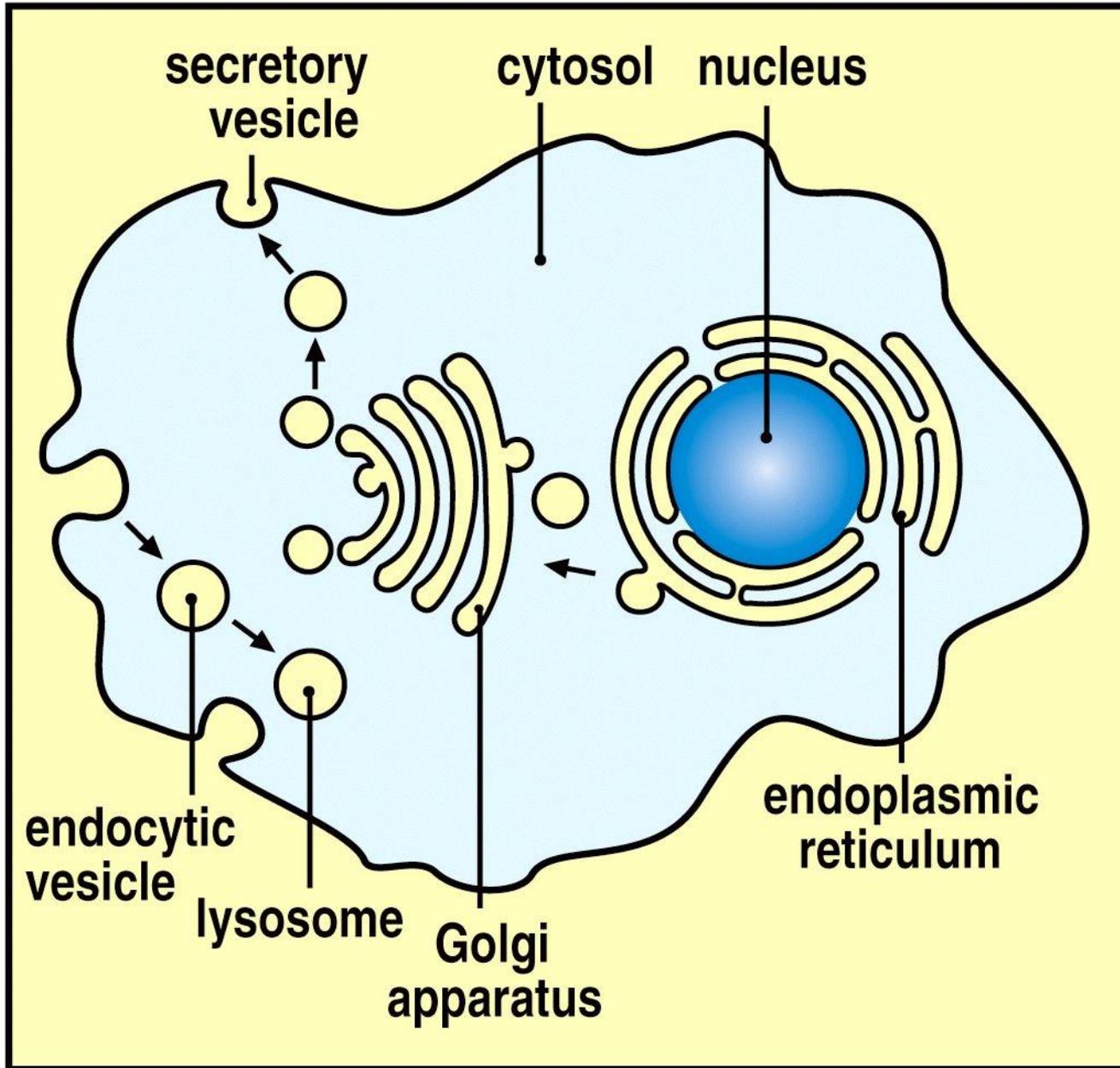


Figure 3-16 The Immune System, 2/e (© Garland Science 2005)

**Peptides produced in the cytosol are transported into the endoplasmic reticulum**

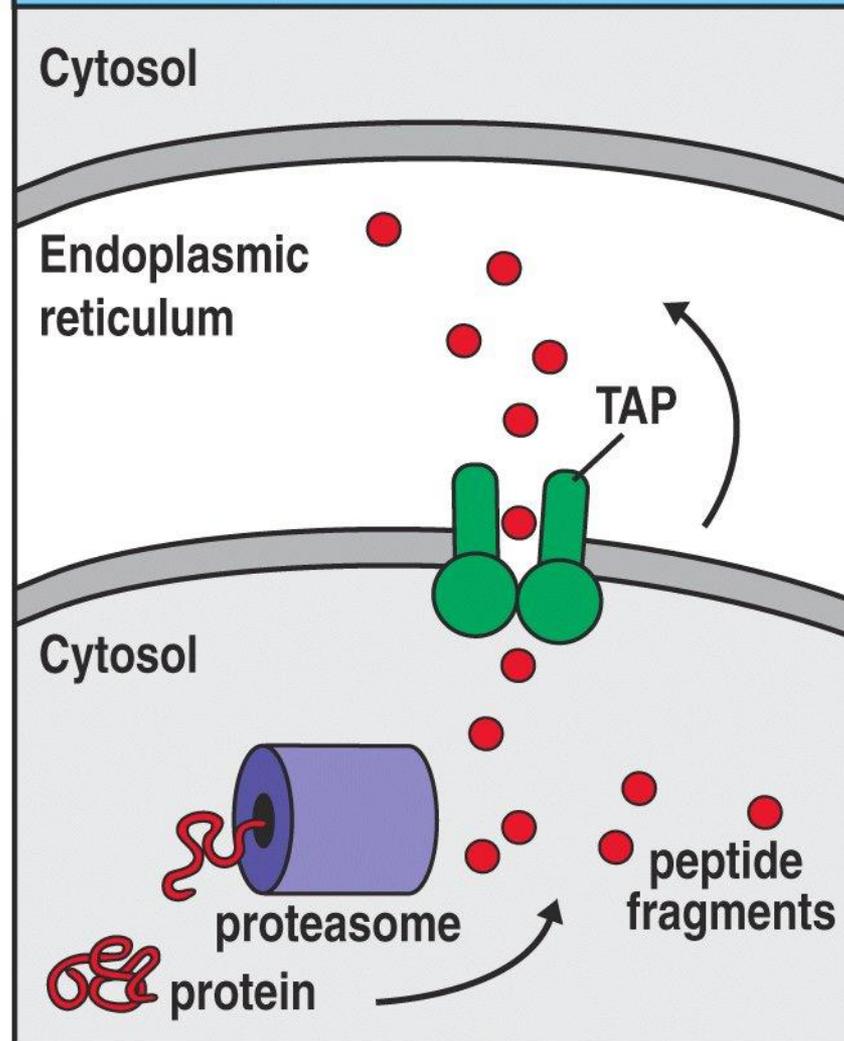


Figure 3-17 The Immune System, 2/e (© Garland Science 2005)

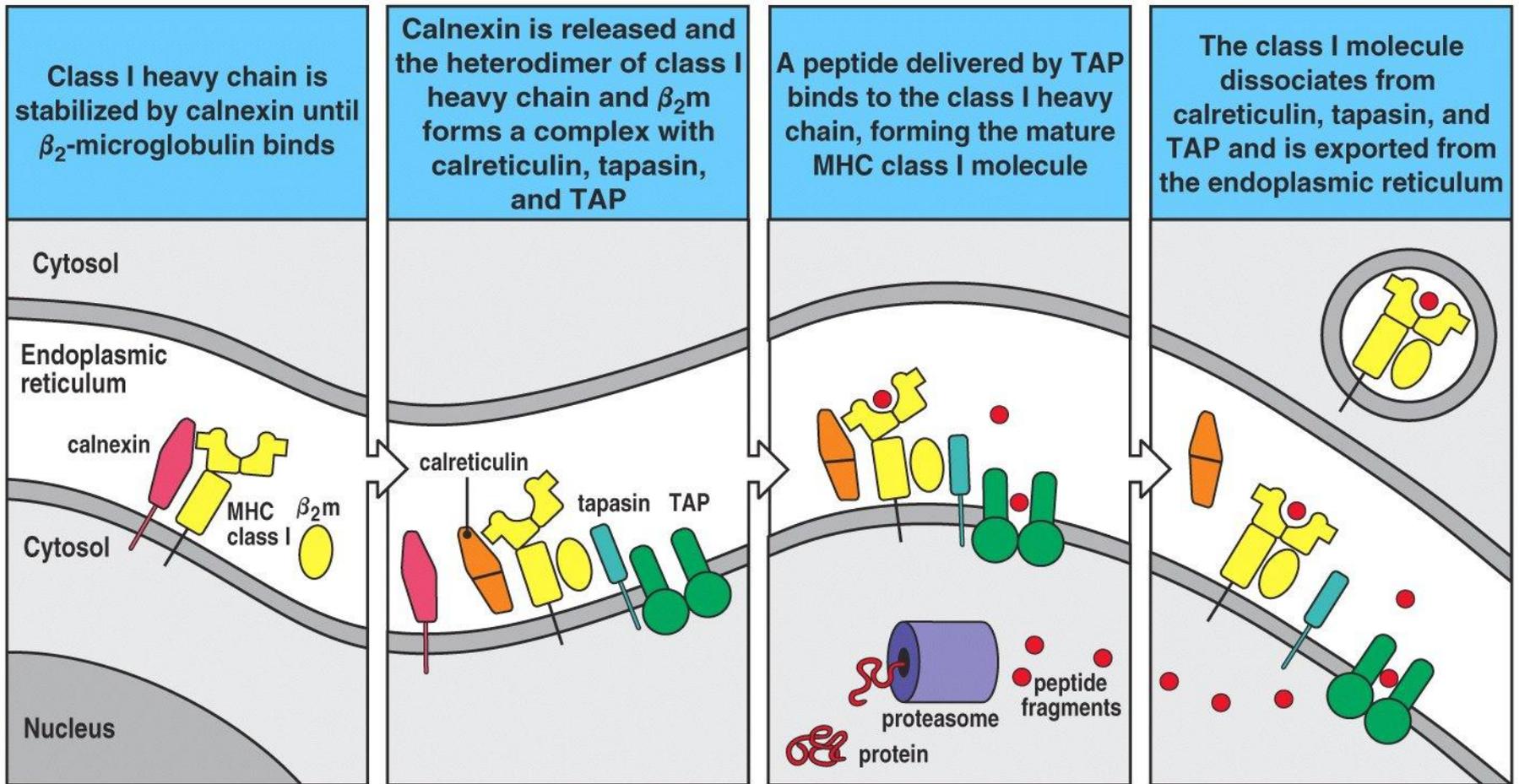


Figure 3-18 The Immune System, 2/e (© Garland Science 2005)

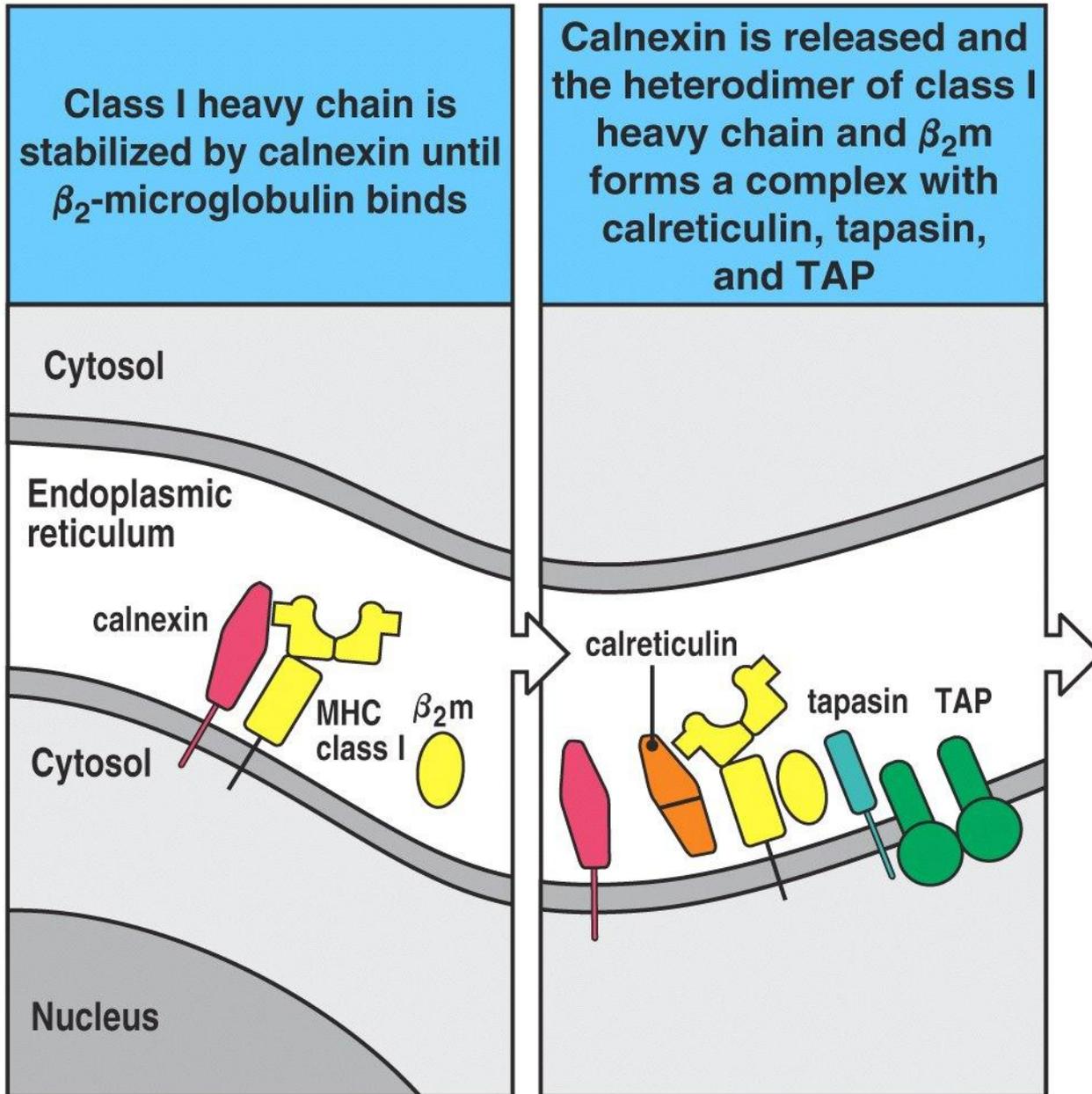


Figure 3-18 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

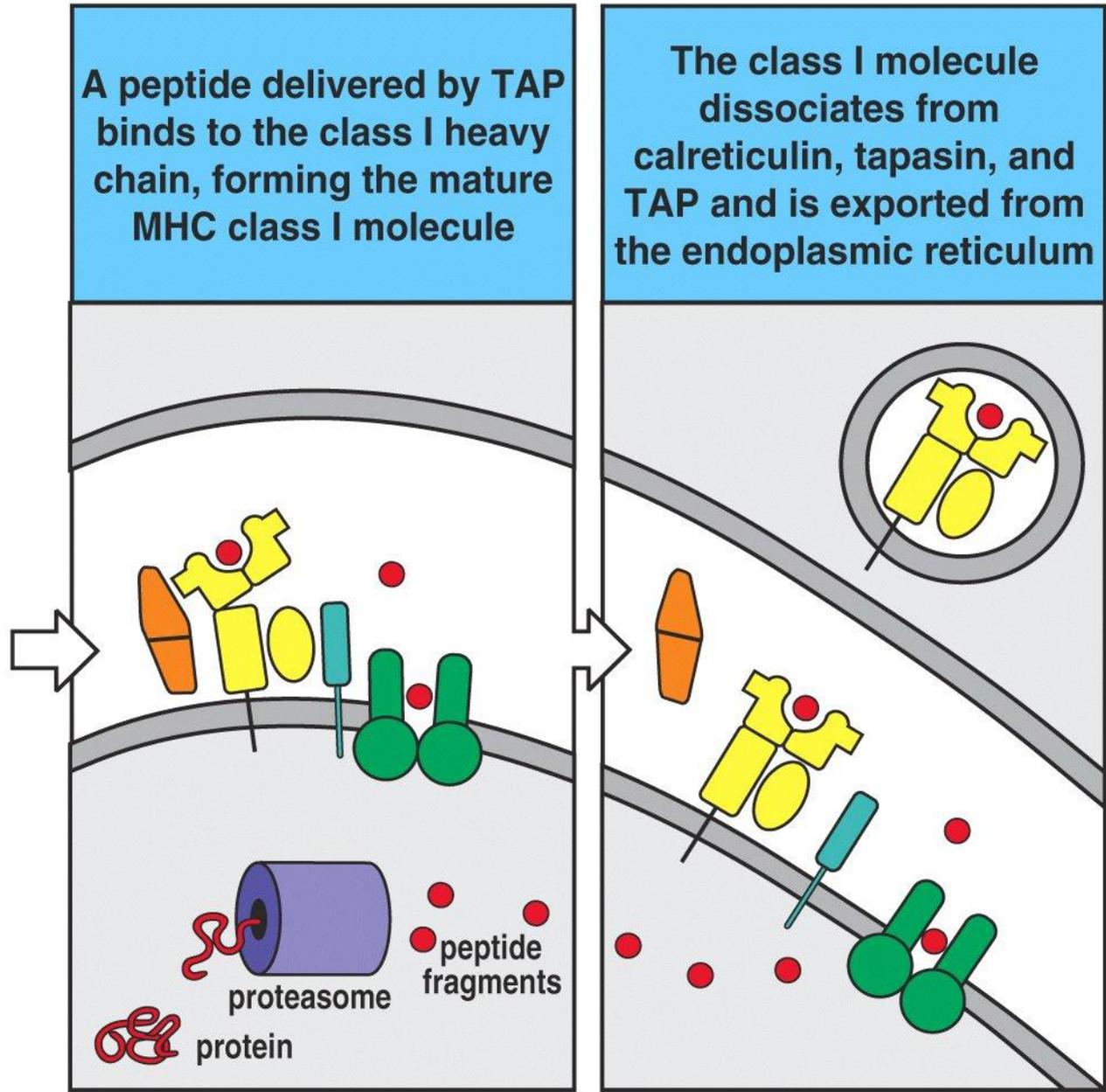


Figure 3-18 part 2 of 2 The Immune System, 2/e (© Garland Science 2005)

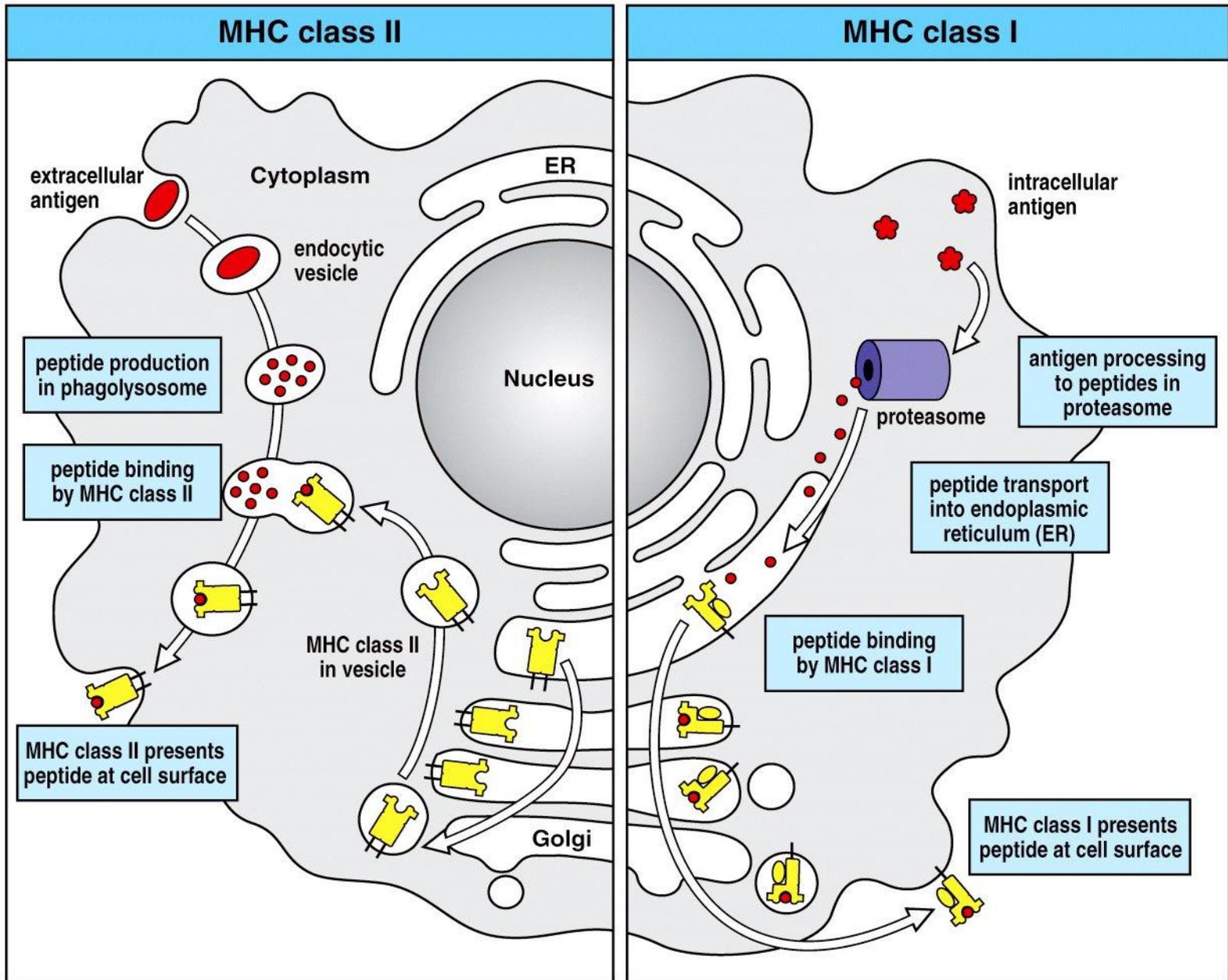


Figure 3-19 The Immune System, 2/e (© Garland Science 2005)

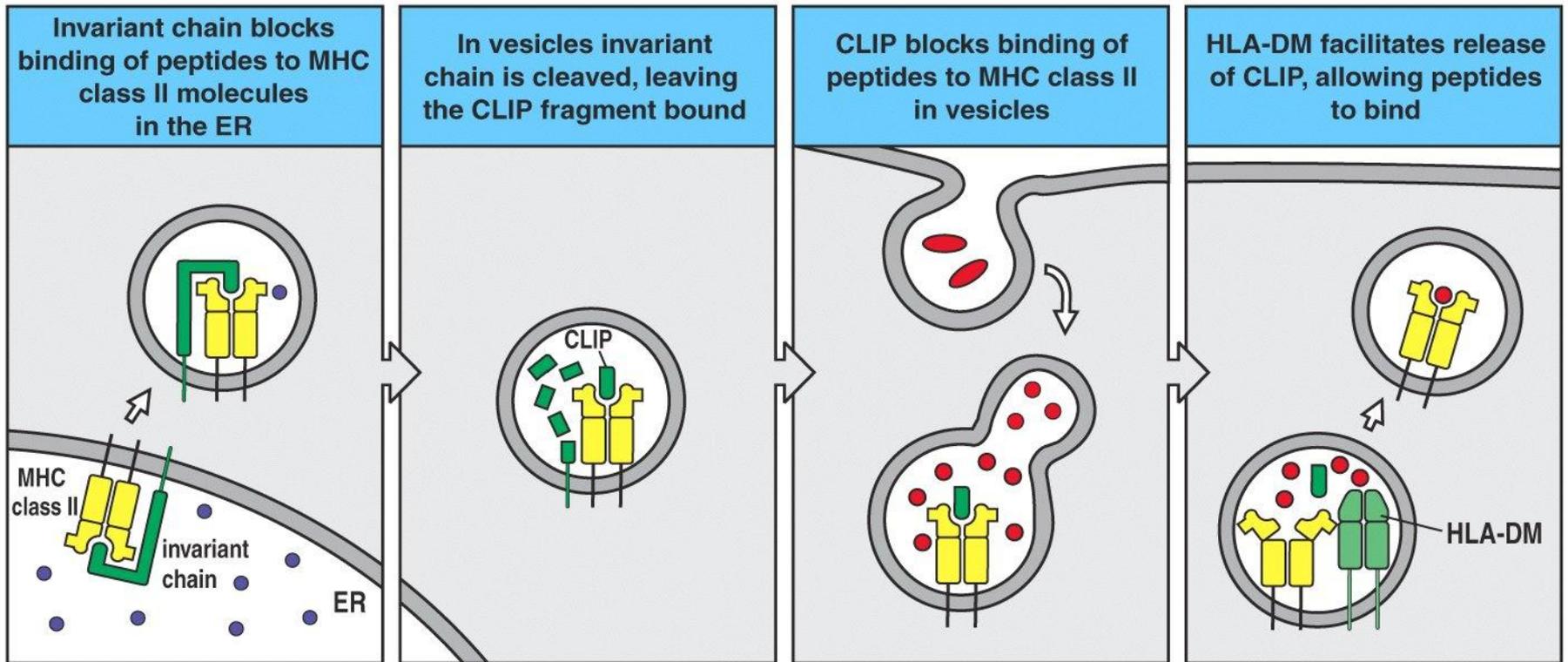


Figure 3-20 The Immune System, 2/e (© Garland Science 2005)

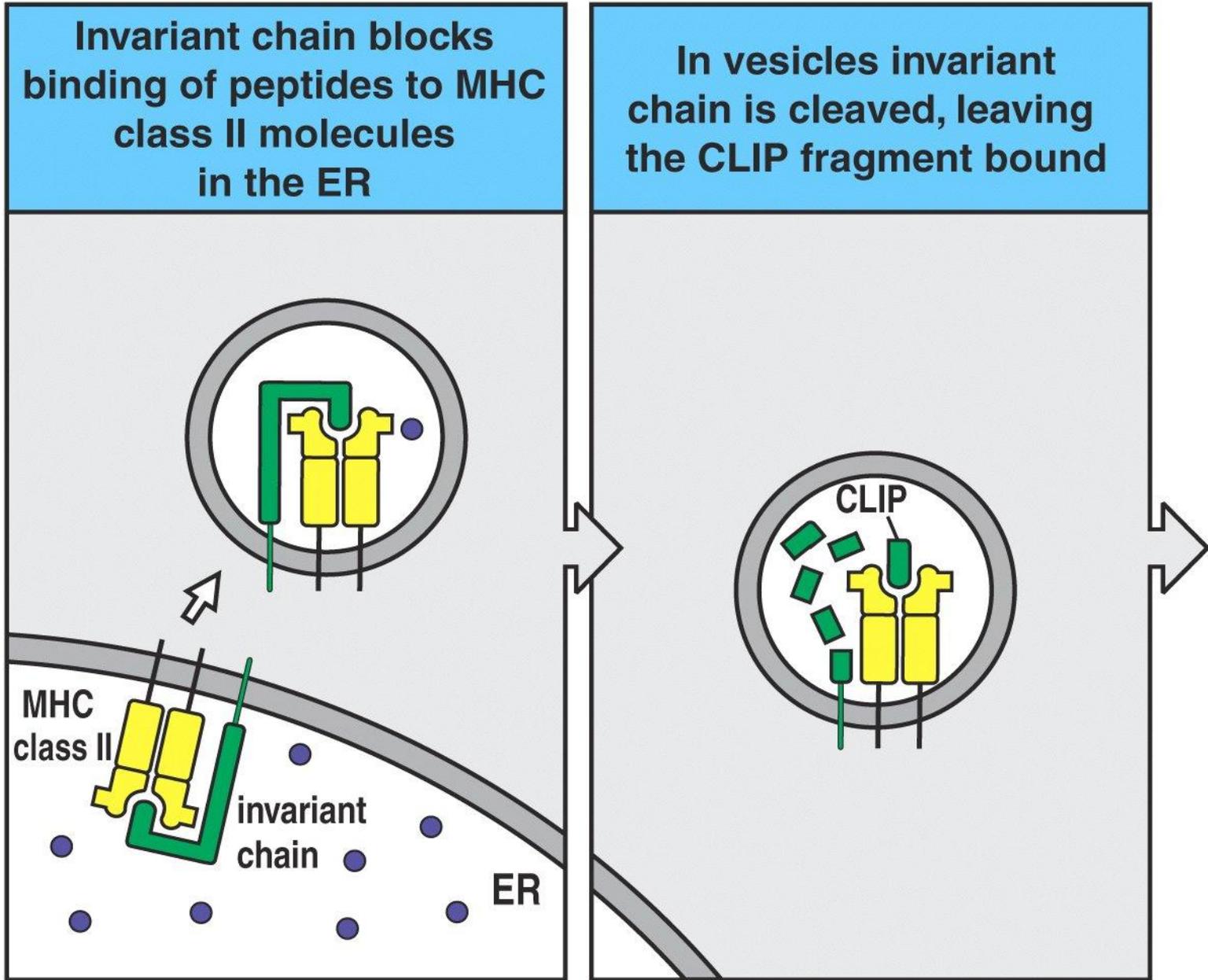


Figure 3-20 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

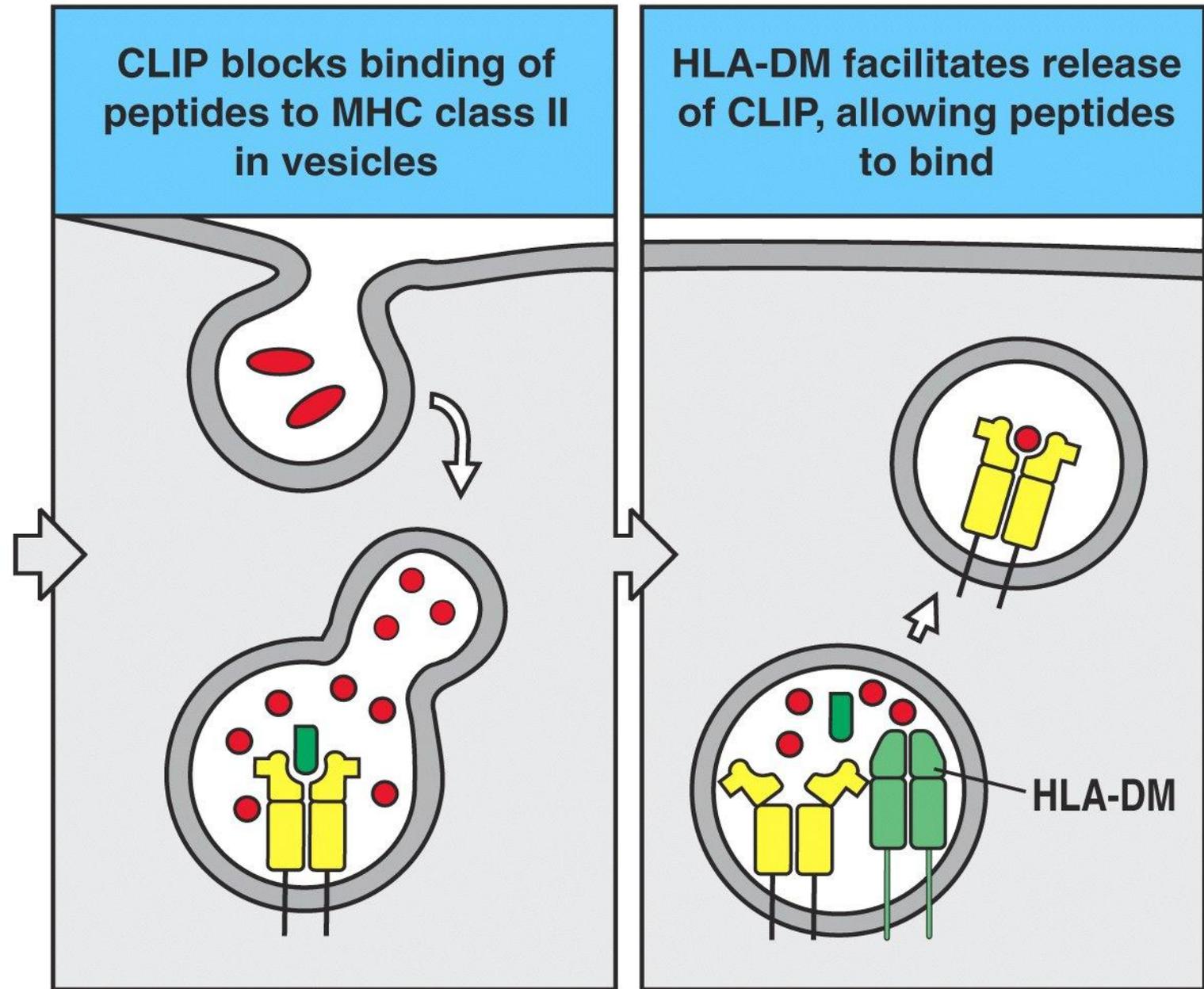


Figure 3-20 part 2 of 2 The Immune System, 2/e (© Garland Science 2005)

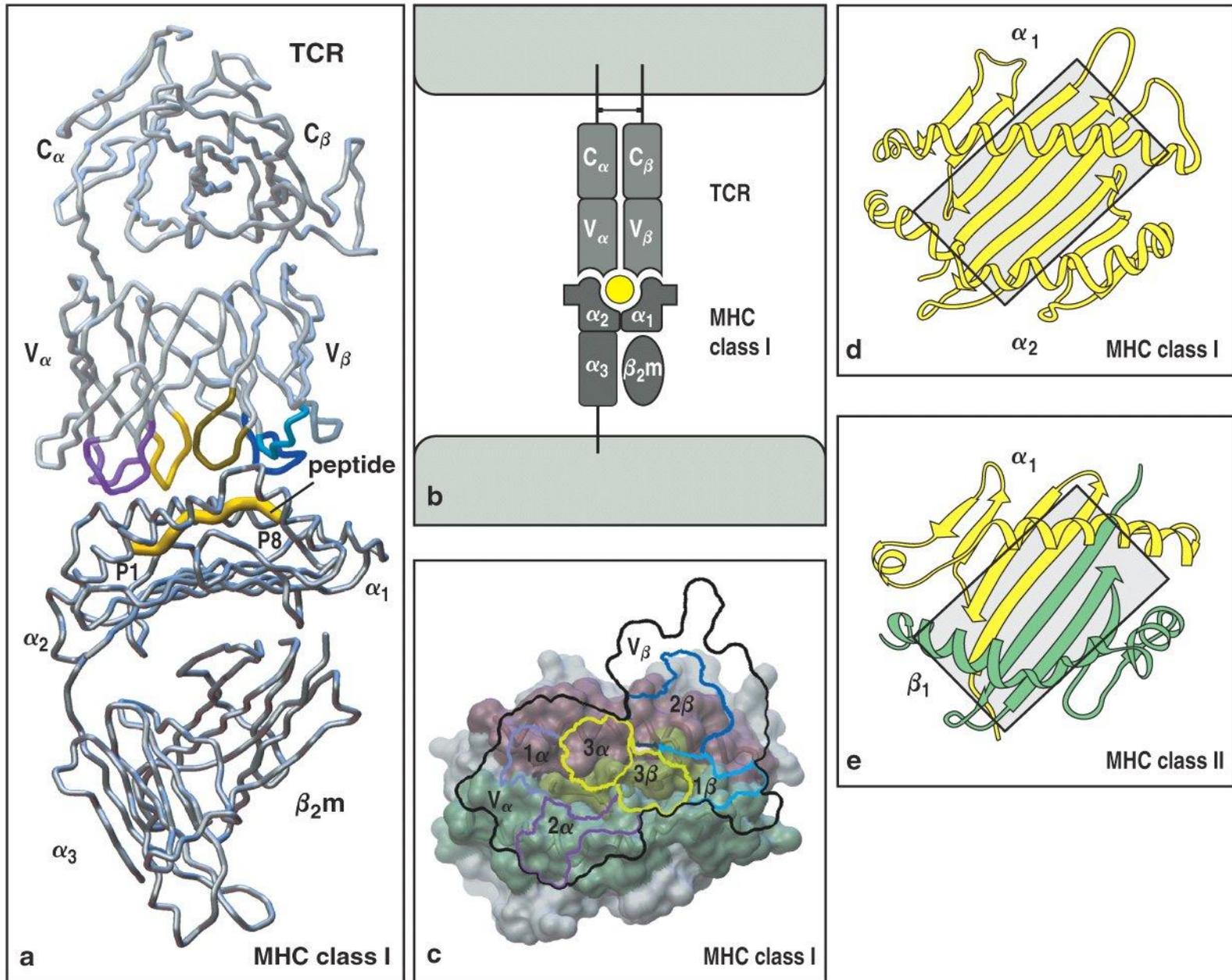


Figure 3-21 The Immune System, 2/e (© Garland Science 2005)

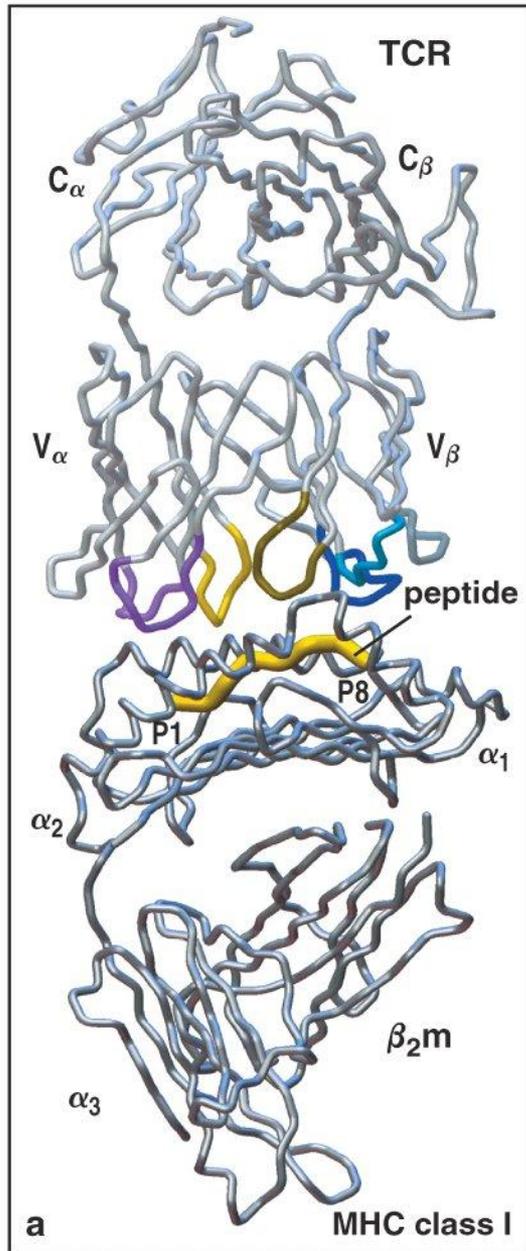


Figure 3-21 part 1 of 3 The Immune System, 2/e (© Garland Science 2005)

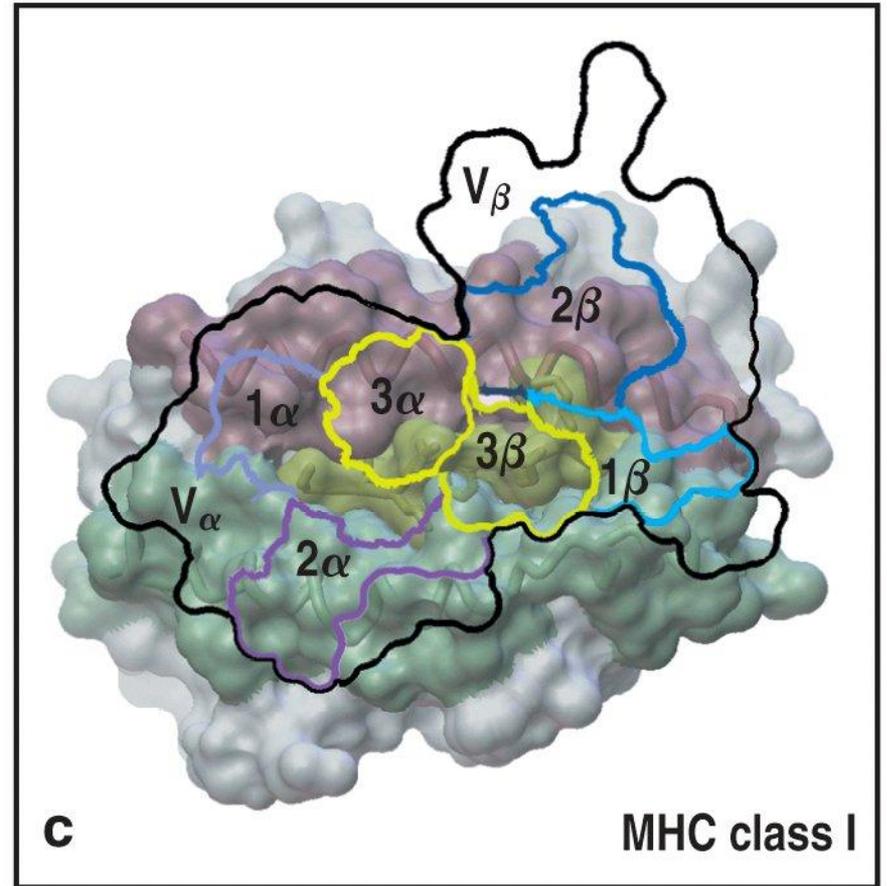
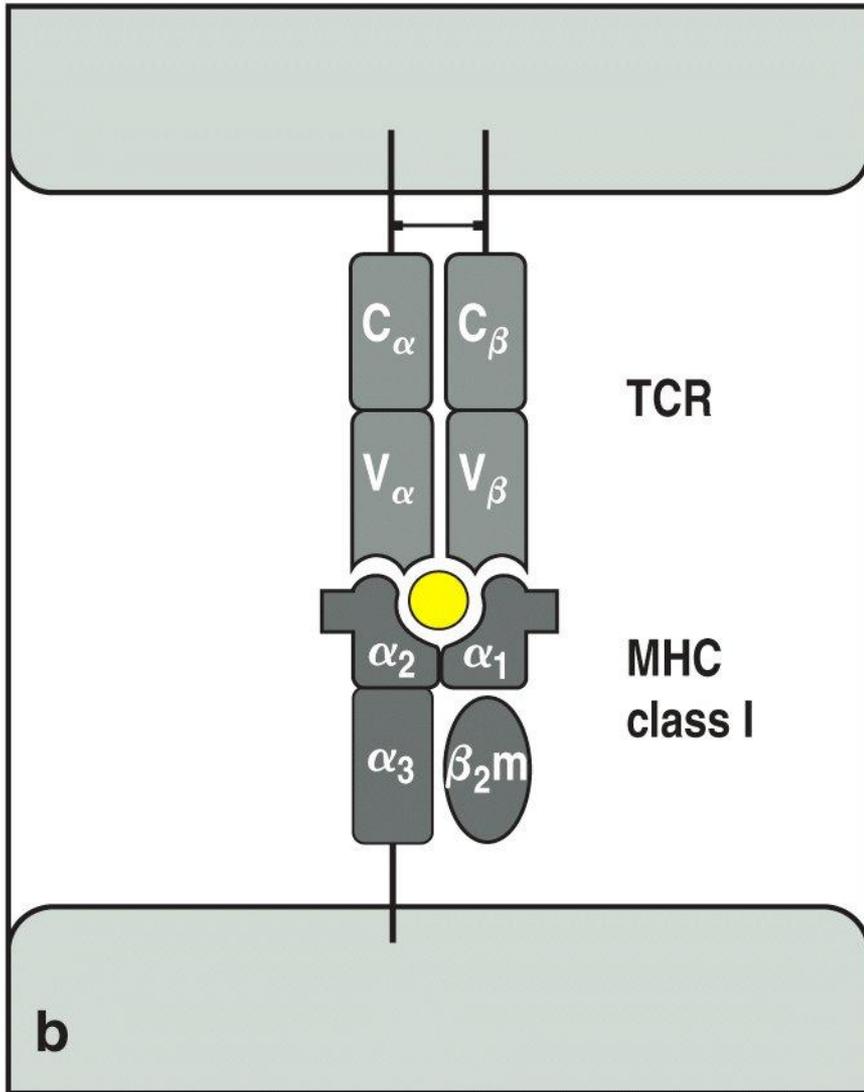


Figure 3-21 part 2 of 3 The Immune System, 2/e (© Garland Science 2005)

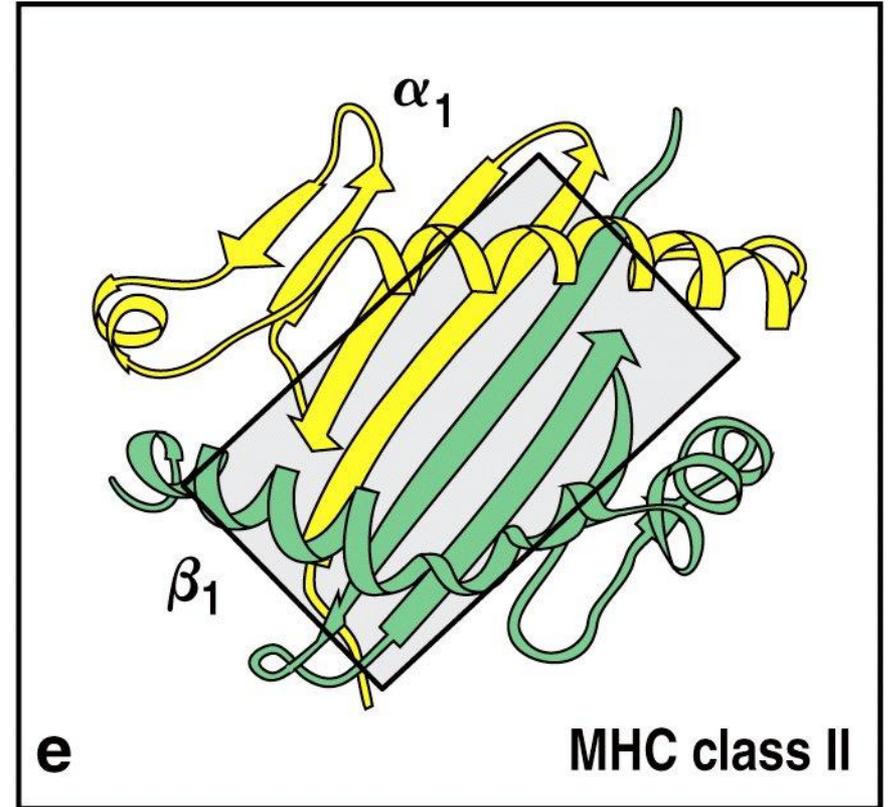
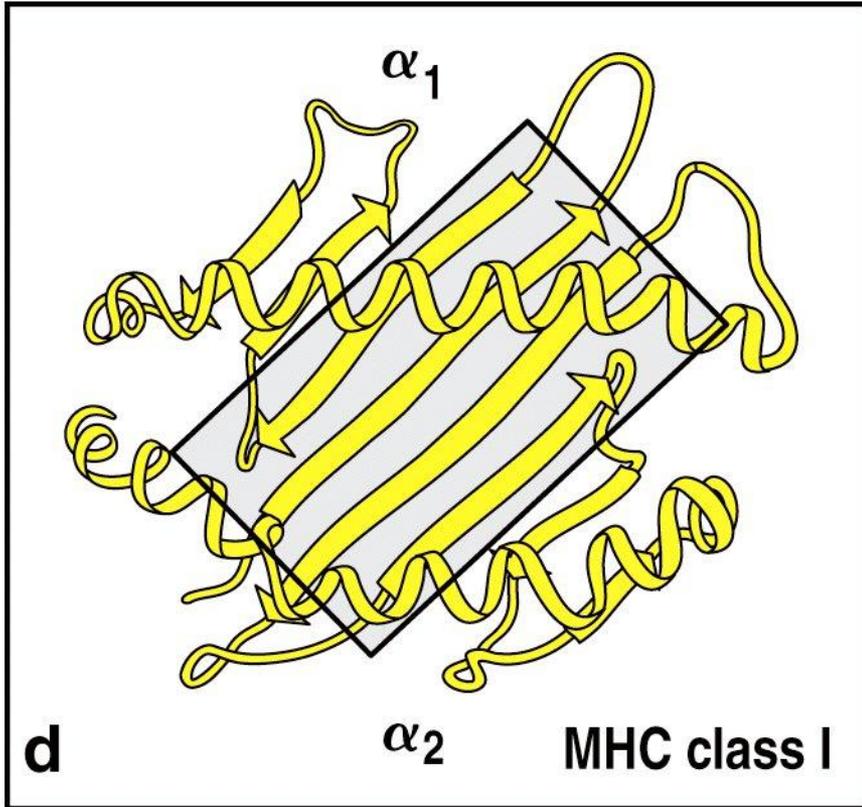


Figure 3-21 part 3 of 3 The Immune System, 2/e (© Garland Science 2005)

Tissue	MHC class I	MHC class II
<b>Lymphoid tissues</b>		
T cells	+++	+
B cells	+++	+++
Macrophages	+++	++
Other antigen-presenting cells (e.g., dendritic cells)	+++	+++
Epithelial cells of the thymus	+	+++
<b>Other nucleated cells</b>		
Neutrophils	+++	-
Hepatocytes	+	-
Kidney	+	-
Brain	+	- †
<b>Non-nucleated cells</b>		
Red blood cells	-	-

Figure 3-22 The Immune System, 2/e (© Garland Science 2005)

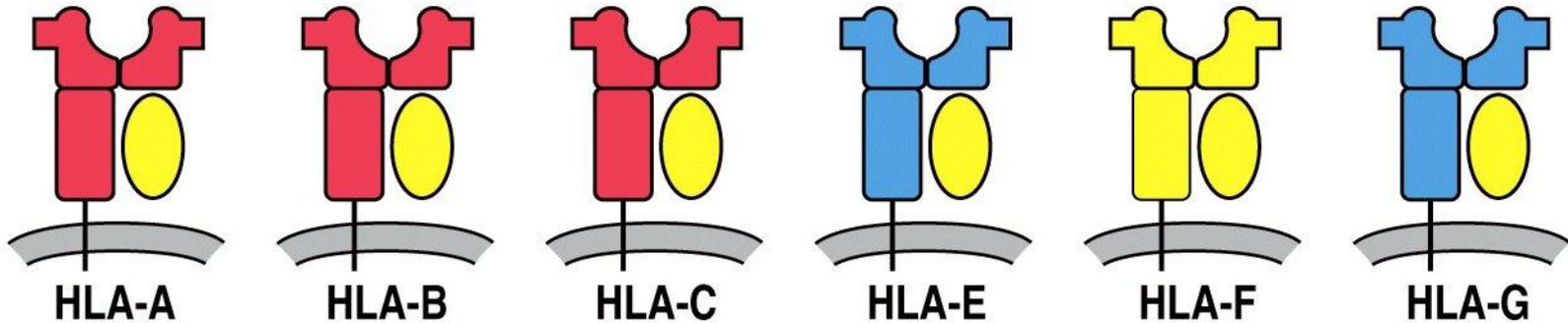
Tissue	MHC class I	MHC class II
<b>Lymphoid tissues</b>		
T cells	+++	+*
B cells	+++	+++
Macrophages	+++	++
Other antigen-presenting cells (e.g., dendritic cells)	+++	+++
Epithelial cells of the thymus	+	+++

Figure 3-22 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

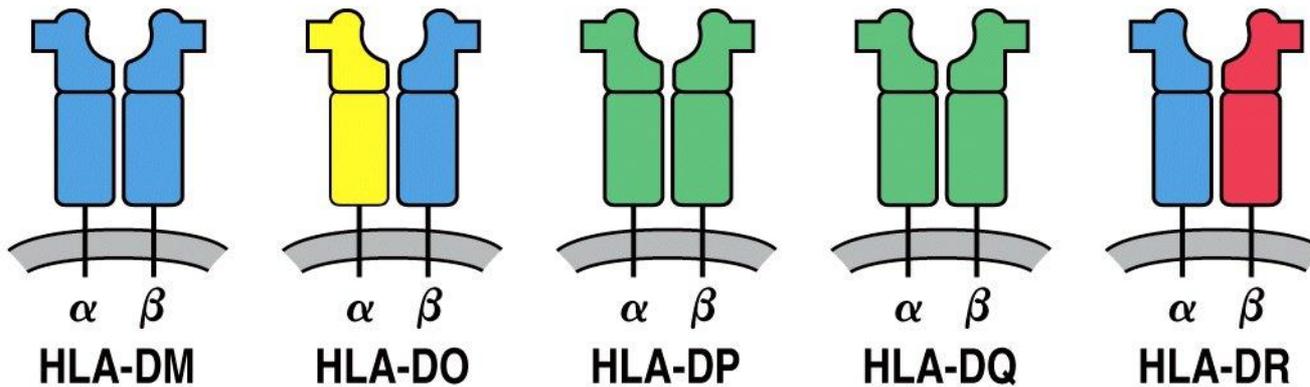
Tissue	MHC class I	MHC class II
<b>Other nucleated cells</b>		
Neutrophils	+++	-
Hepatocytes	+	-
Kidney	+	-
Brain	+	- †
<b>Non-nucleated cells</b>		
Red blood cells	-	-

Figure 3-22 part 2 of 2 The Immune System, 2/e (© Garland Science 2005)

## Human MHC class I isotypes



## Human MHC class II isotypes



■ highly polymorphic   
 ■ polymorphic   
 ■ oligomorphic   
 ■ monomorphic

Figure 3-23 The Immune System, 2/e (© Garland Science 2005)

HLA polymorphism		
MHC class	HLA locus	Number of allotypes
MHC class I	A	218
	B	439
	C	96
	E	4
	F	1
	G	6
MHC class II	DMA	4
	DMB	6
	DOA	1
	DOB	2
	DPA1	12
	DPB1	88
	DQA1	17
	DQB1	42
	DRA	2
	DRB1	269
	DRB3	30
	DRB4	7
DRB5	12	

Figure 3-24 The Immune System, 2/e (© Garland Science 2005)

# HLA polymorphism

MHC class	HLA locus	Number of allotypes
MHC class I	A	218
	B	439
	C	96
	E	4
	F	1
	G	6

Figure 3-24 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

HLA polymorphism		
MHC class	HLA locus	Number of allotypes
MHC class II	DMA	4
	DMB	6
	DOA	1
	DOB	2
	DPA1	12
	DPB1	88
	DQA1	17
	DQB1	42
	DRA	2
	DRB1	269
	DRB3	30
	DRB4	7
	DRB5	12

Figure 3-24 part 2 of 2 The Immune System, 2/e (© Garland Science 2005)

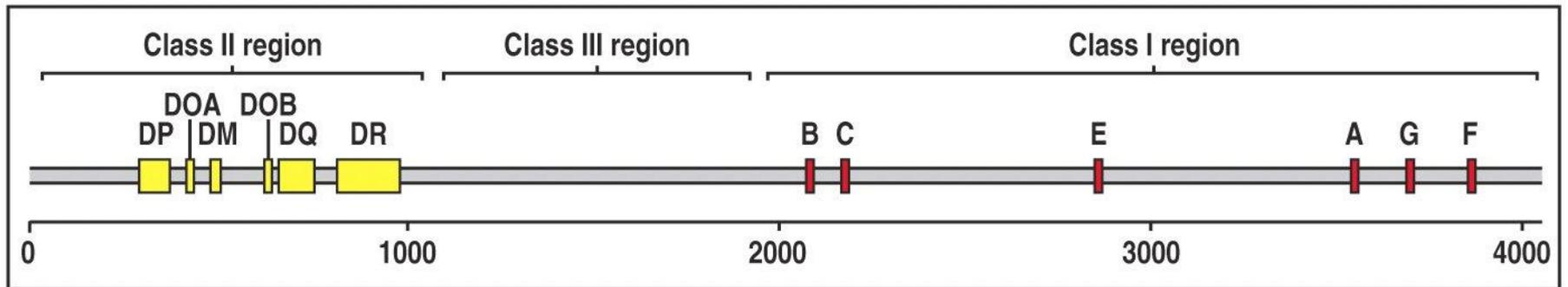


Figure 3-25 The Immune System, 2/e (© Garland Science 2005)

# Diversity of gene content in the HLA-DR subdivision

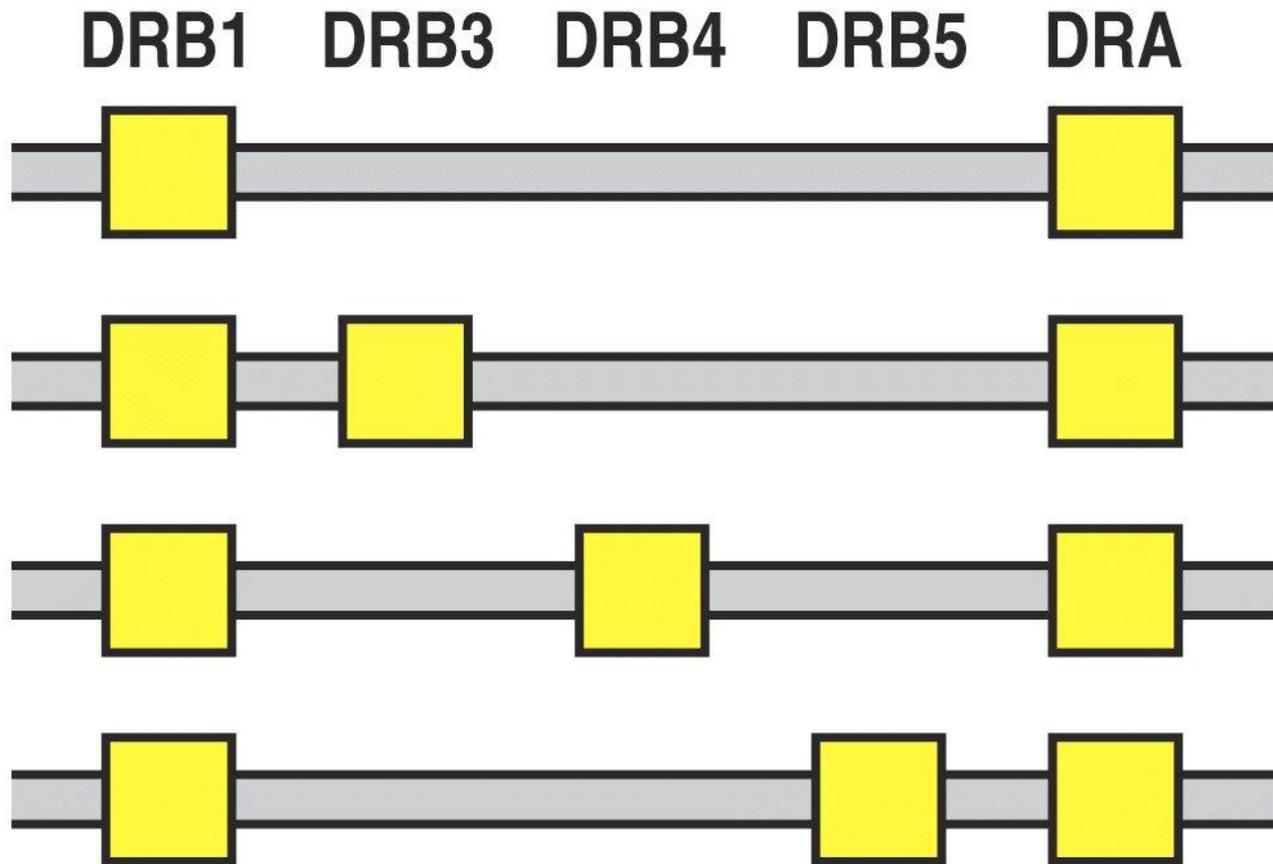


Figure 3-26 The Immune System, 2/e (© Garland Science 2005)

## HLA class II region

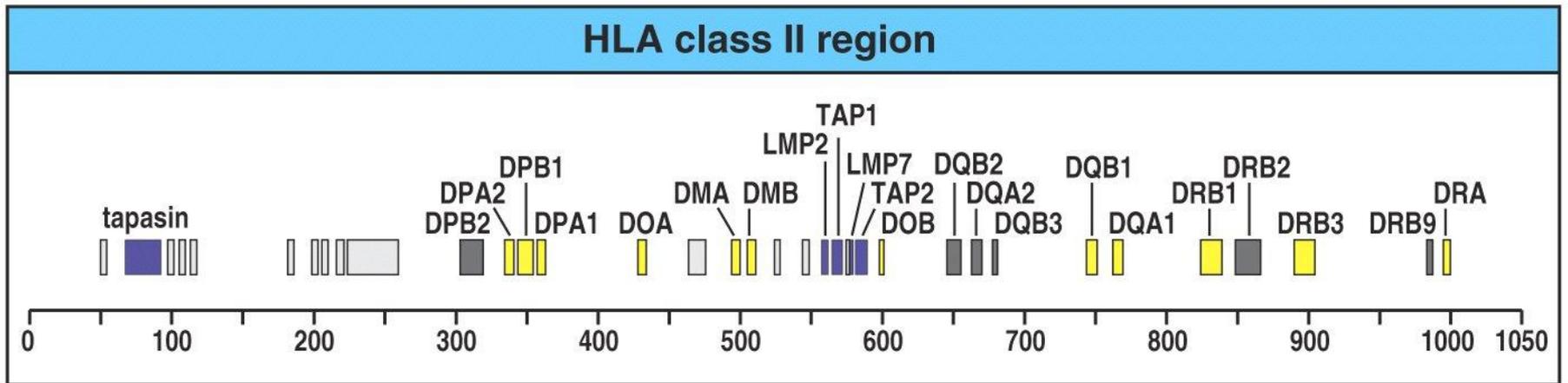
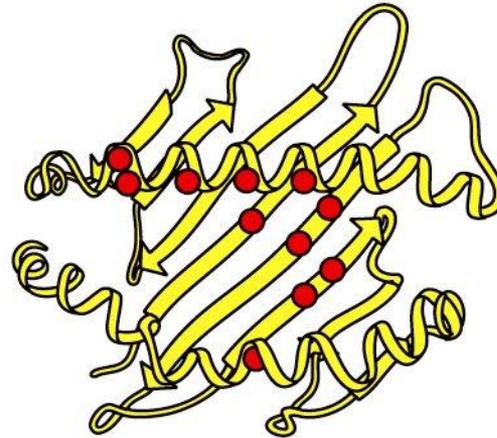
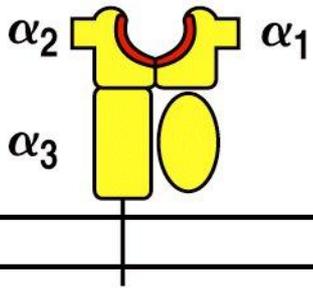


Figure 3-27 The Immune System, 2/e (© Garland Science 2005)

## MHC class I variability



## MHC class II variability

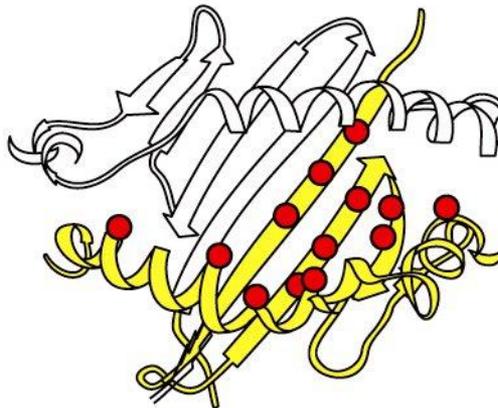
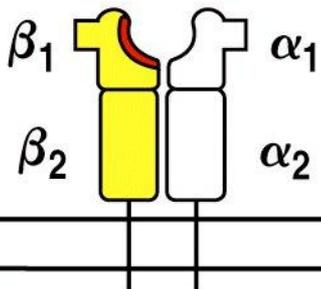


Figure 3-28 The Immune System, 2/e (© Garland Science 2005)

## MHC class I variability

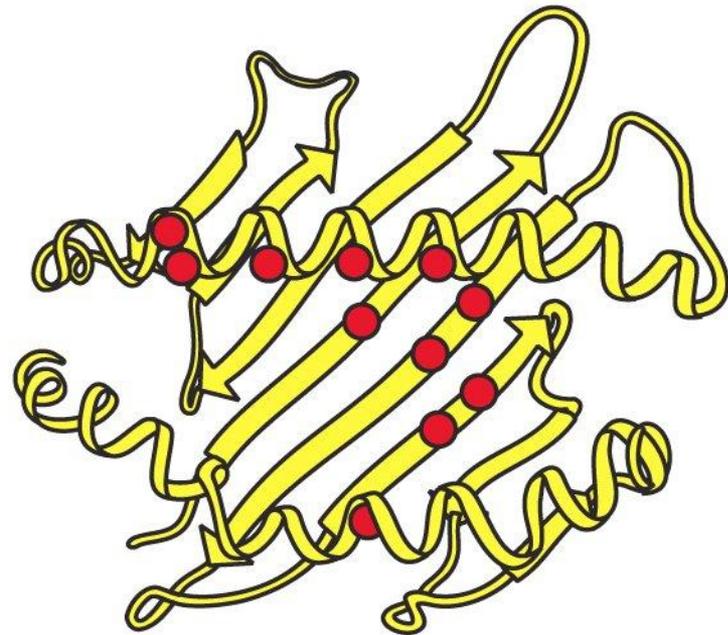
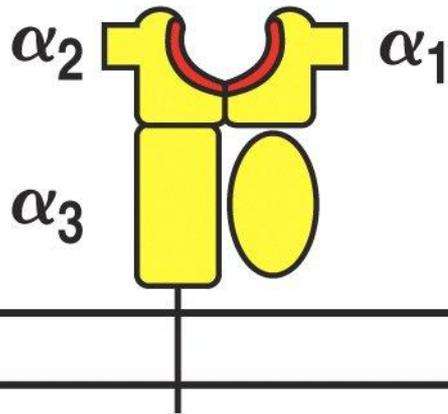


Figure 3-28 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

## MHC class II variability

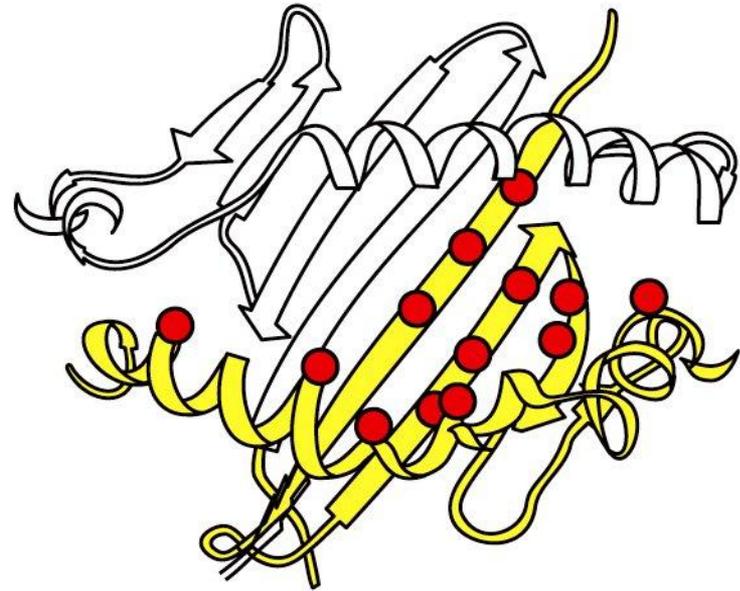
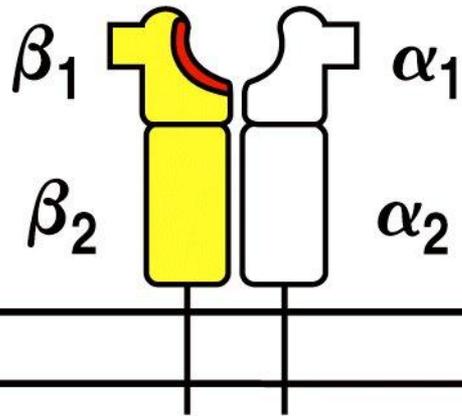


Figure 3-28 part 2 of 2 The Immune System, 2/e (© Garland Science 2005)

MHC molecule	Amino-acid sequence of peptide-binding motifs and bound peptides	Source of bound peptide
Position in peptide sequence N—1 2 3 4 5 6 7 8 9—C		
Class I	HLA-A*0201 Peptide-binding motif: □ L/M □ □ □ V □ □ V/L Bound peptide: I L K E P V H G V	HIV reverse transcriptase
	HLA-B*2705 Peptide-binding motif: □ R □ □ □ □ □ L/F Bound peptide: R R Y P D A V Y L	Measles virus F protein
Class II	HLA-DRB1*0401 Self peptide: G V Y F Y L Q W G R S T L V S V S	Igκ light chain
	HLA-DQA1*0501 HLA-DQB1*0301 Self peptide: I P E L N K V A R A A A	Transferrin receptor

Figure 3-29 The Immune System, 2/e (© Garland Science 2005)

# MHC restriction

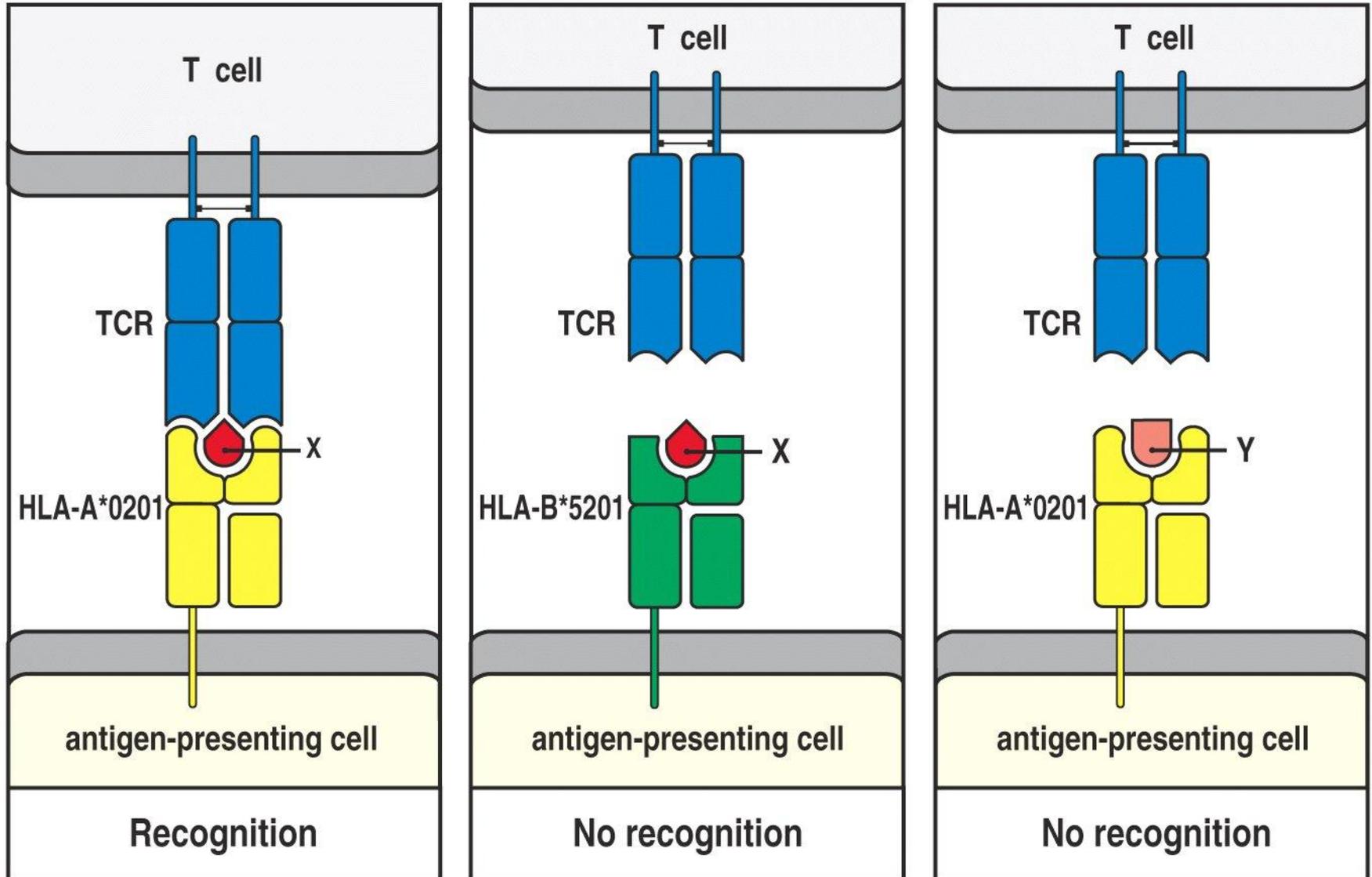
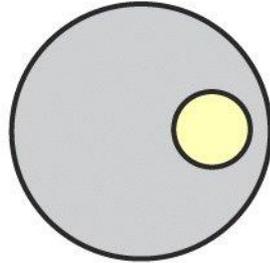
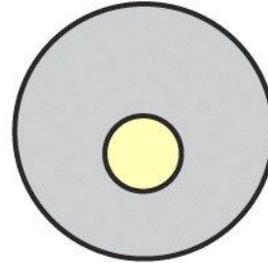


Figure 3-30 The Immune System, 2/e (© Garland Science 2005)

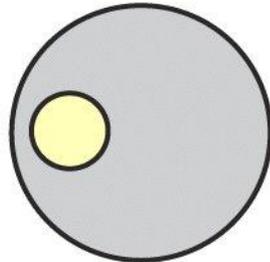
## Heterozygote advantage in peptide selection



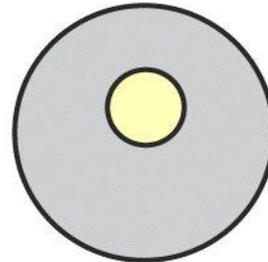
Haplotype 1



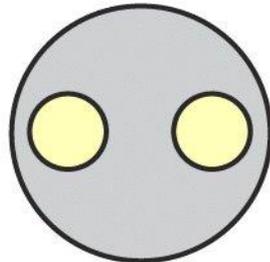
Haplotype 3



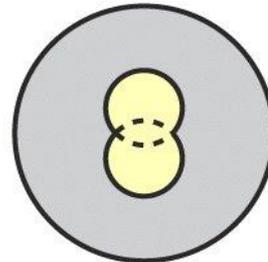
Haplotype 2



Haplotype 4



Haplotypes 1 + 2



Haplotypes 3 + 4

Figure 3-31 The Immune System, 2/e (© Garland Science 2005)

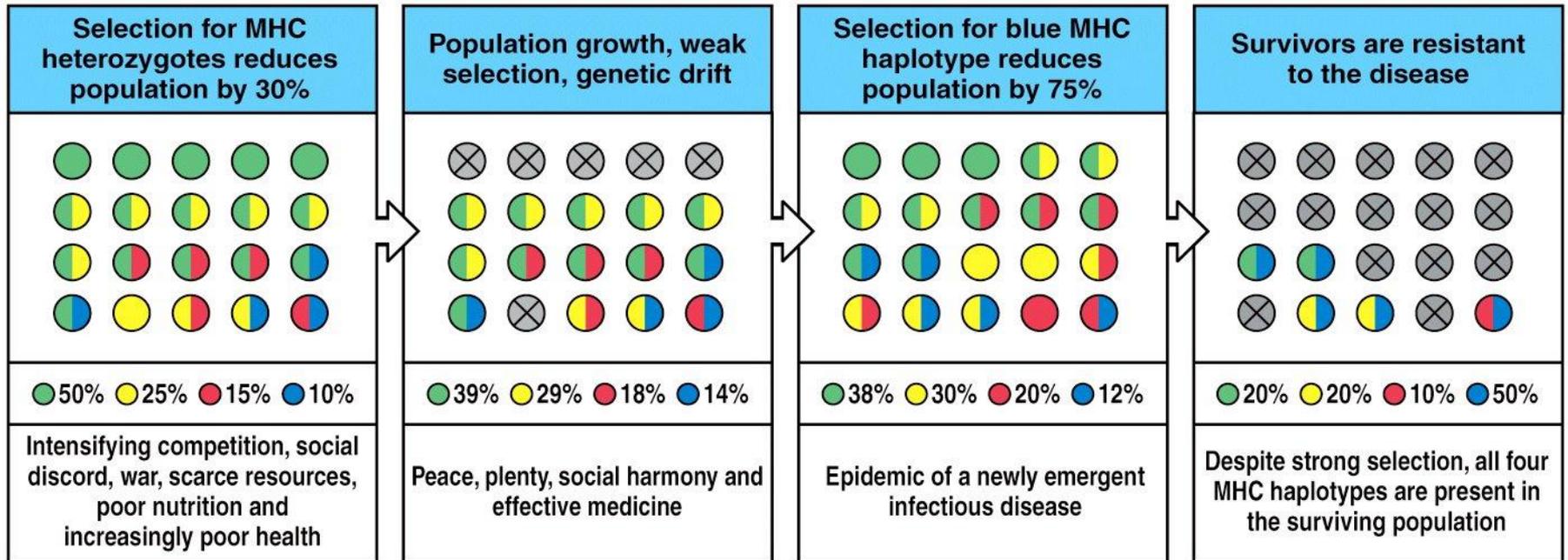


Figure 3-32 The Immune System, 2/e (© Garland Science 2005)

**Selection for MHC heterozygotes reduces population by 30%**

● 50% ● 25% ● 15% ● 10%

**Intensifying competition, social discord, war, scarce resources, poor nutrition and increasingly poor health**



**Population growth, weak selection, genetic drift**

● 39% ● 29% ● 18% ● 14%

**Peace, plenty, social harmony and effective medicine**



Figure 3-32 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

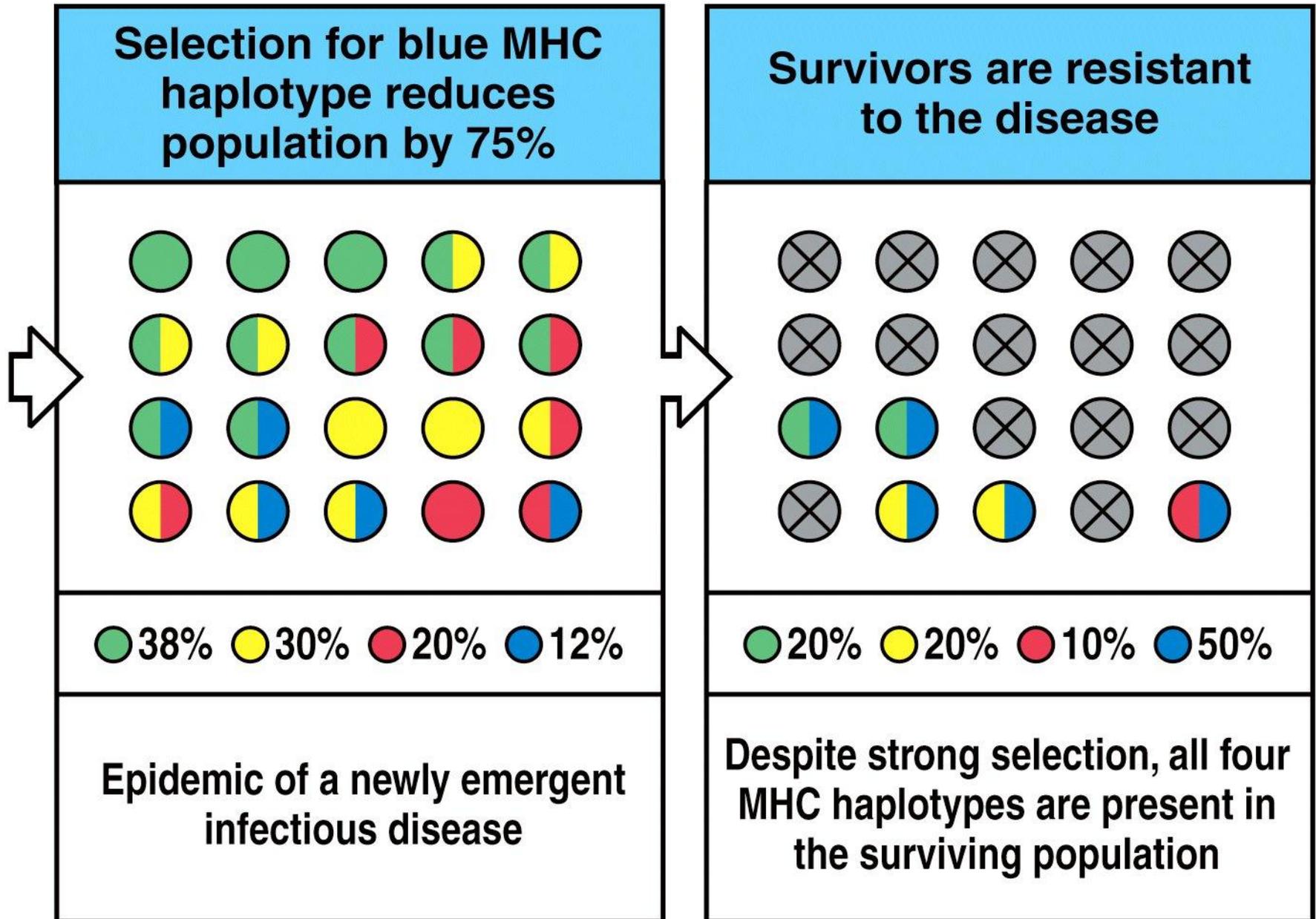


Figure 3-32 part 2 of 2 The Immune System, 2/e (© Garland Science 2005)

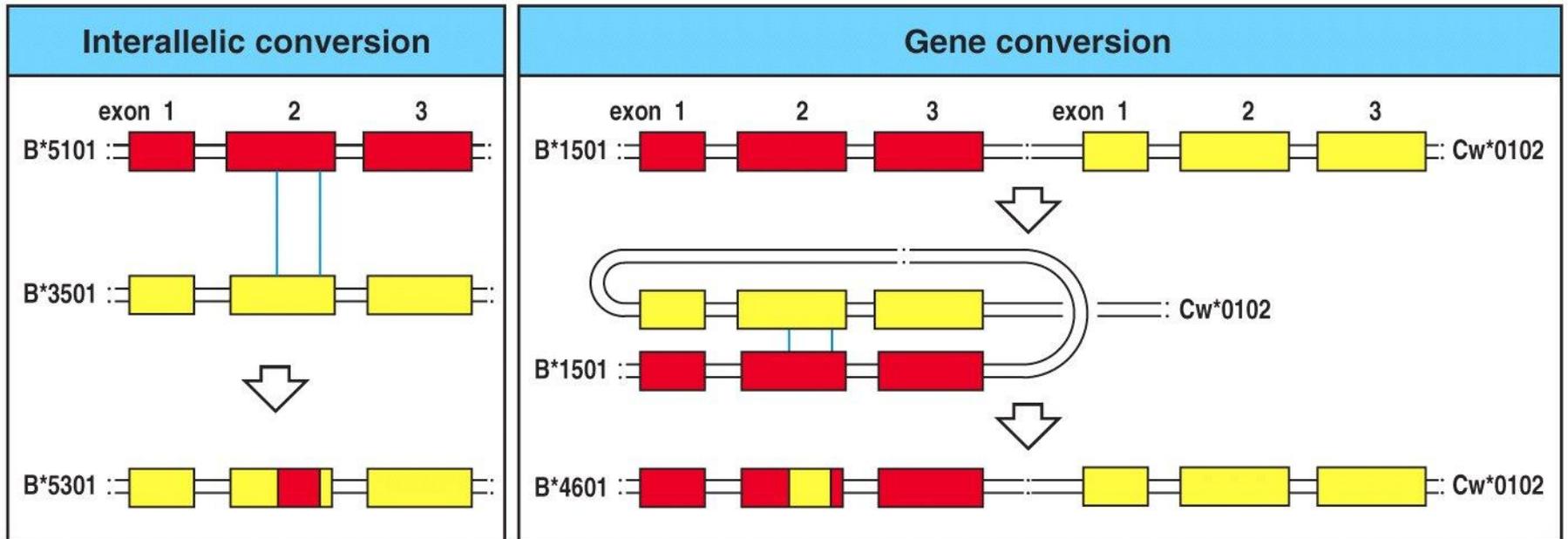


Figure 3-33 The Immune System, 2/e (© Garland Science 2005)

# Interallelic conversion

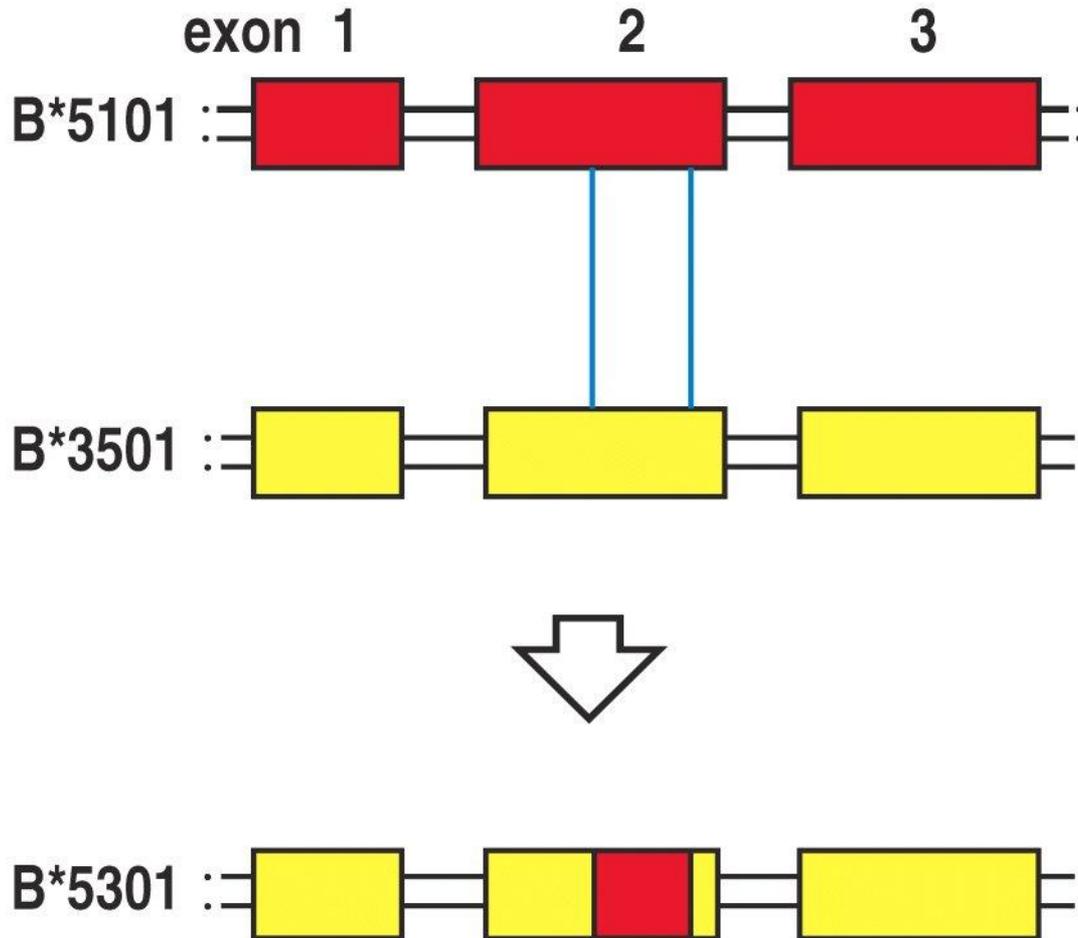


Figure 3-33 part 1 of 2 The Immune System, 2/e (© Garland Science 2005)

## Gene conversion

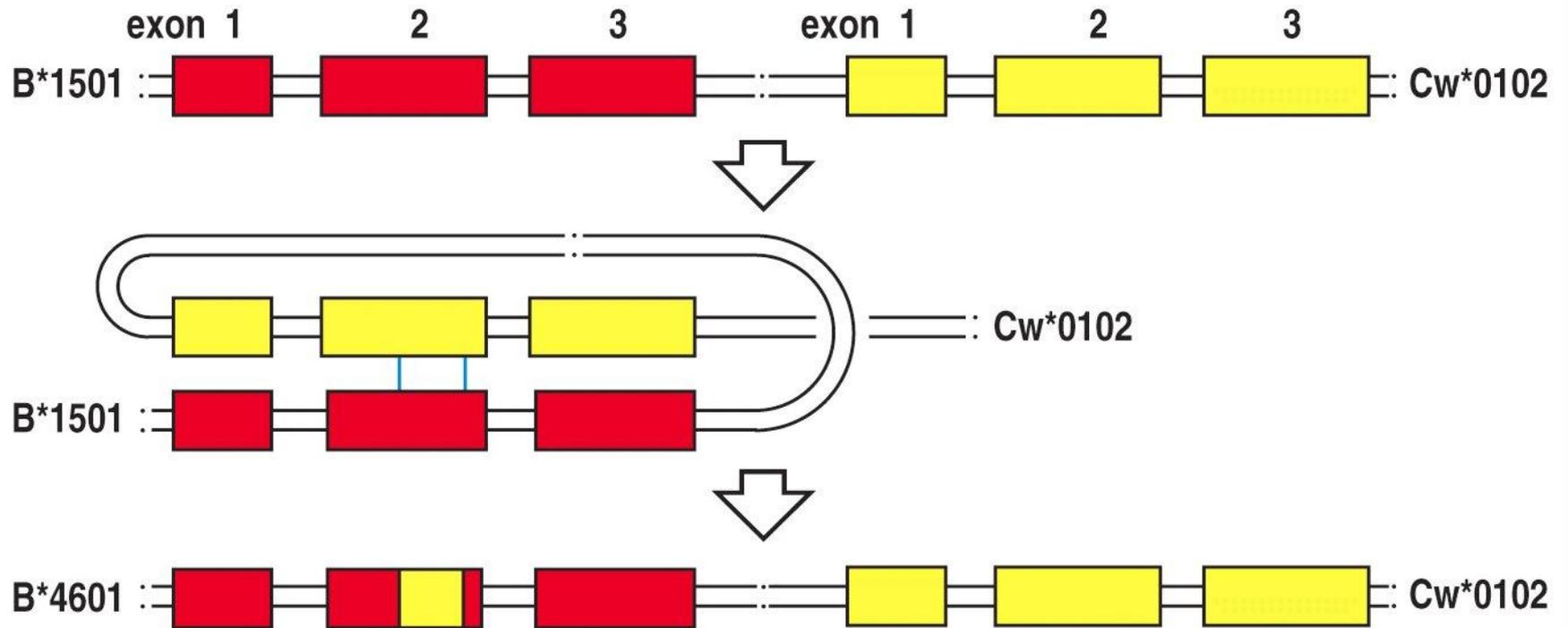


Figure 3-33 part 2 of 2 The Immune System, 2/e (© Garland Science 2005)

**Proportion  
of HIV-  
infected  
individuals  
who remain  
AIDS free**

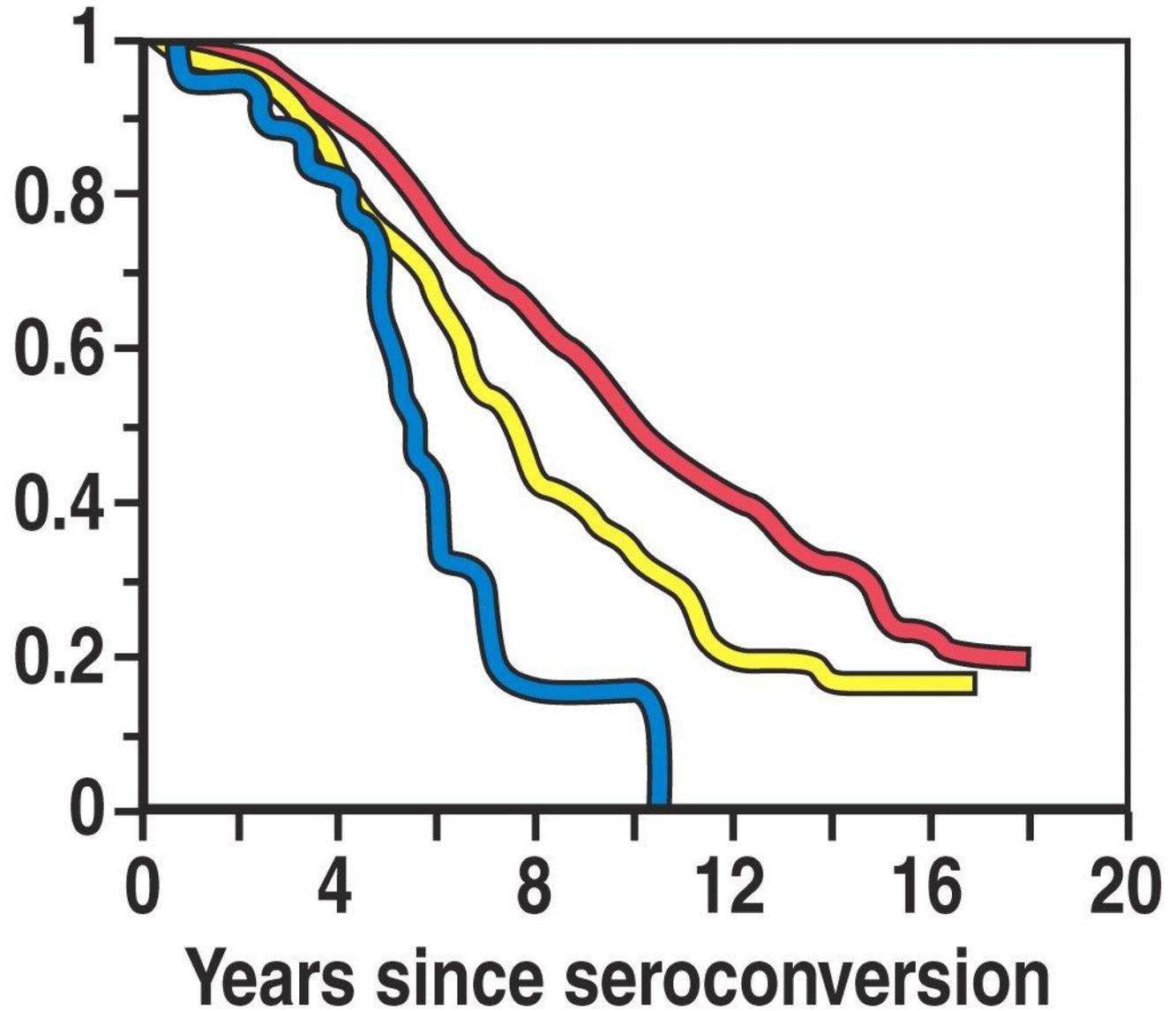


Figure 3-34 The Immune System, 2/e (© Garland Science 2005)