



Introduction à l'immunologie  
*A la découverte  
de notre armée intérieure*

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Chargé de Recherche INSERM

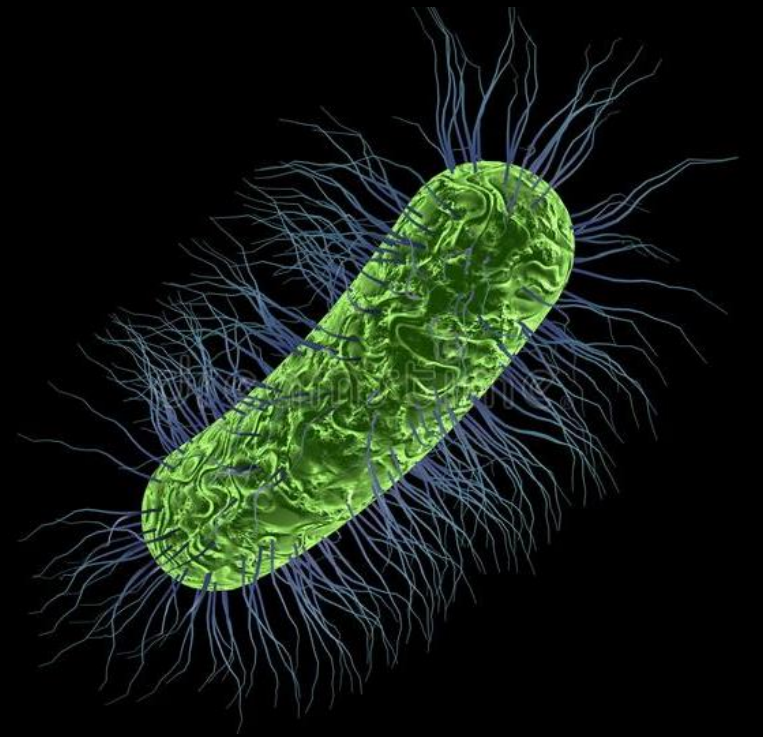
[nicolas.boisgerault@inserm.fr](mailto:nicolas.boisgerault@inserm.fr)



# « Immunité »

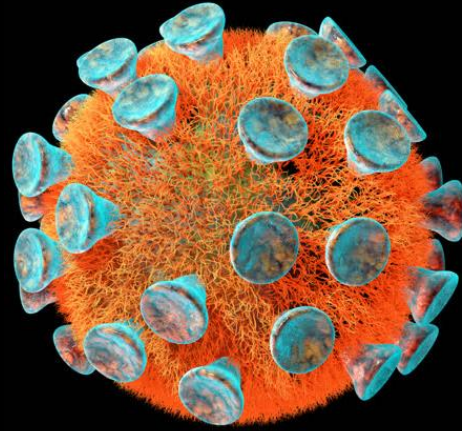
du latin *immunis*, « exempt »

« Ensemble des mécanismes de défense d'un organisme contre les éléments étrangers à l'organisme, en particulier les agents infectieux (virus, bactéries ou parasites). »



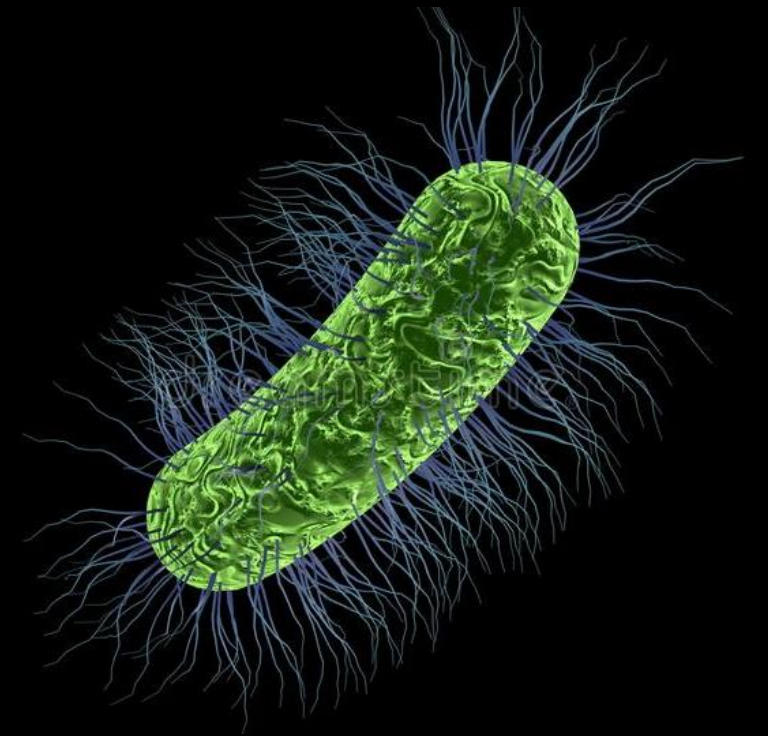
# Bactéries

*Escherichia coli*  
*Salmonella enterica*  
*Listeria monocytogenes*  
*Mycobacterium tuberculosis*



## Virus

Rougeole  
Ebola  
Hépatite B  
SARS-CoV-2

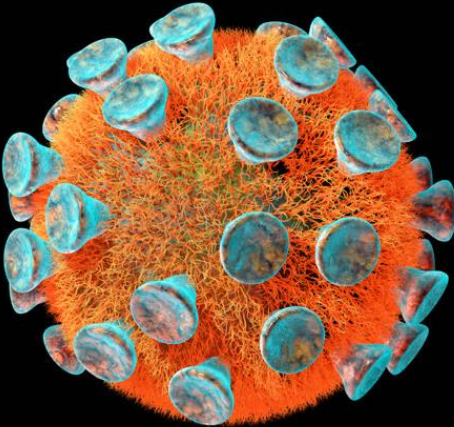


## Bactéries

*Escherichia coli*  
*Salmonella enterica*  
*Listeria monocytogenes*  
*Mycobacterium tuberculosis*

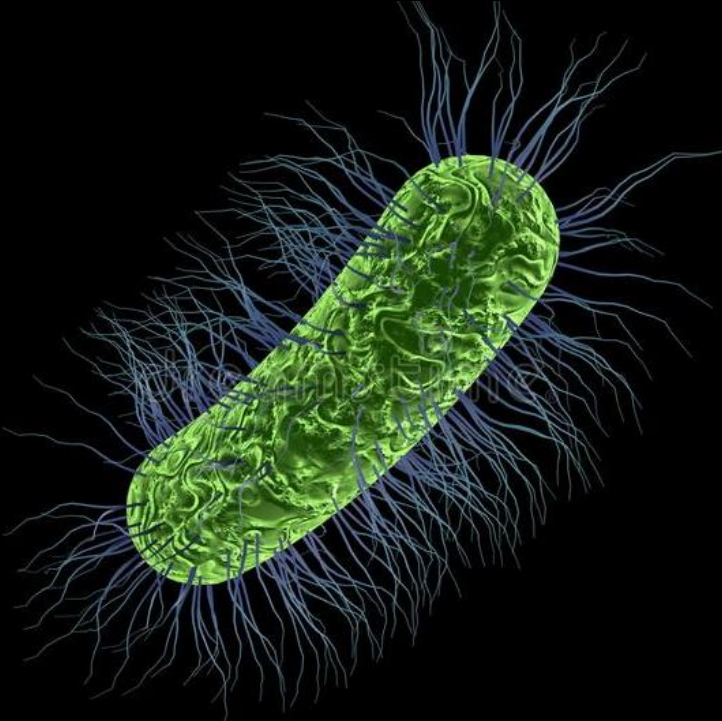
# Parasites

*Trichomonas vaginalis*  
*Plasmodium falciparum*



# Virus

Rougeole  
Ebola  
Hépatite B  
SARS-CoV-2



# Bactéries

*Escherichia coli*  
*Salmonella enterica*  
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*Mycobacterium tuberculosis*

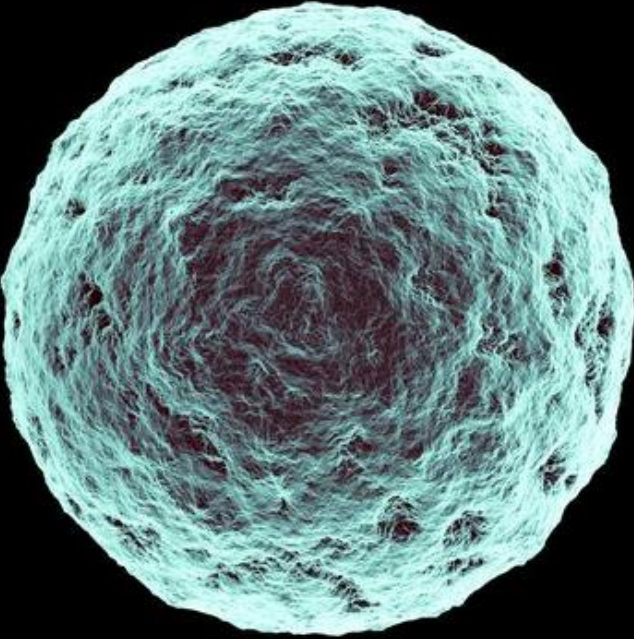
# Parasites

*Trichomonas vaginalis*  
*Plasmodium falciparum*



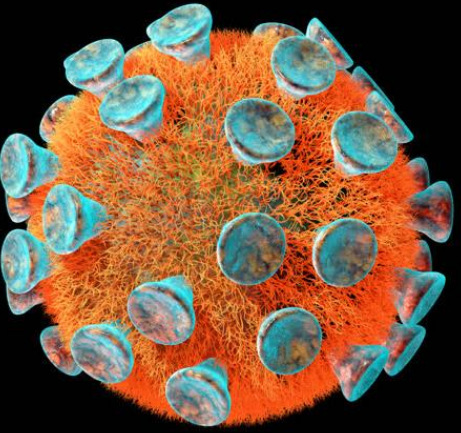
# Cancers

Mélanome  
Sein  
Prostate  
Leucémie  
Colorectal



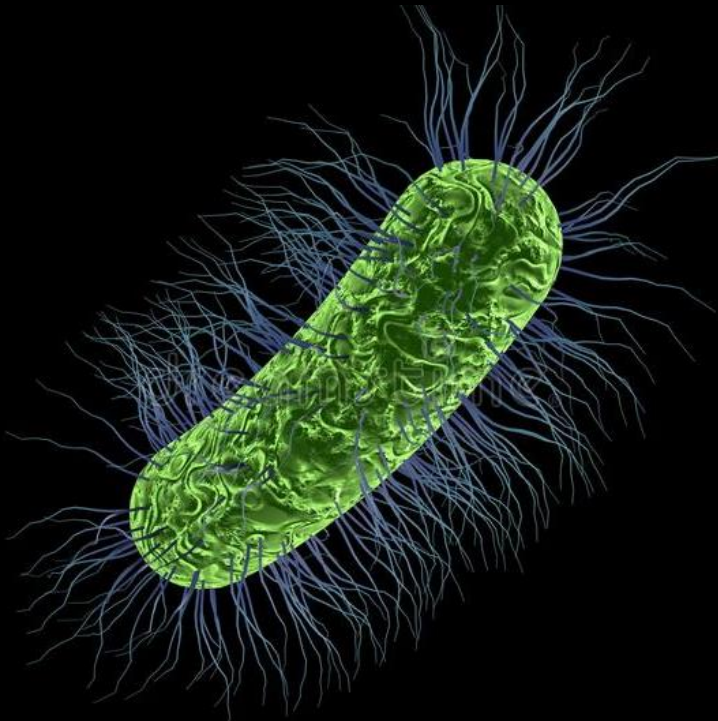
# Virus

Rougeole  
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SARS-CoV-2



# Bactéries

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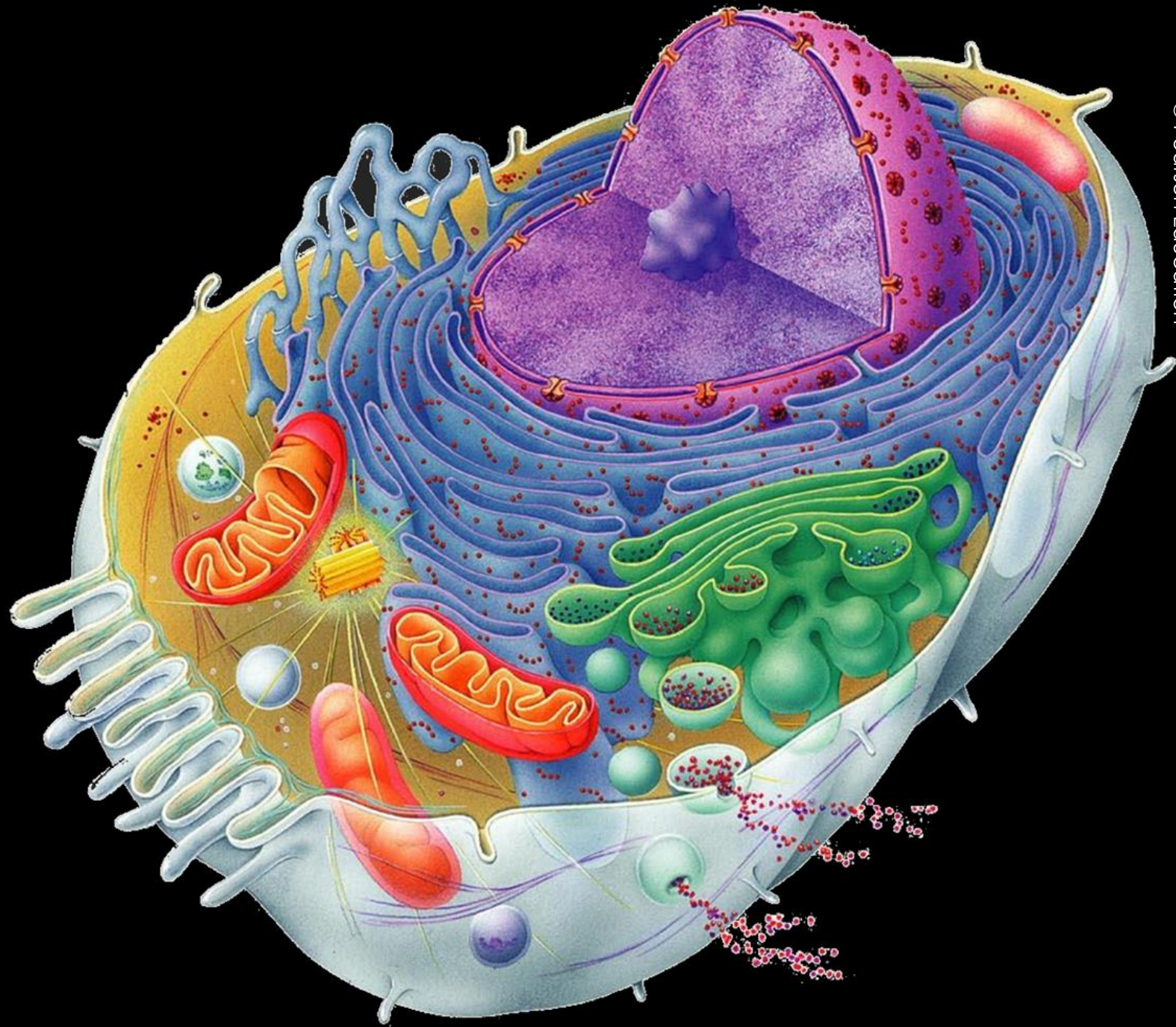


*Un peu de biologie  
pour commencer...*

La cellule



# La cellule

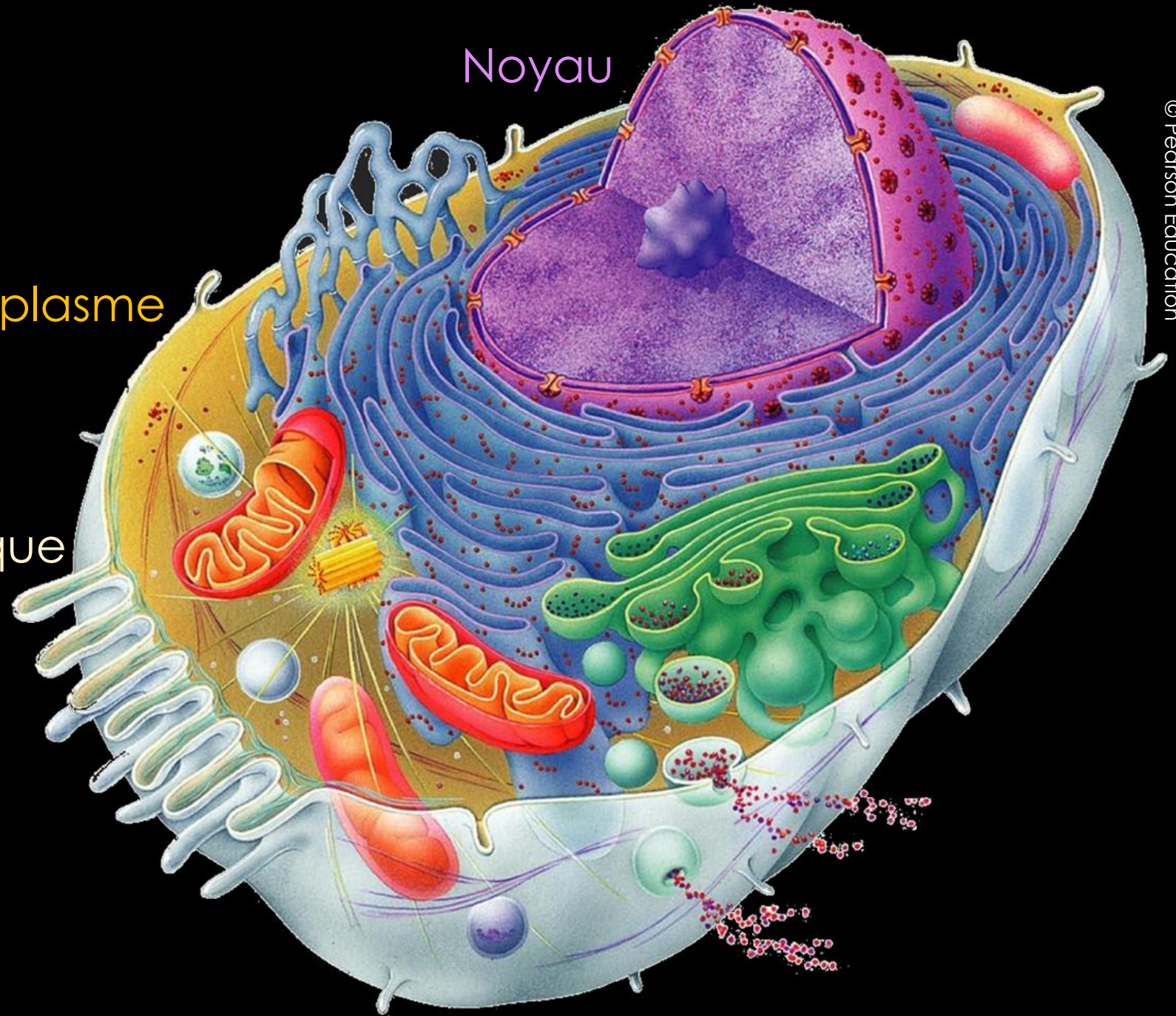


# La cellule

Membrane plasmique

Cytoplasme

Noyau



A diagram of a cell. On the left, a large blue circle represents the nucleus, labeled 'Noyau'. The rest of the cell is a large black circle representing the cytoplasm, labeled 'Cytoplasme'. A thin yellow line on the right side of the black circle represents the plasma membrane, labeled 'Membrane plasmique'.

Noyau

Cytoplasme

Membrane  
plasmique

Noyau



Cytoplasme

Membrane  
plasmique

ADN

Acide DésoxyriboNucléique

Noyau



Cytoplasme

Membrane  
plasmique

ADN

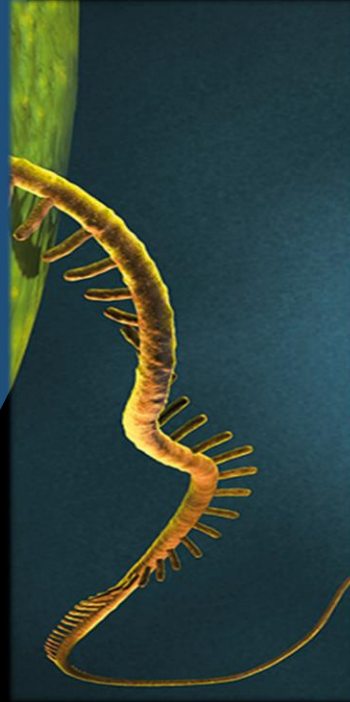
Acide DésoxyriboNucléique



Noyau



Cytoplasme



Membrane  
plasmique

ADN

Acide DésoxyriboNucléique



ARNm

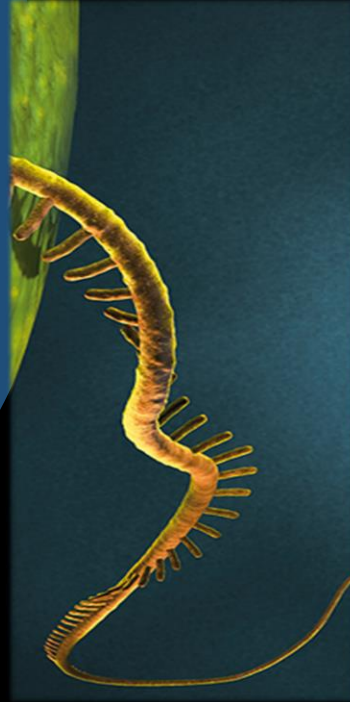
Acide RiboNucléique



Noyau



Cytoplasme



Membrane  
plasmique

ADN

Acide DésoxyriboNucléique



ARNm

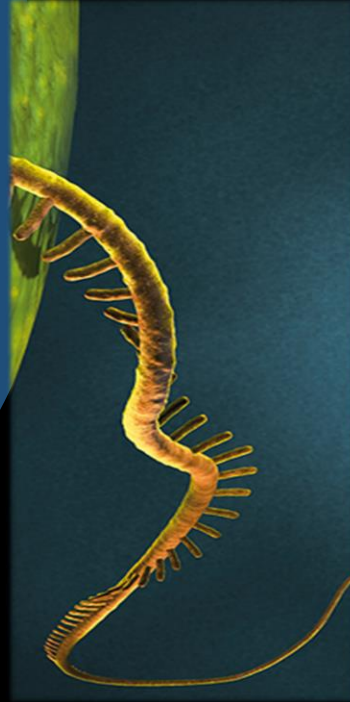
Acide RiboNucléique



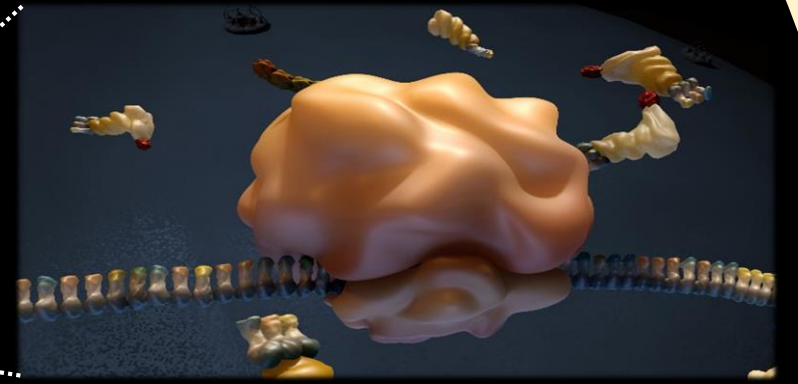
Noyau



Cytoplasme



Membrane plasmique



ADN

Acide DésoxyriboNucléique



ARNm

Acide RiboNucléique

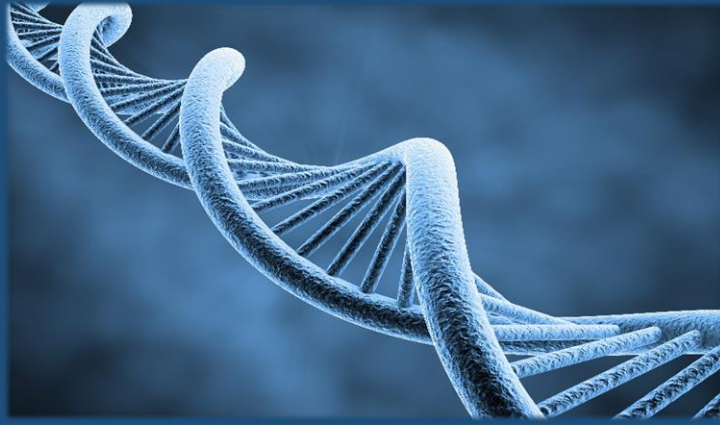


Protéine

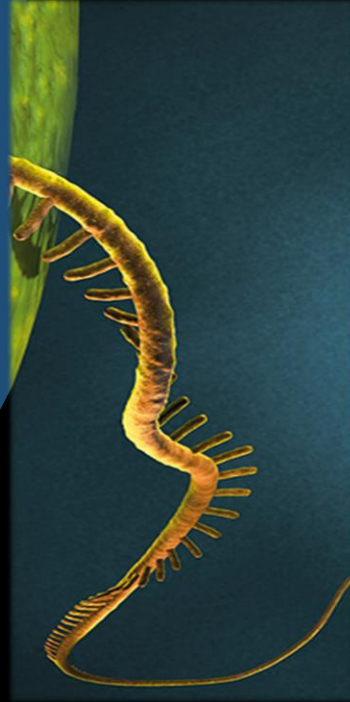




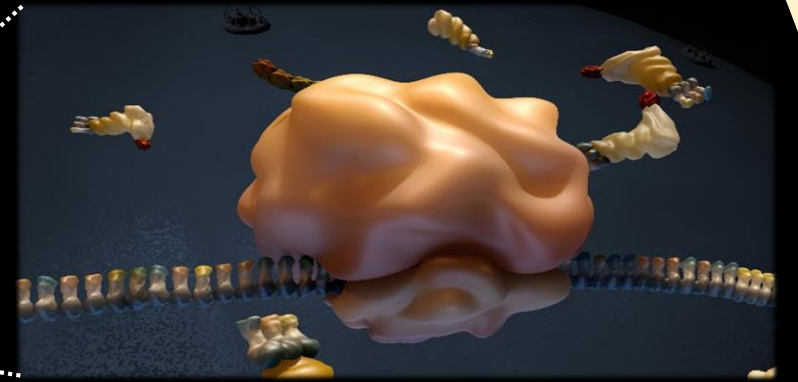
Noyau



Cytoplasme



Membrane plasmique



ADN

Acide DésoxyriboNucléique



ARNm

Acide RiboNucléique



Protéine



*Notre système immunitaire*

Végétations adénoïdes

Amygdales

Moelle osseuse

Intestin

Plaques de Peyer

Appendice

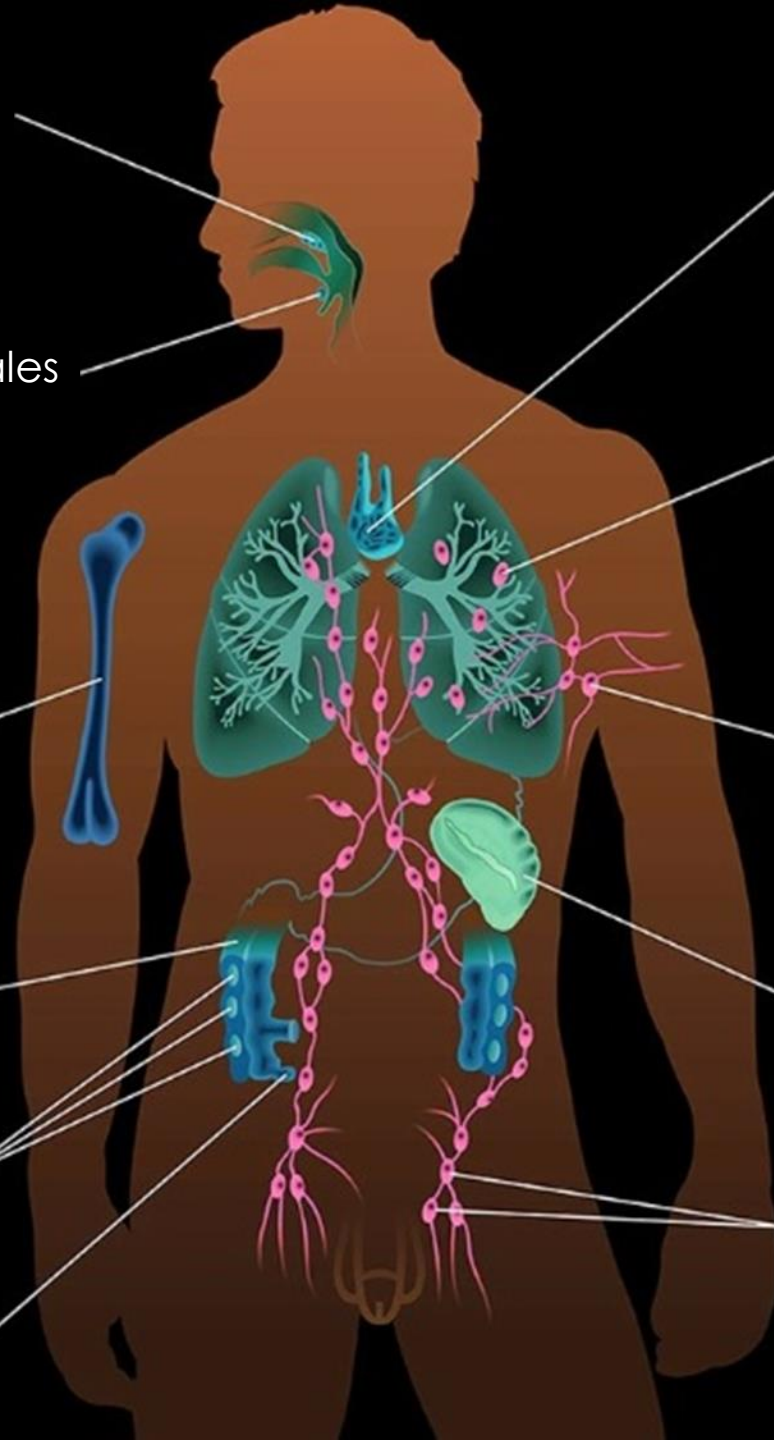
Thymus

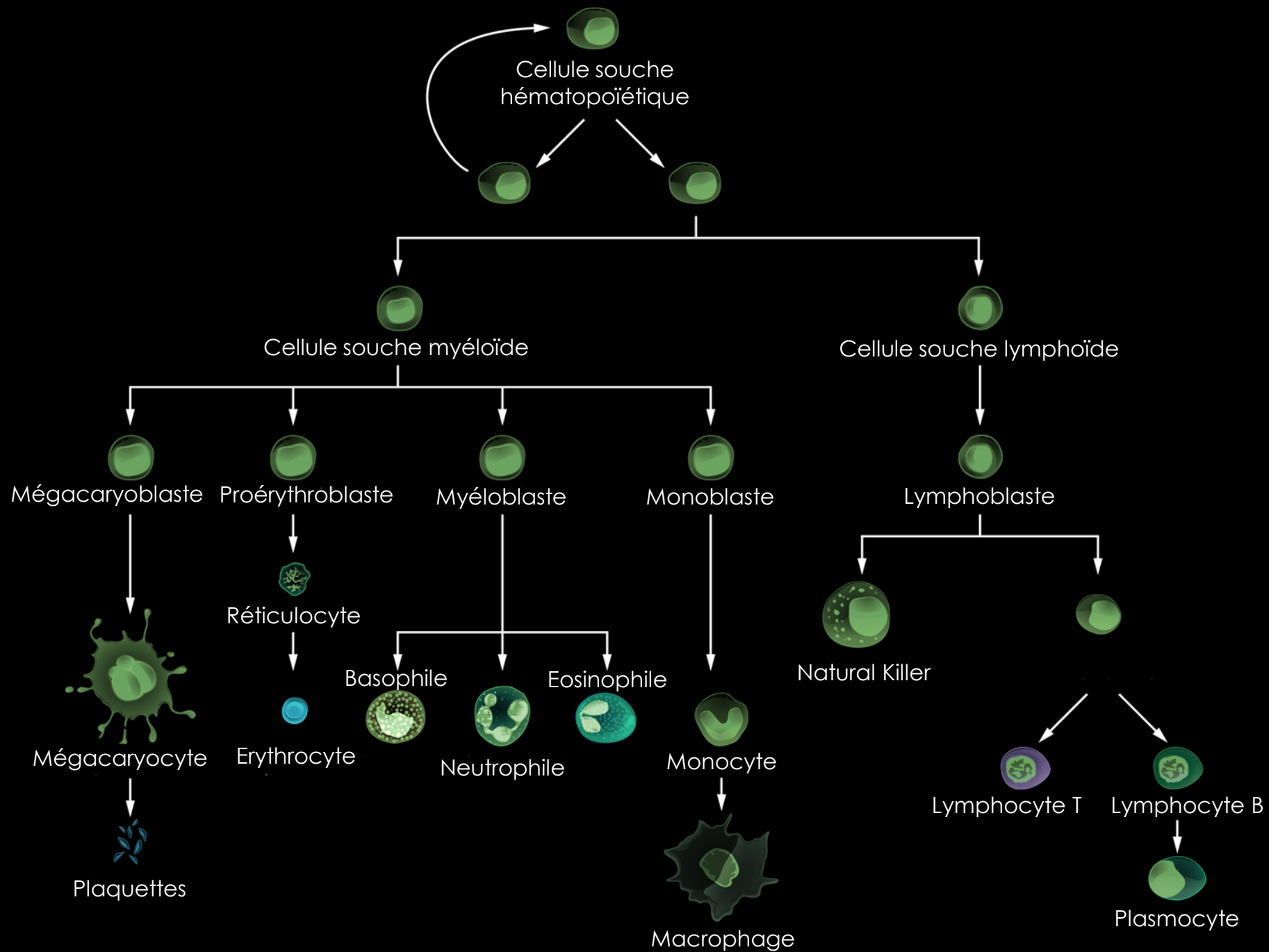
Tissus lymphoïdes  
du poumon

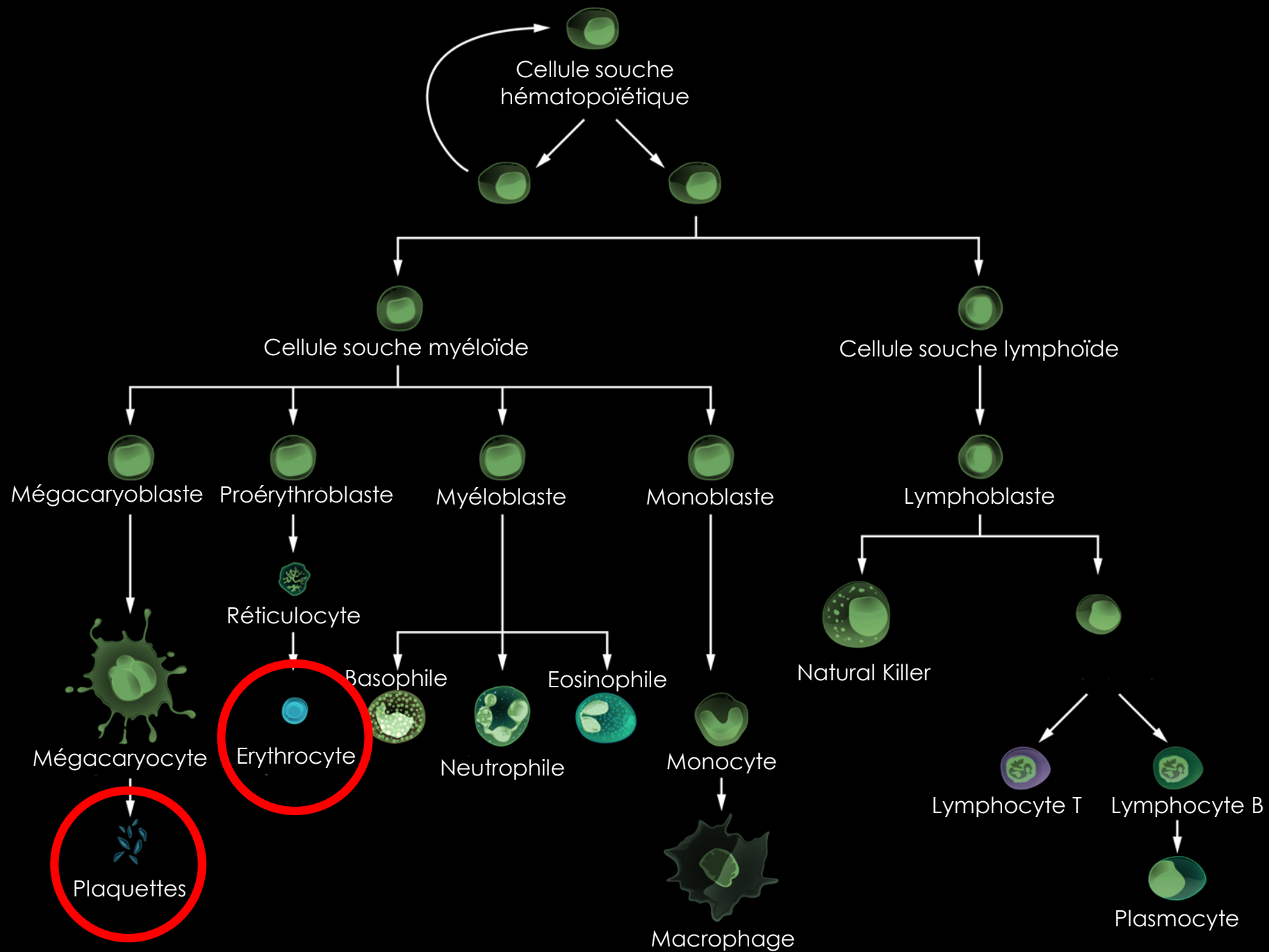
Ganglions  
axillaires

Rate

Ganglions inguinaux



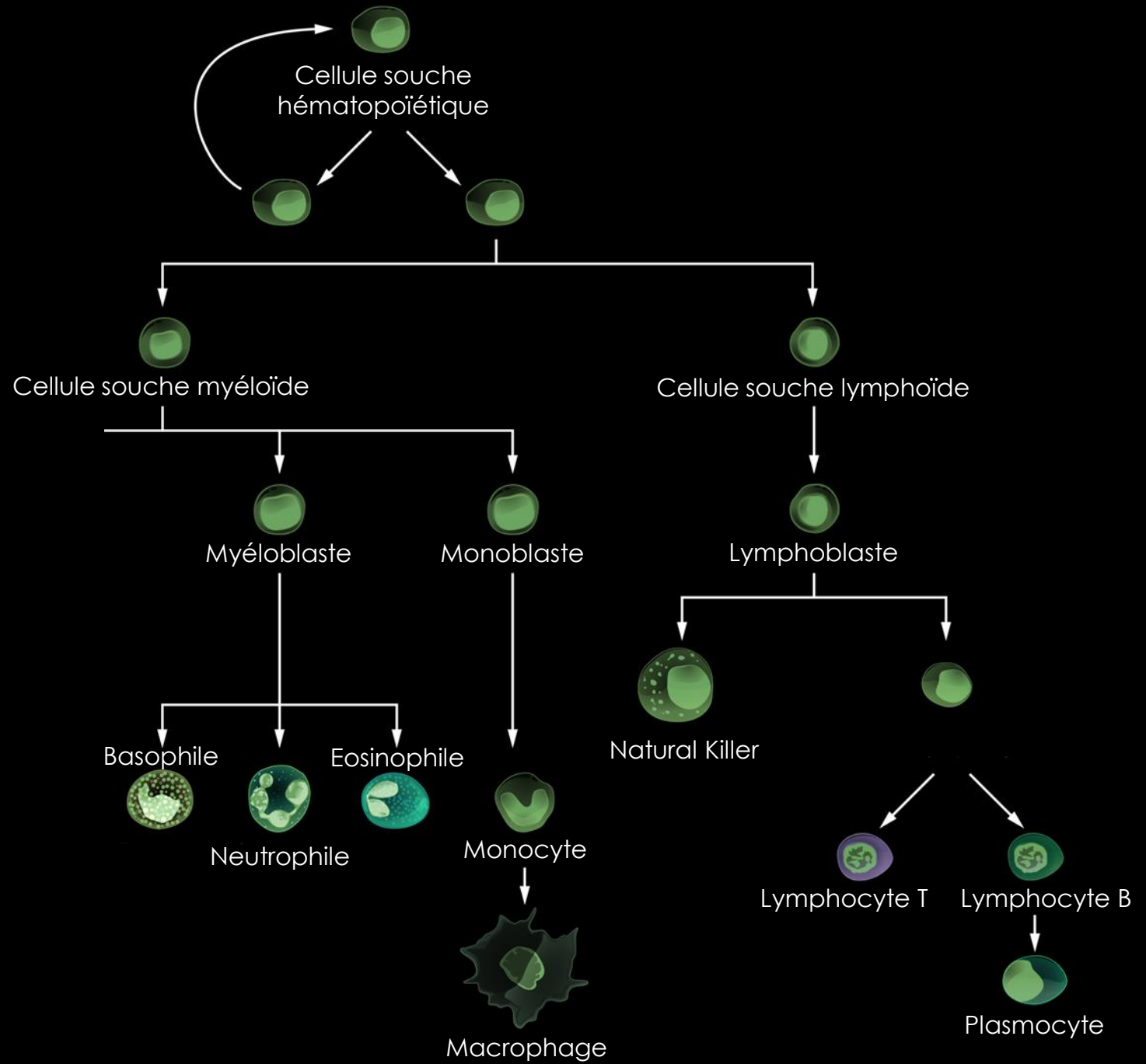




Mégacaryocyte / Plaquettes

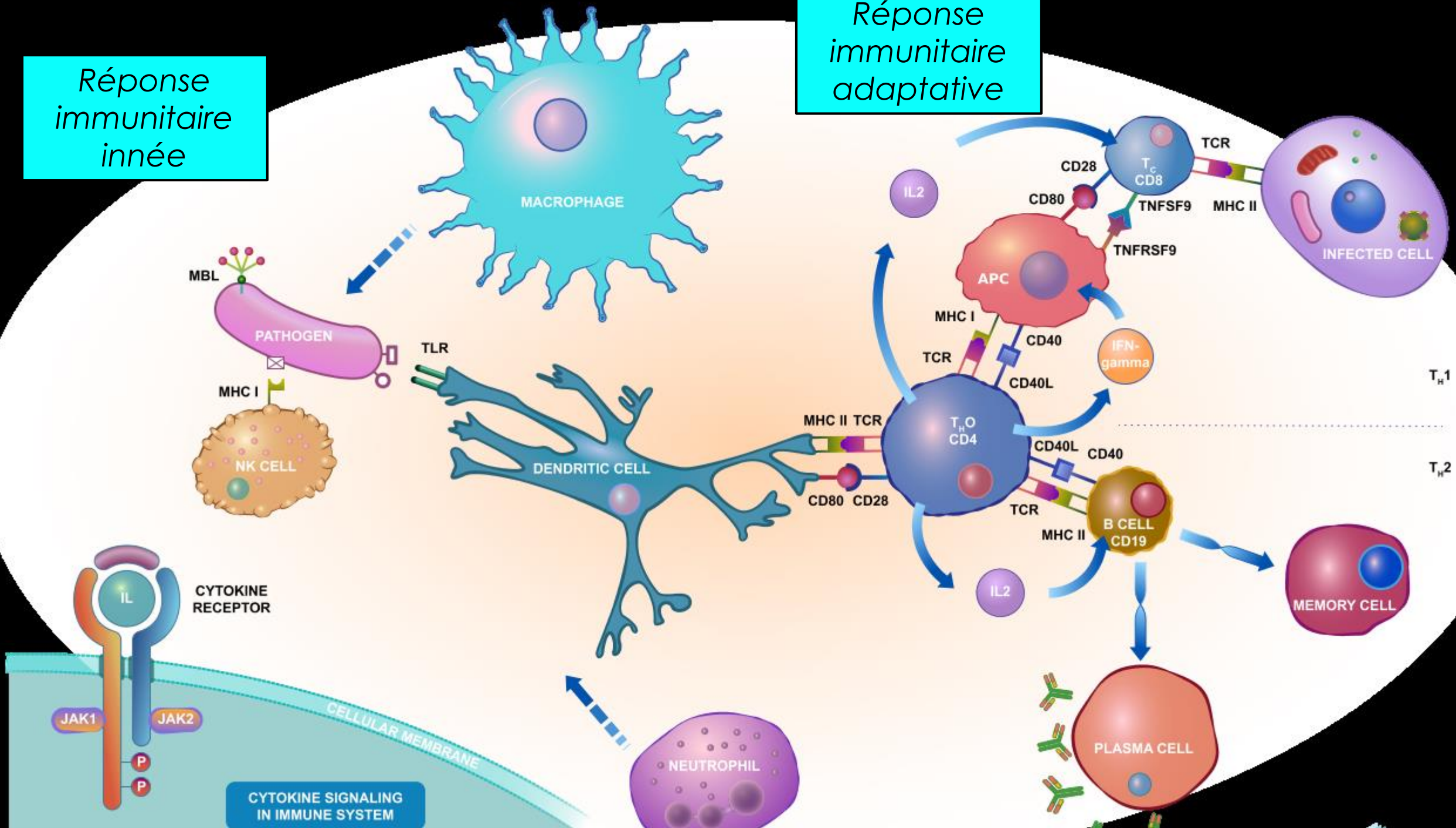


Erythrocytes / Globules rouges



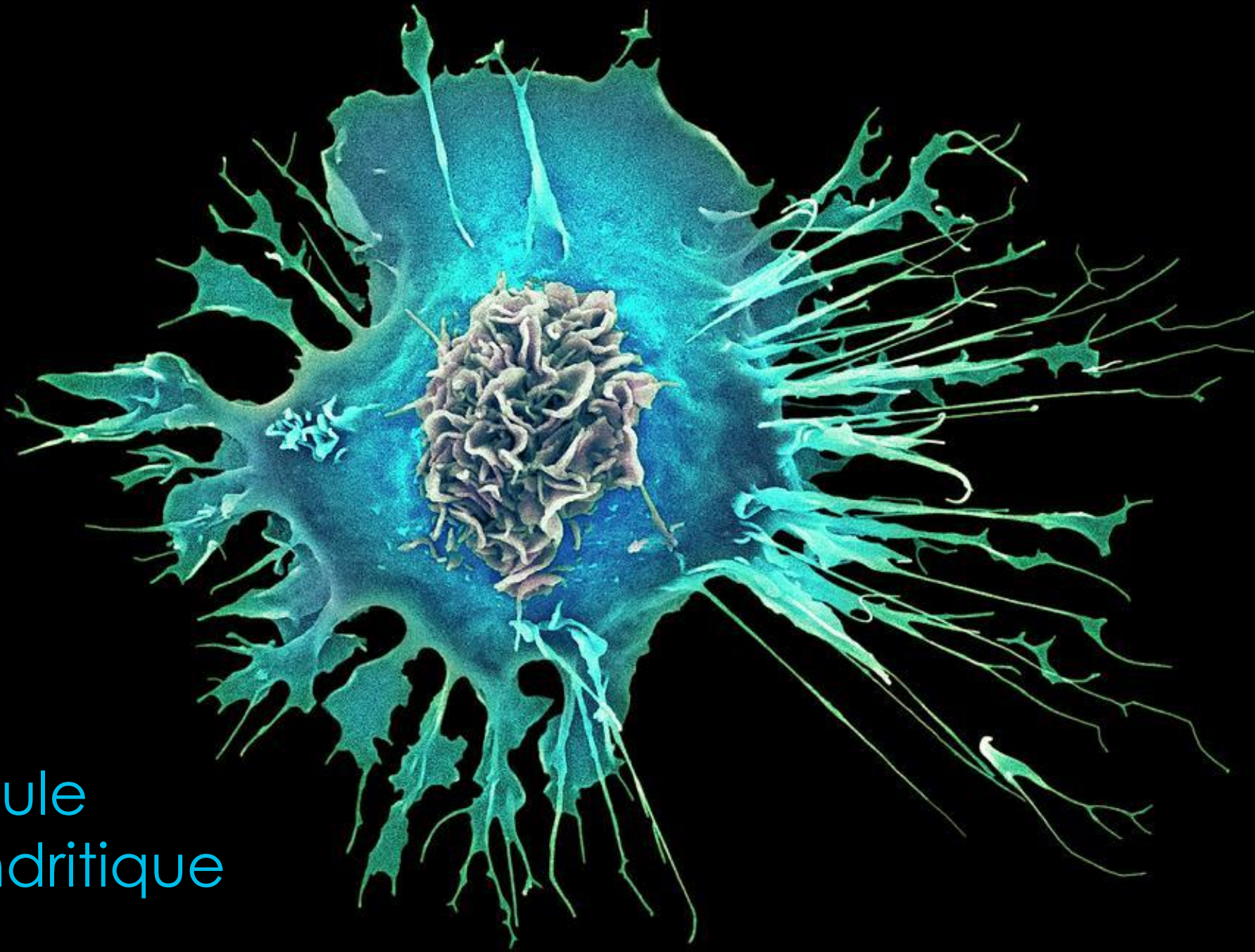
Réponse immunitaire innée

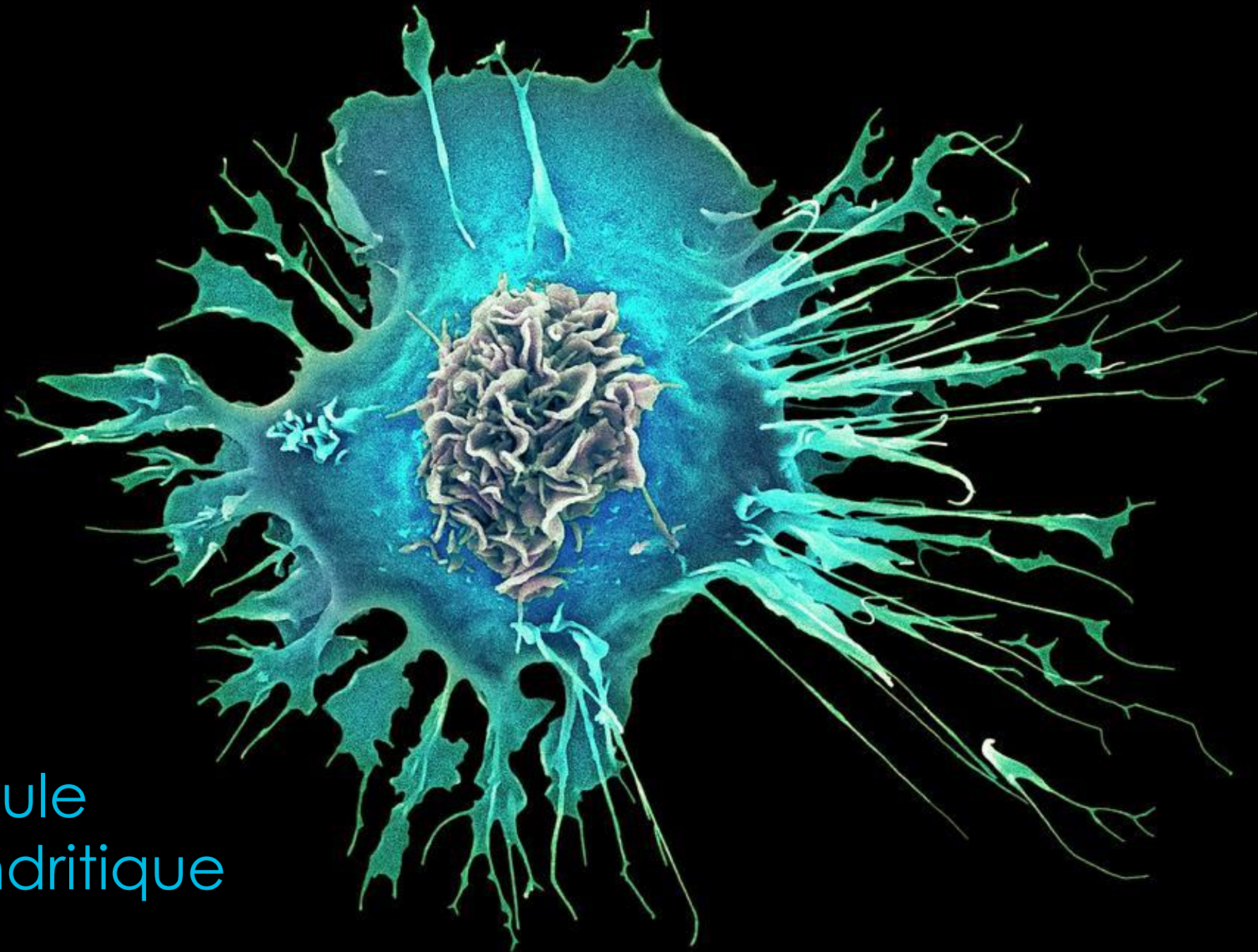
Réponse immunitaire adaptative



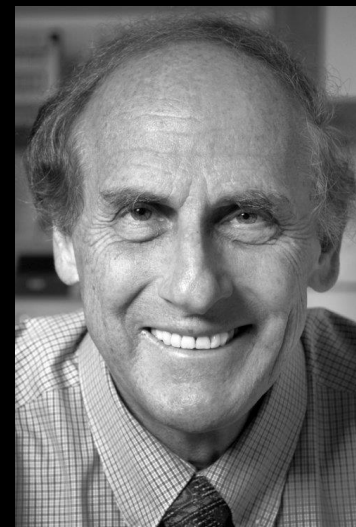


Cellule  
dendritique

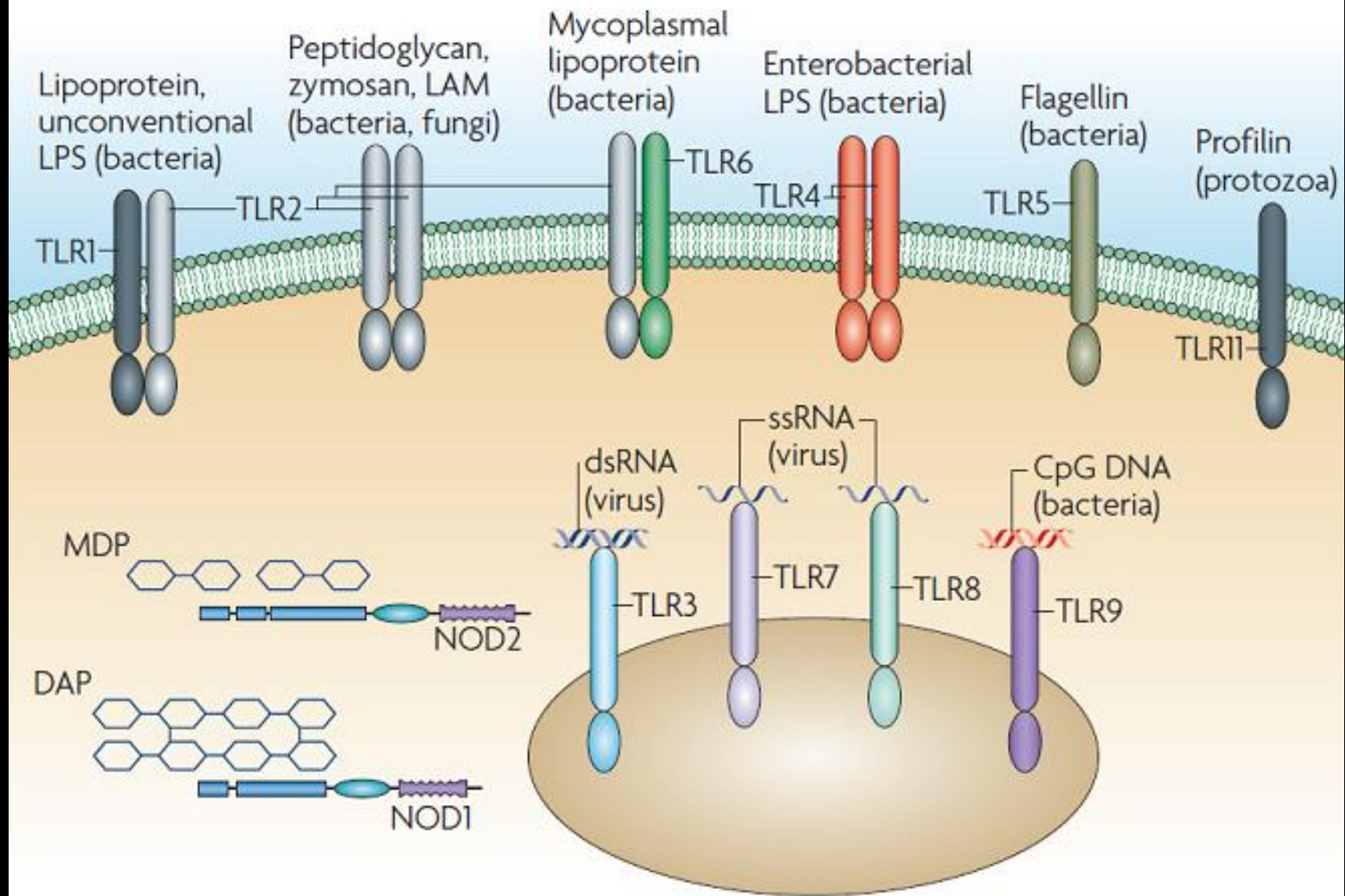


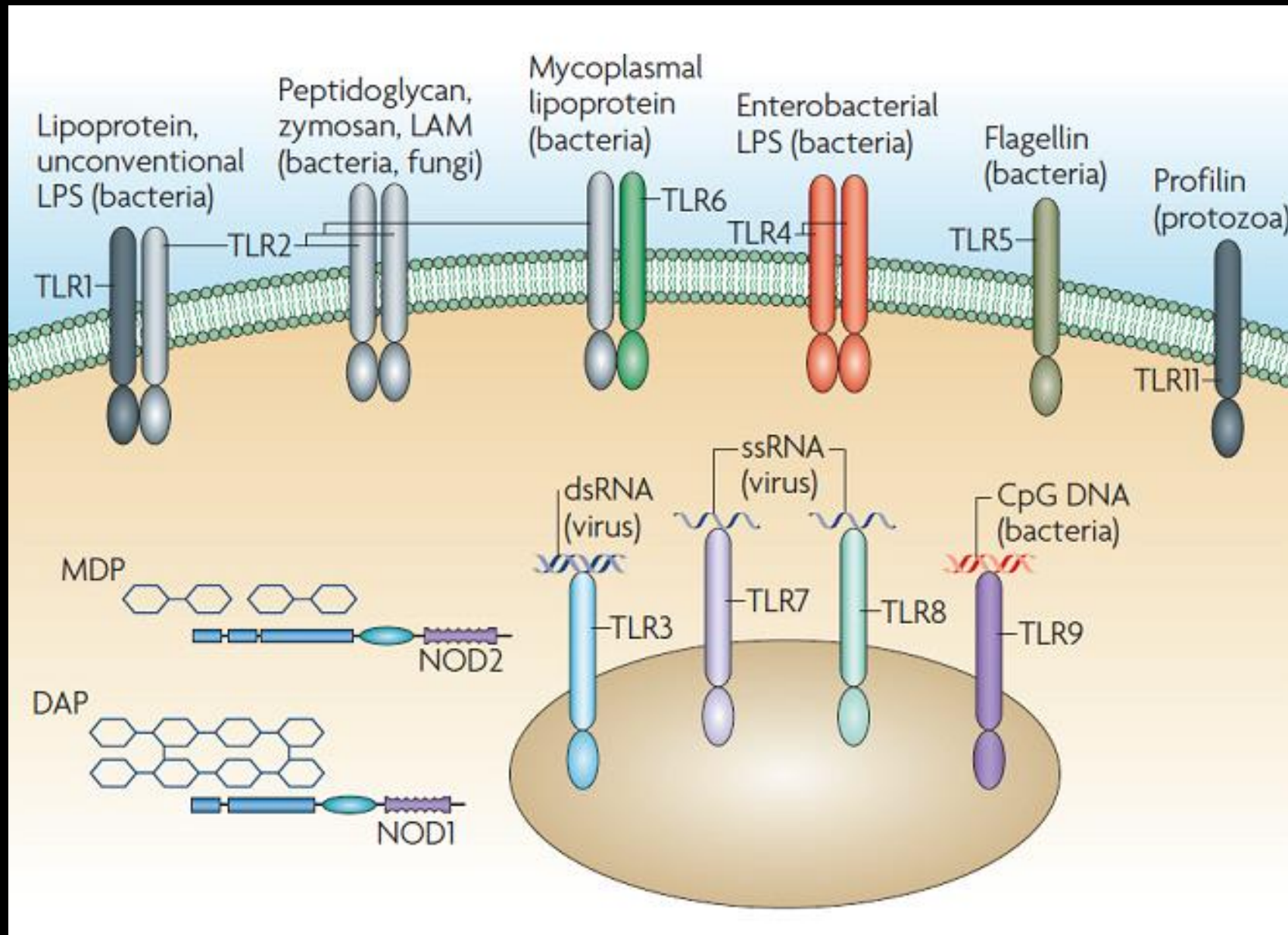


Cellule  
dendritique



**Ralph Steinman**  
Prix Nobel 2011



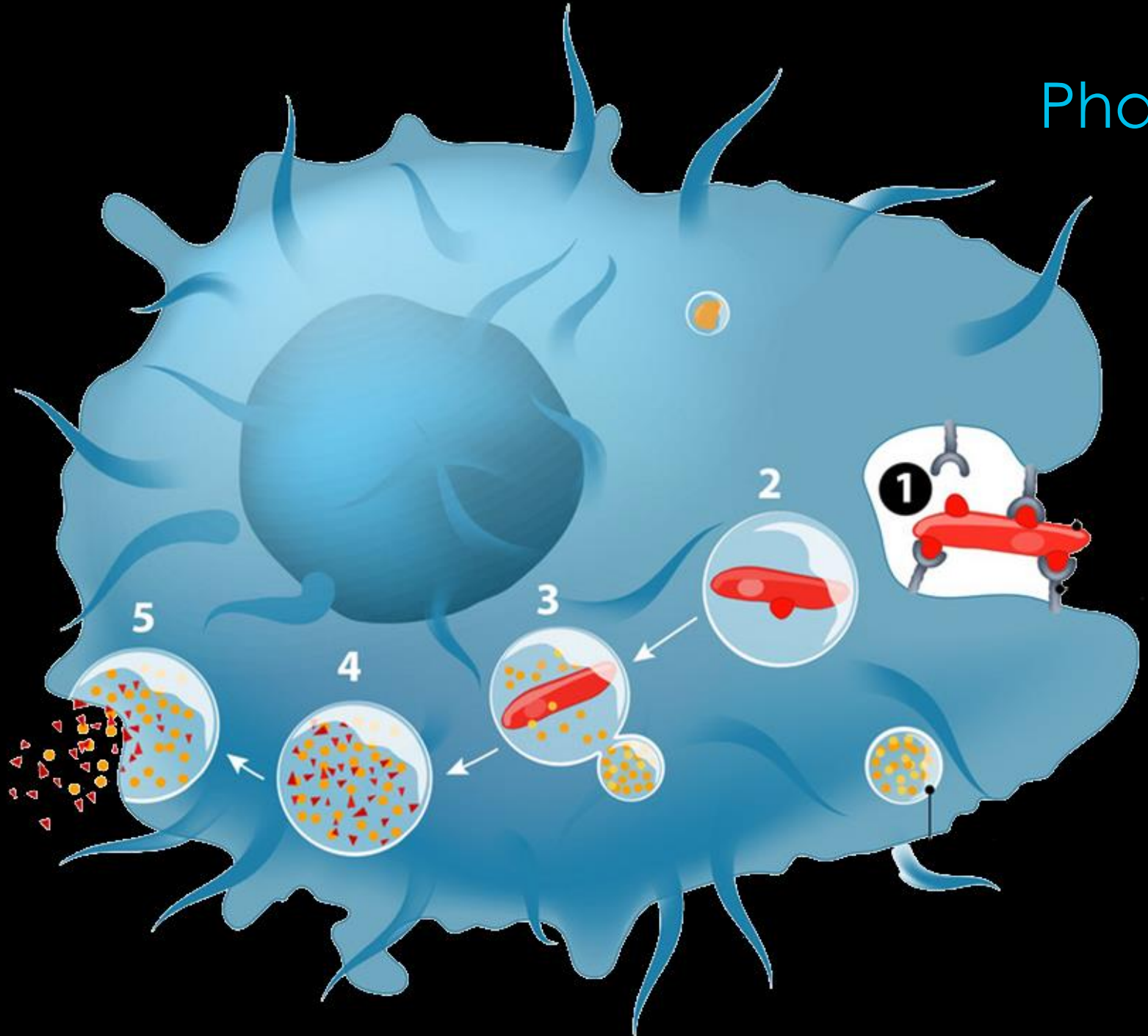


**Jules Hoffmann**  
Prix Nobel 2011

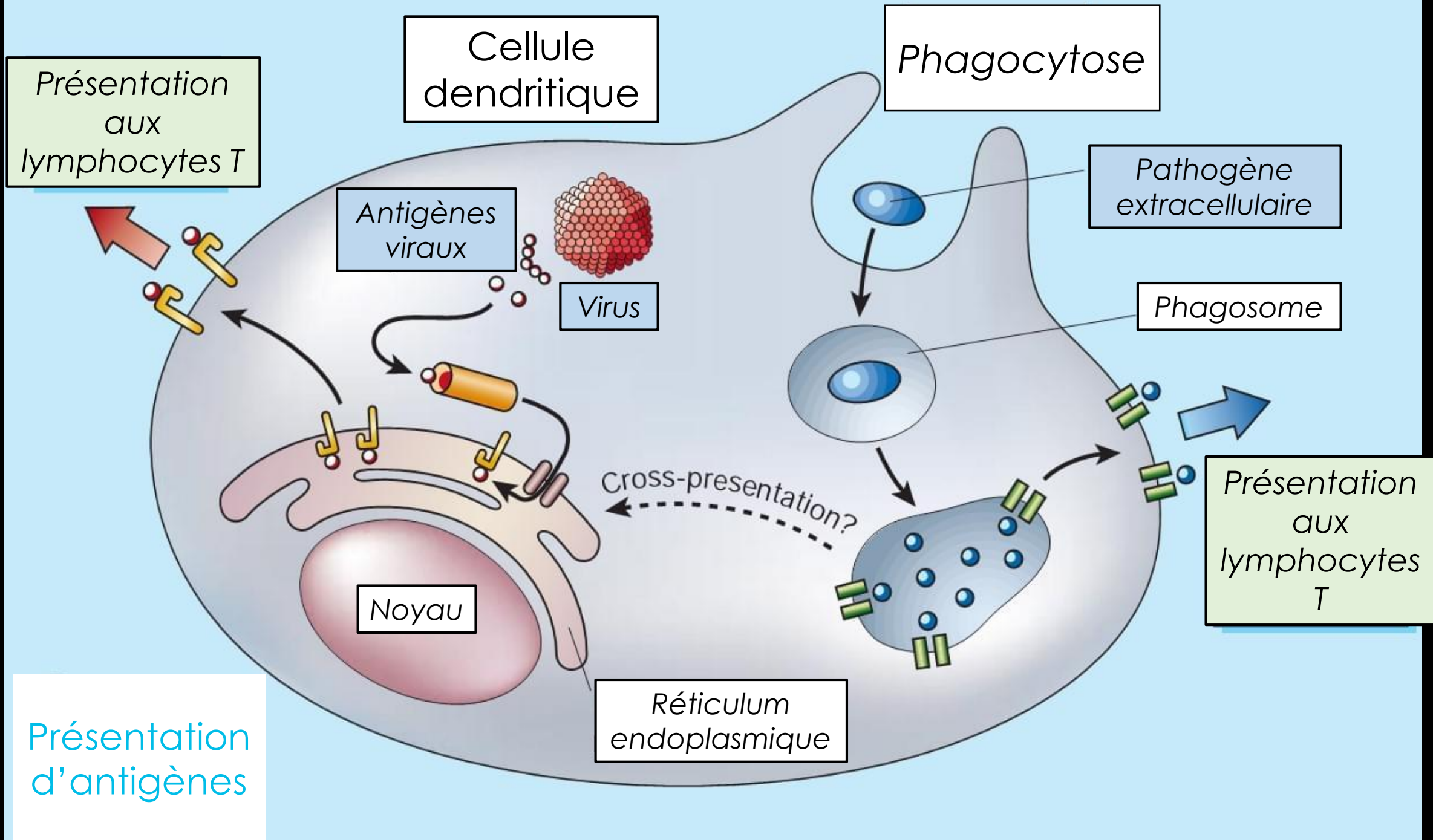


# Phagocytose

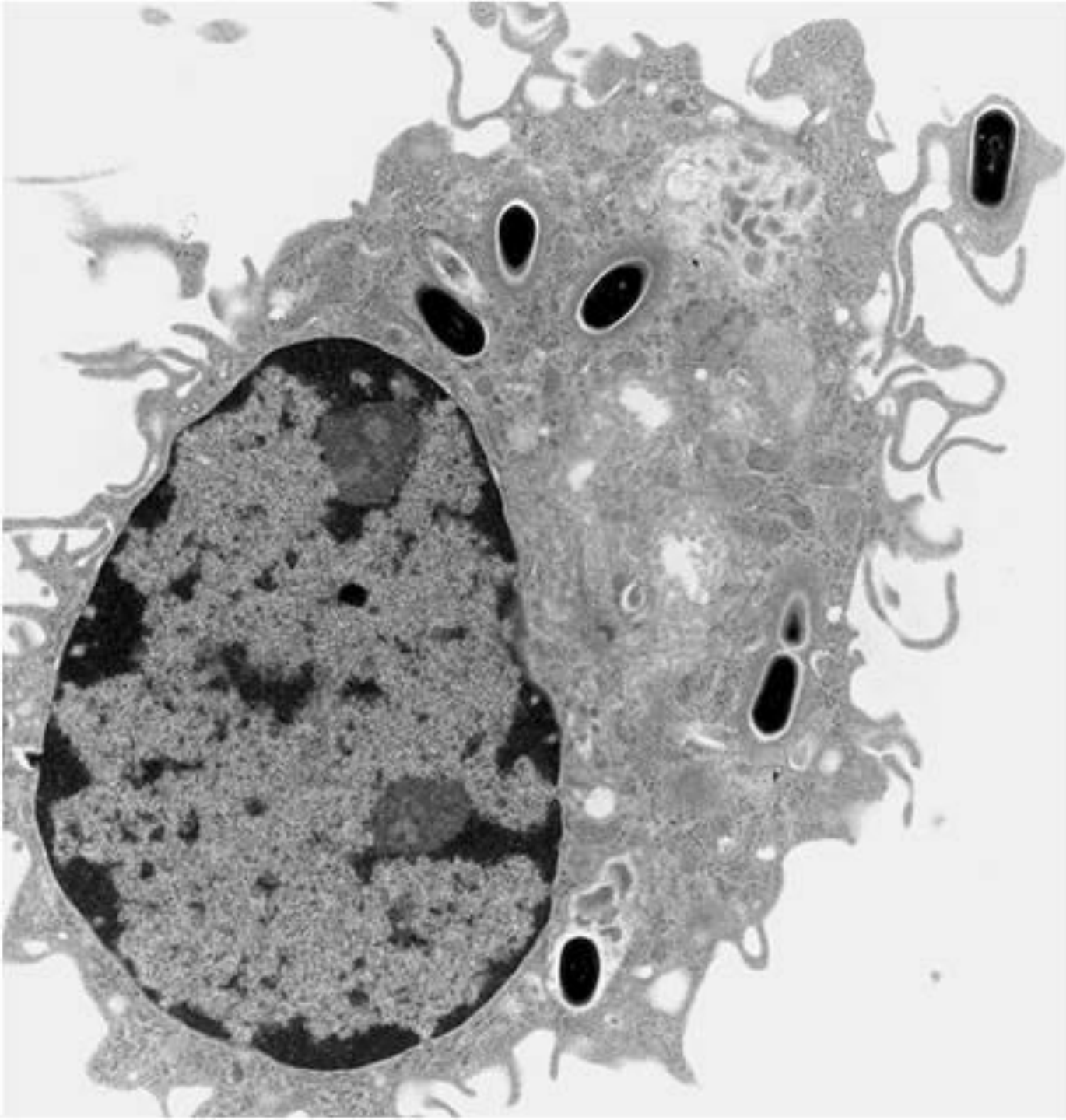
# Phagocytose



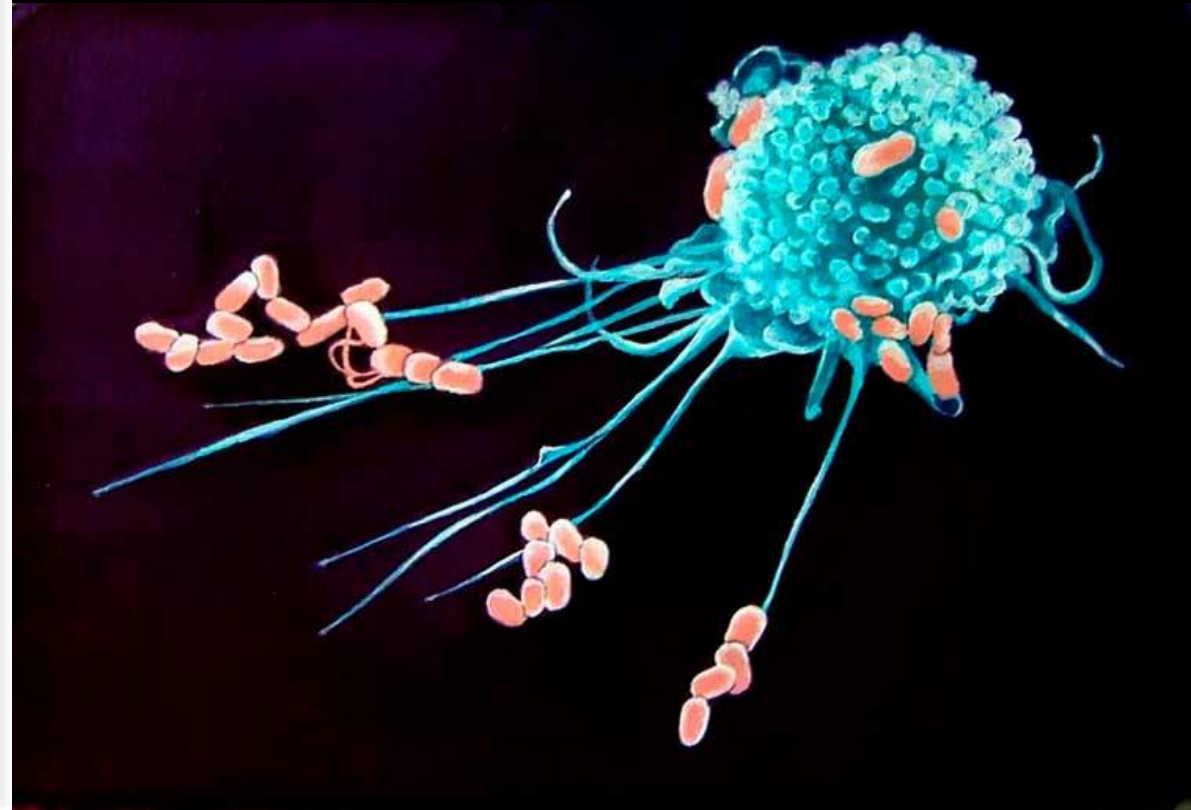
Présentation  
d'antigènes

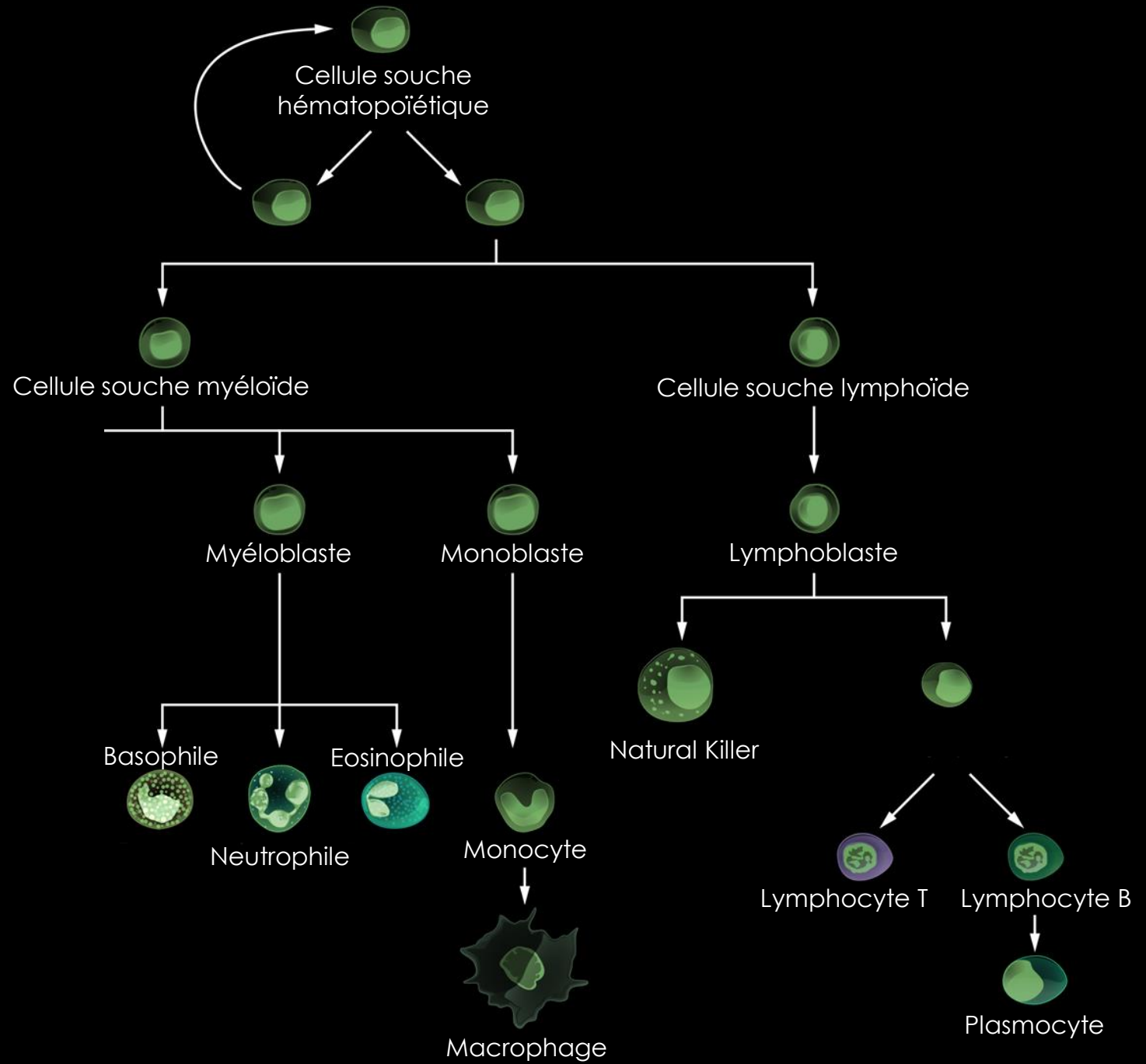






Macrophage

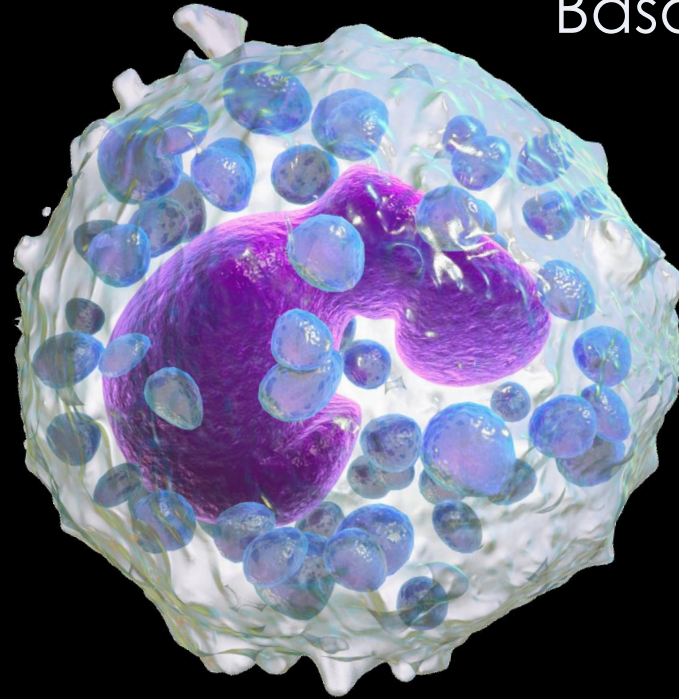
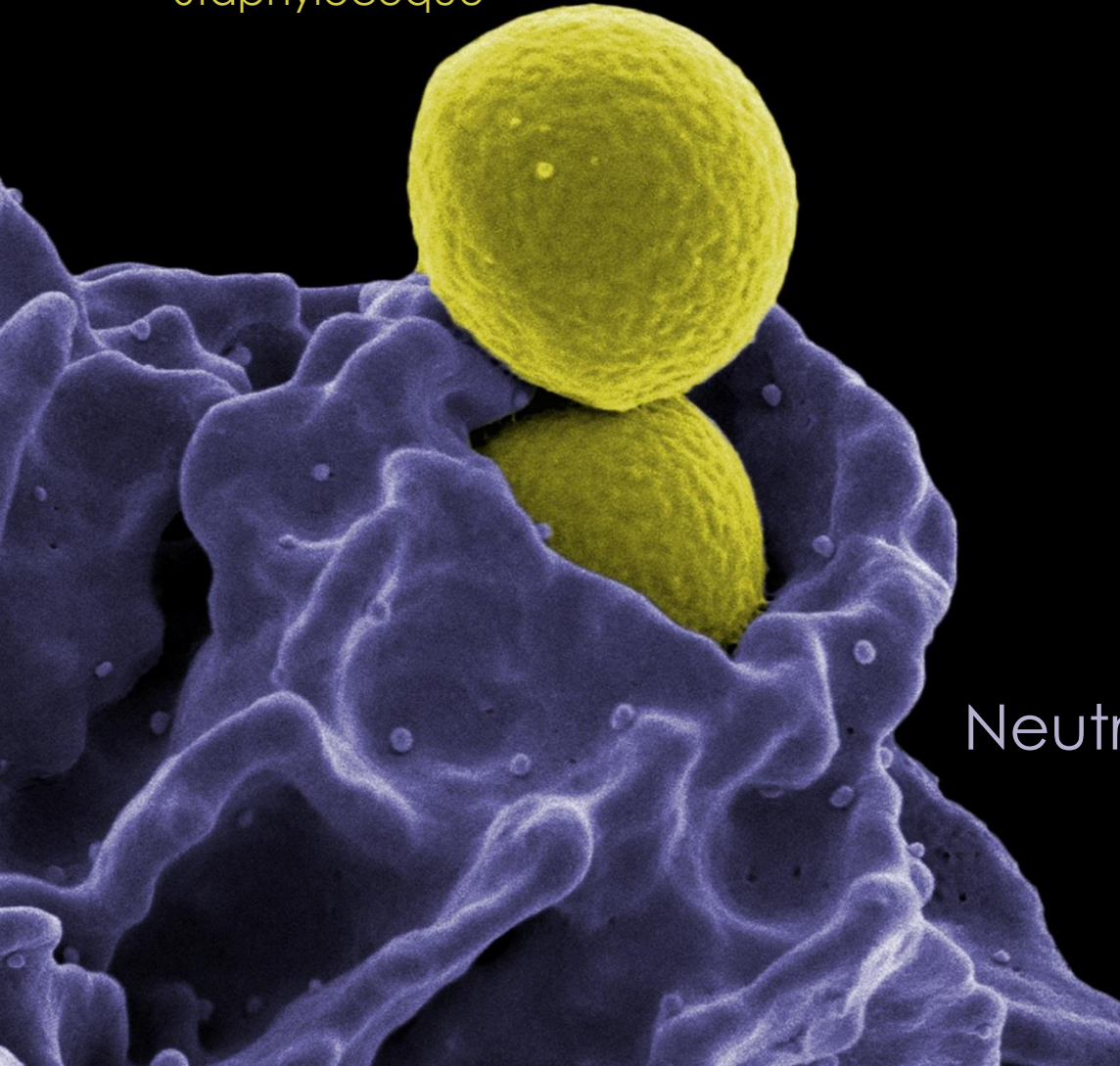




# Polynucléaires

Basophiles

Staphylocoque

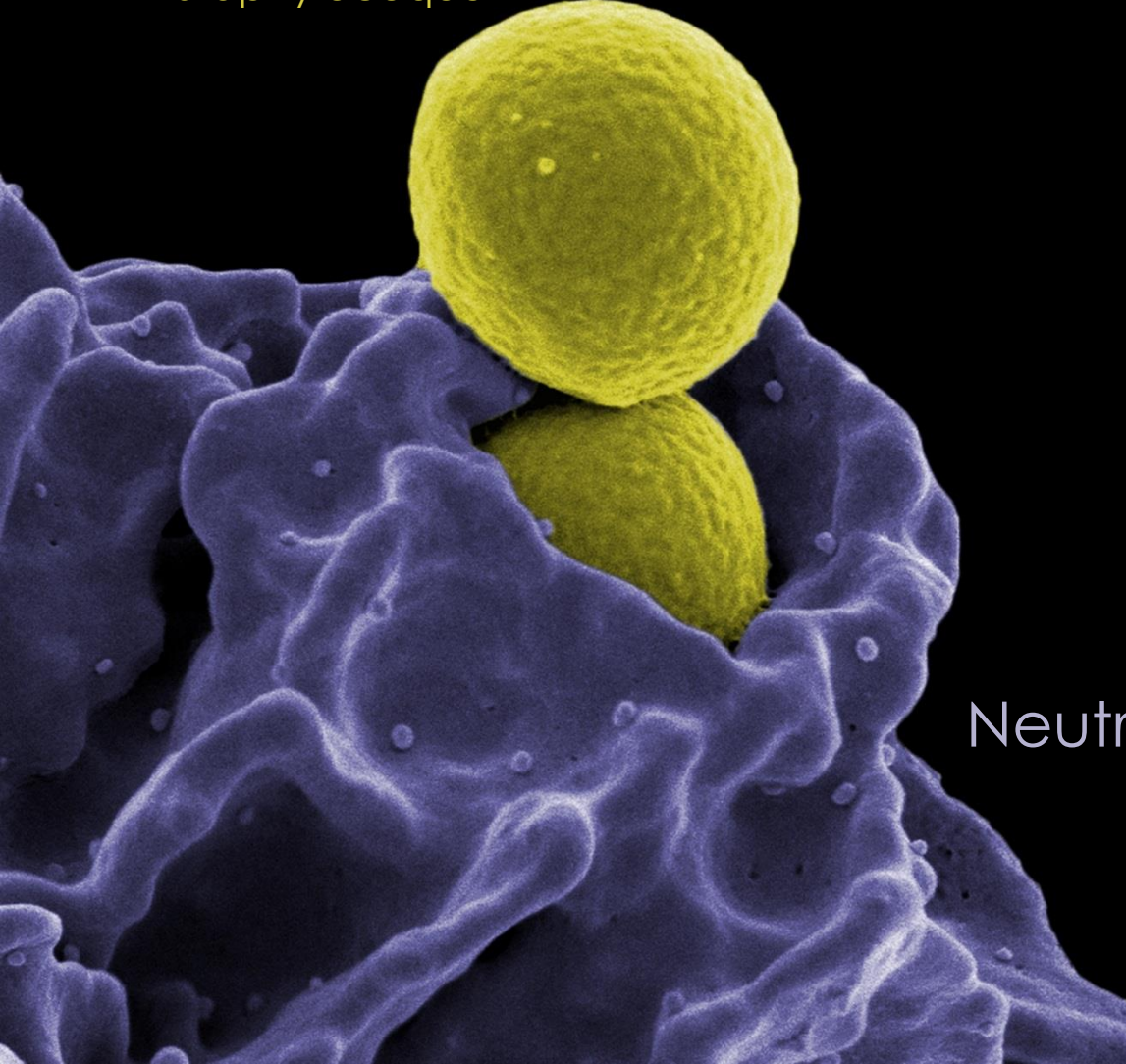


Neutrophile

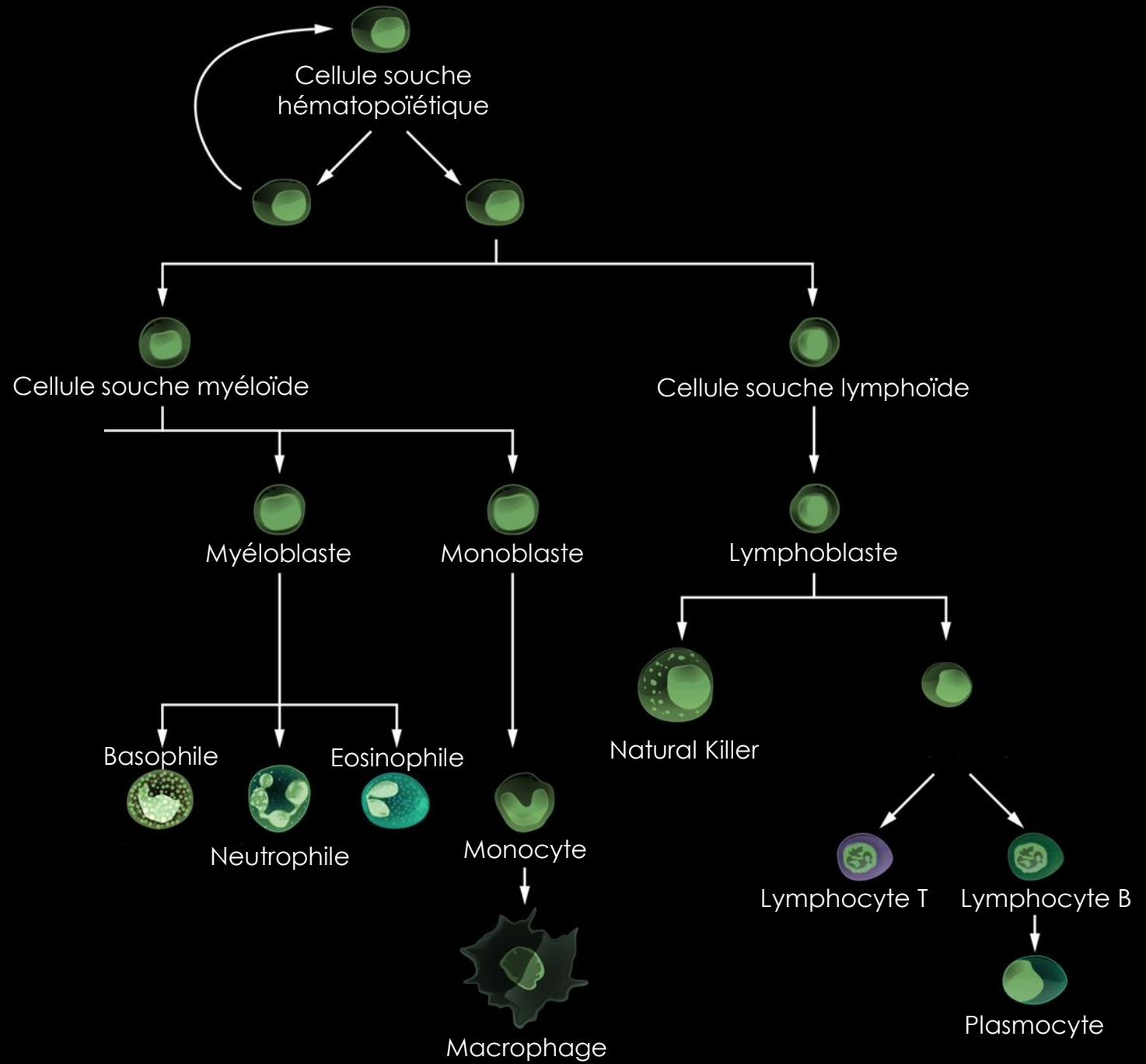


Eosinophiles

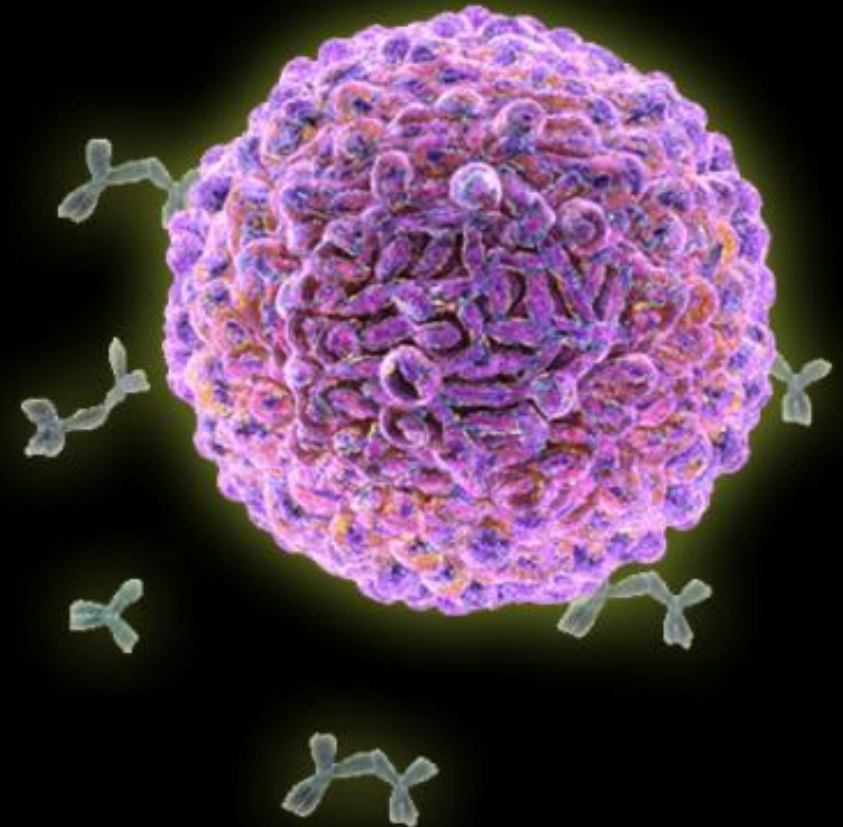
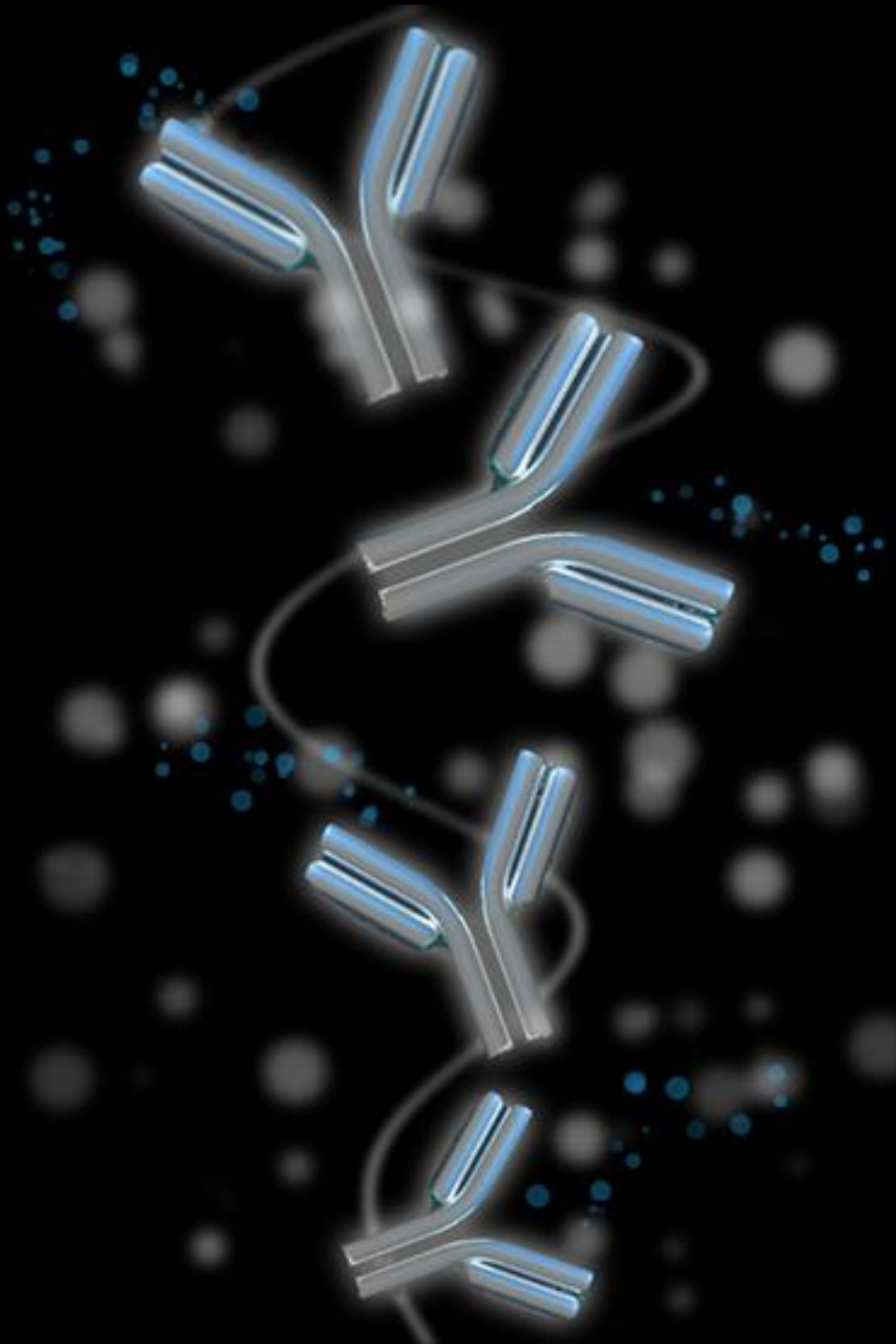
Staphylocoque



Neutrophile



# Lymphocyte B

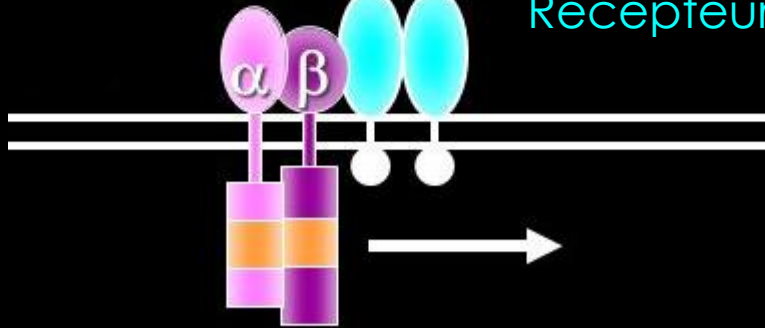


Sites de reconnaissance  
de l'antigène

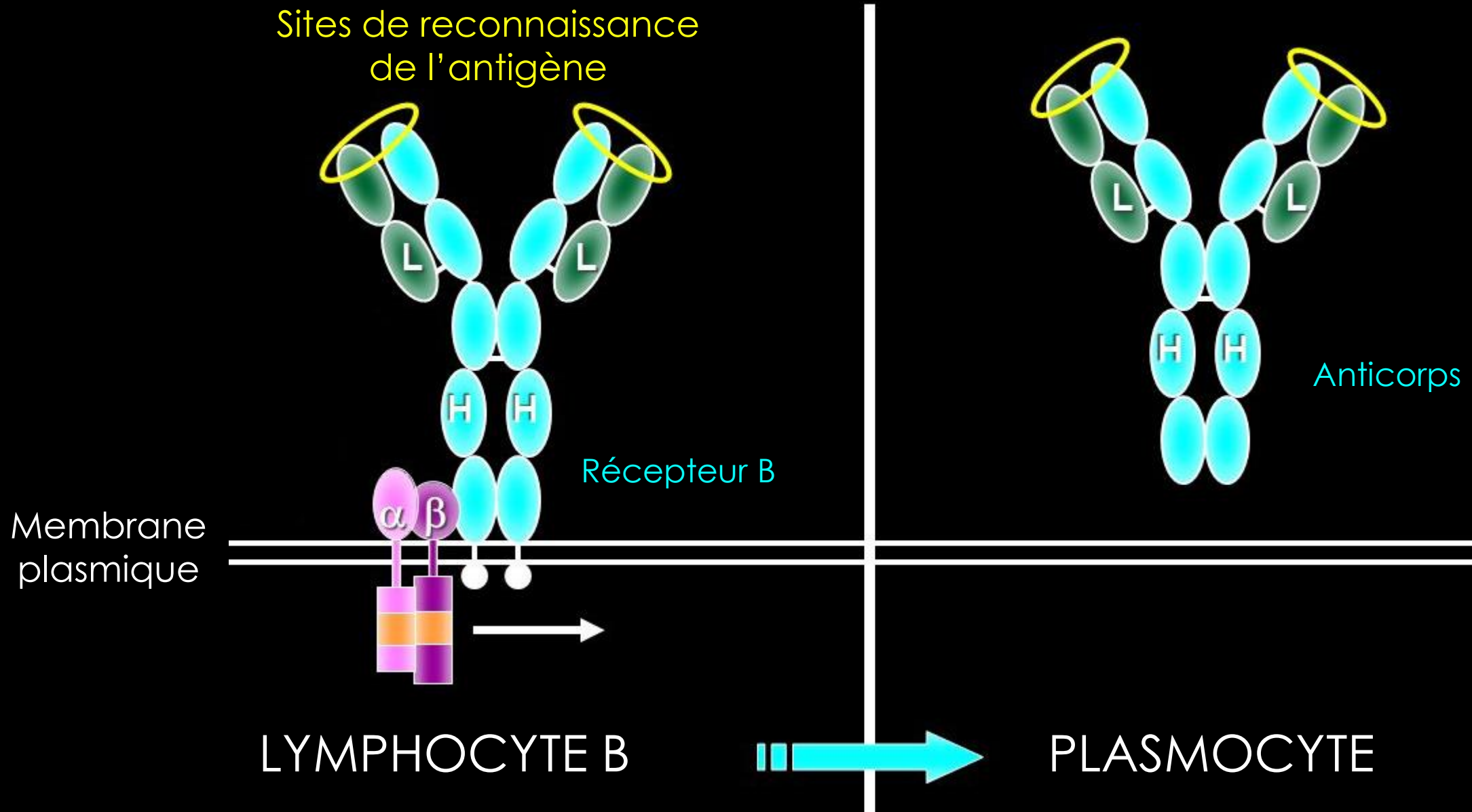


Récepteur B

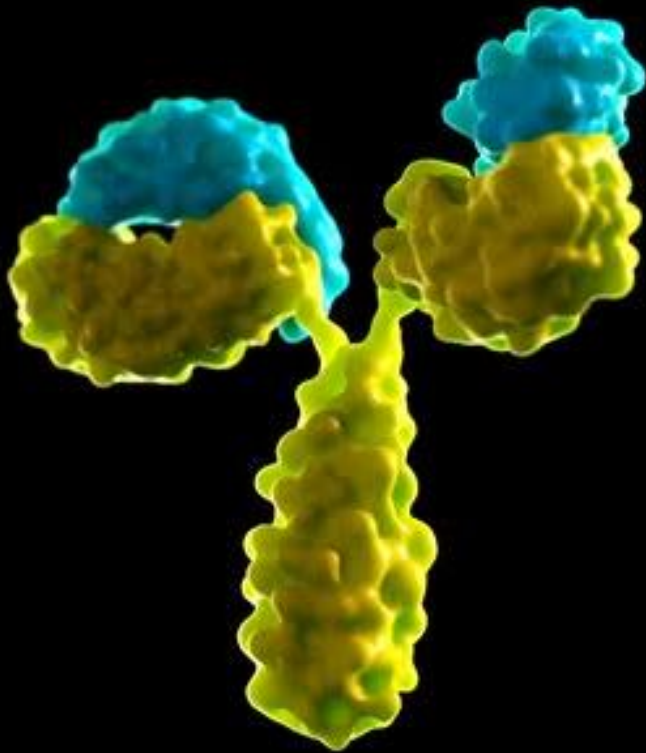
Membrane  
plasmique



LYMPHOCYTE B

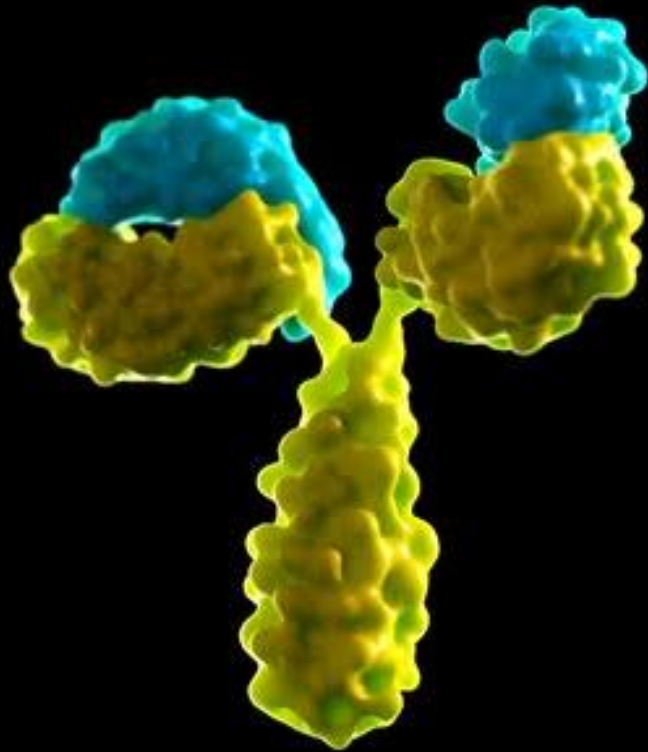
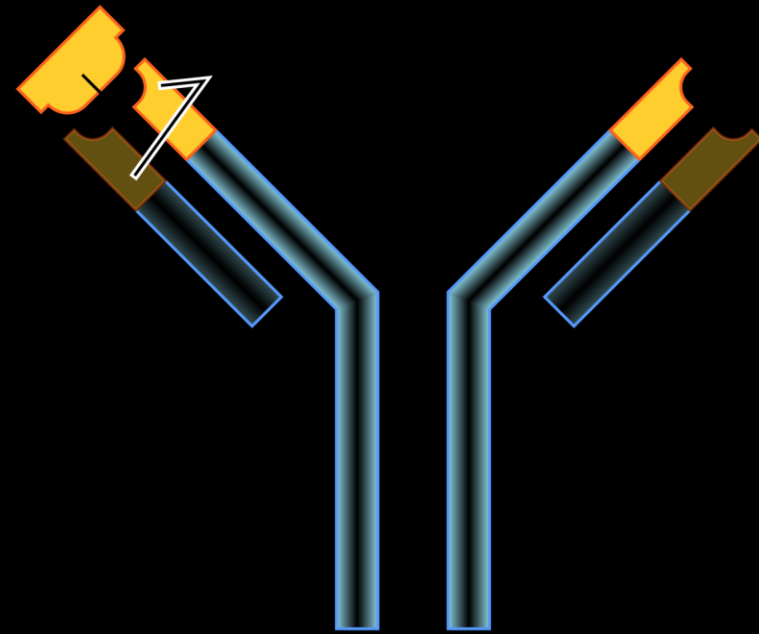




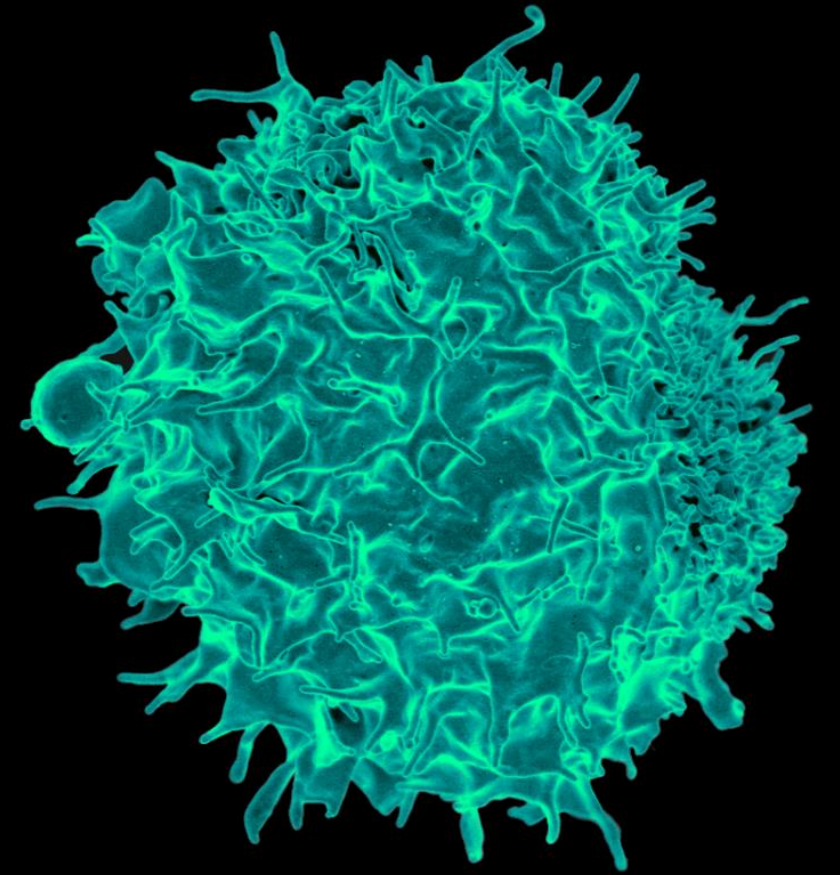


Anticorps

Antigènes



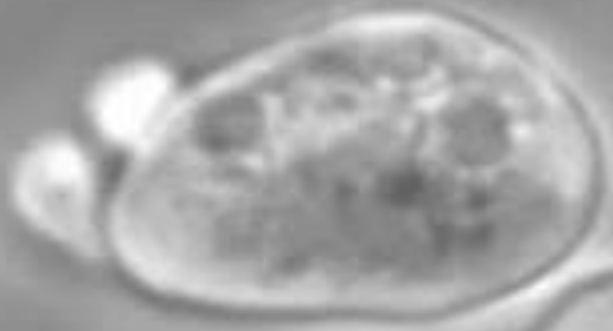
Anticorps



Lymphocyte T

Tom Hickn 2010

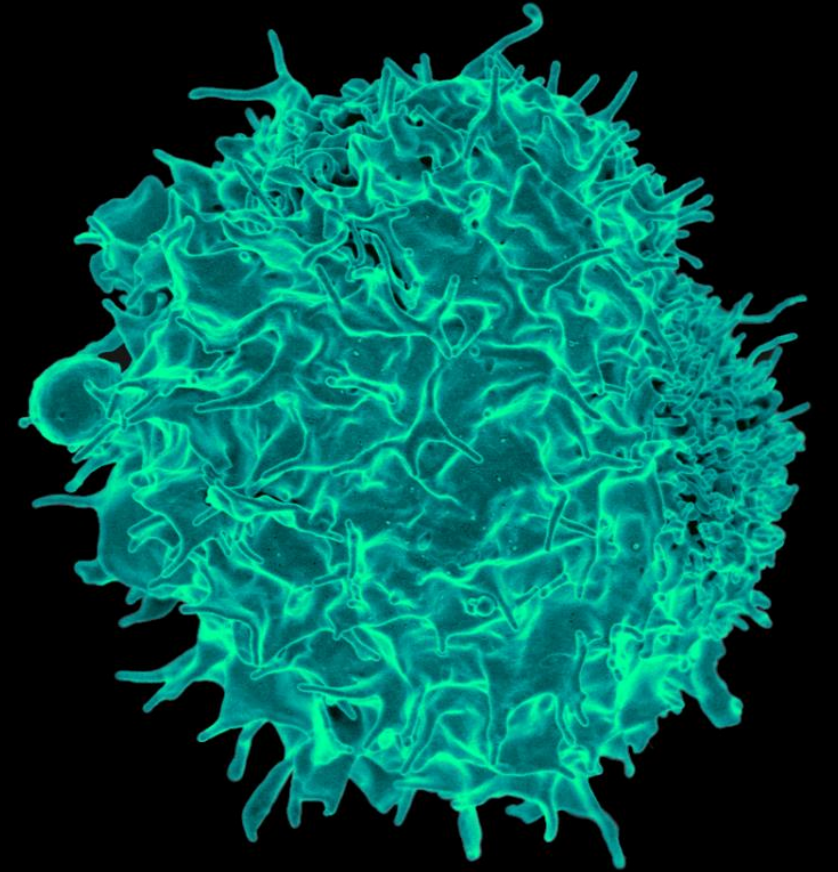
Cellule cible



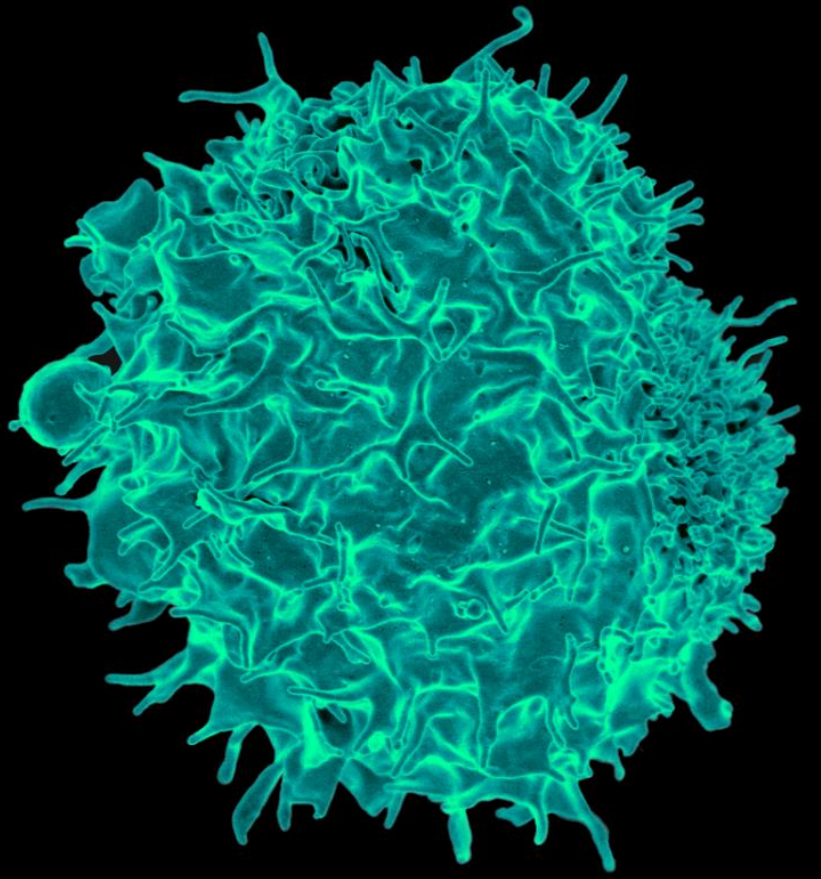
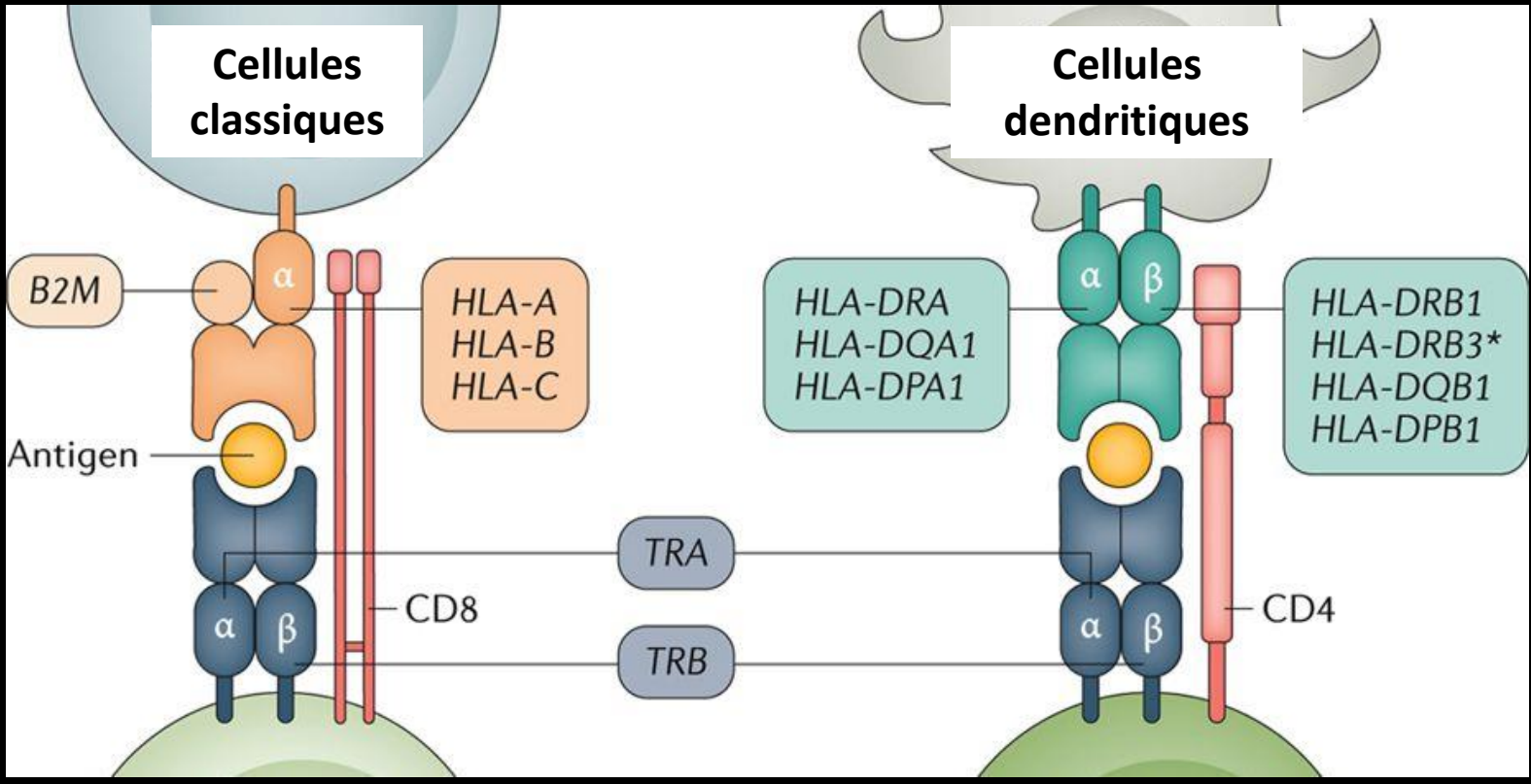
Lymphocyte T



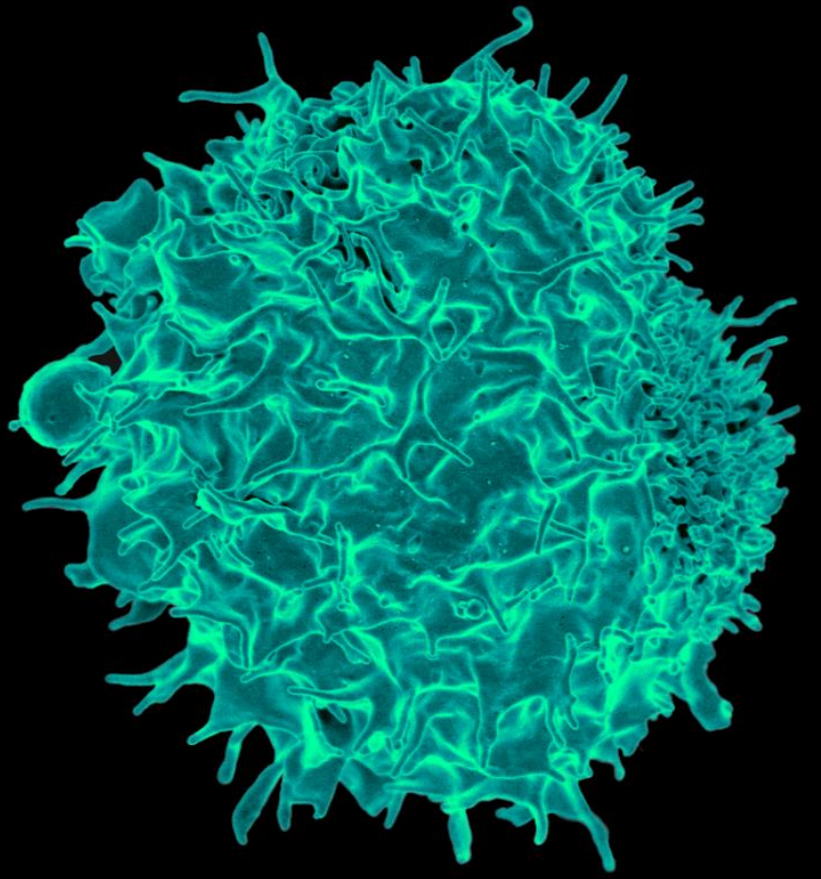
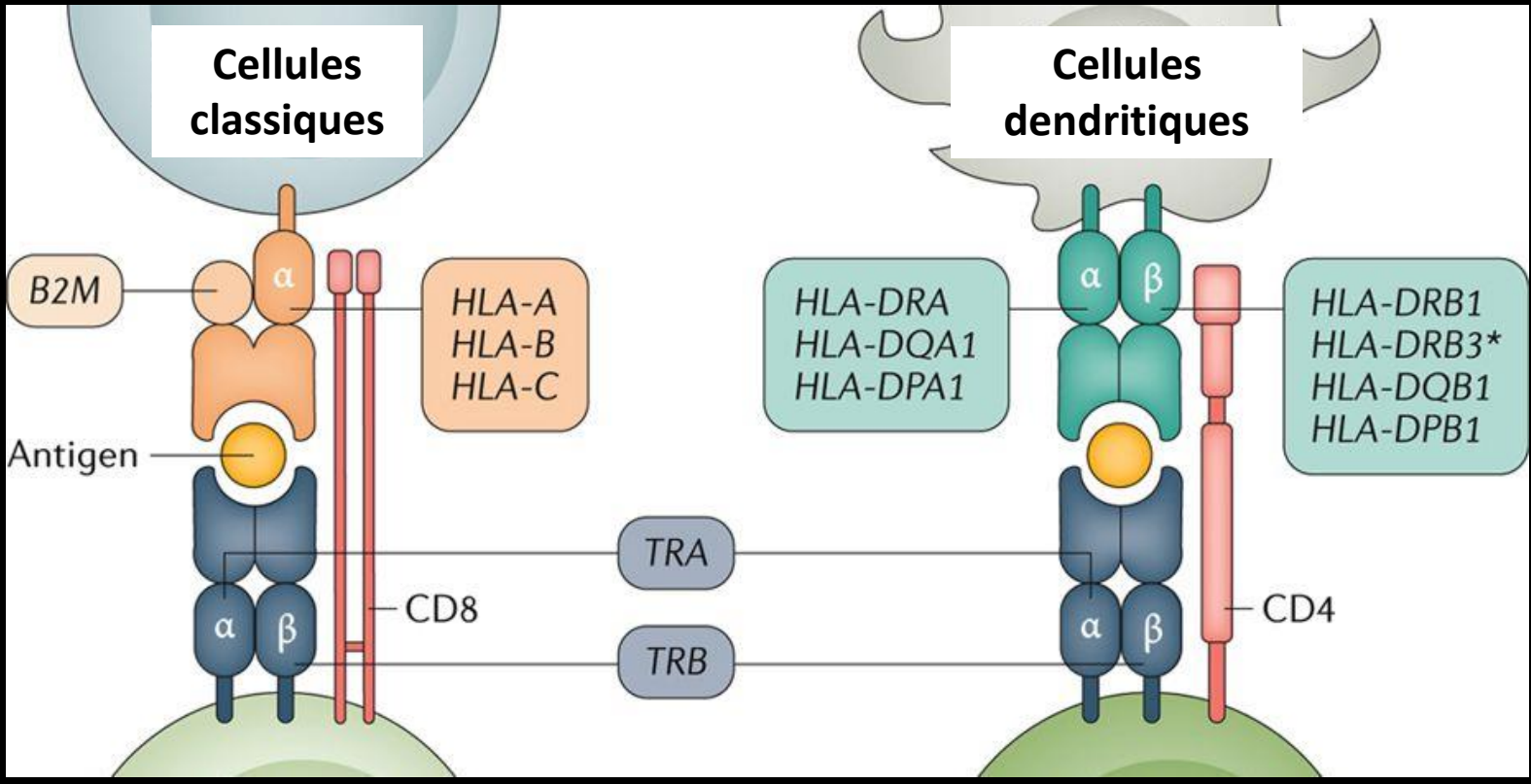
MakeAGIF.com



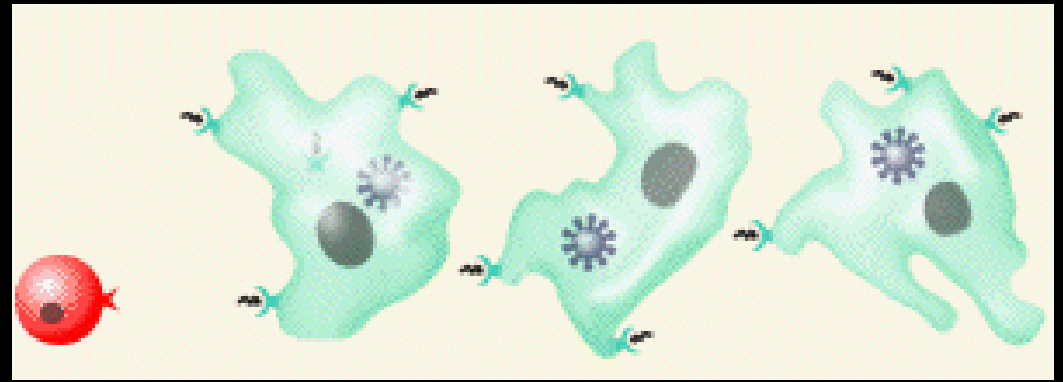
Lymphocyte T



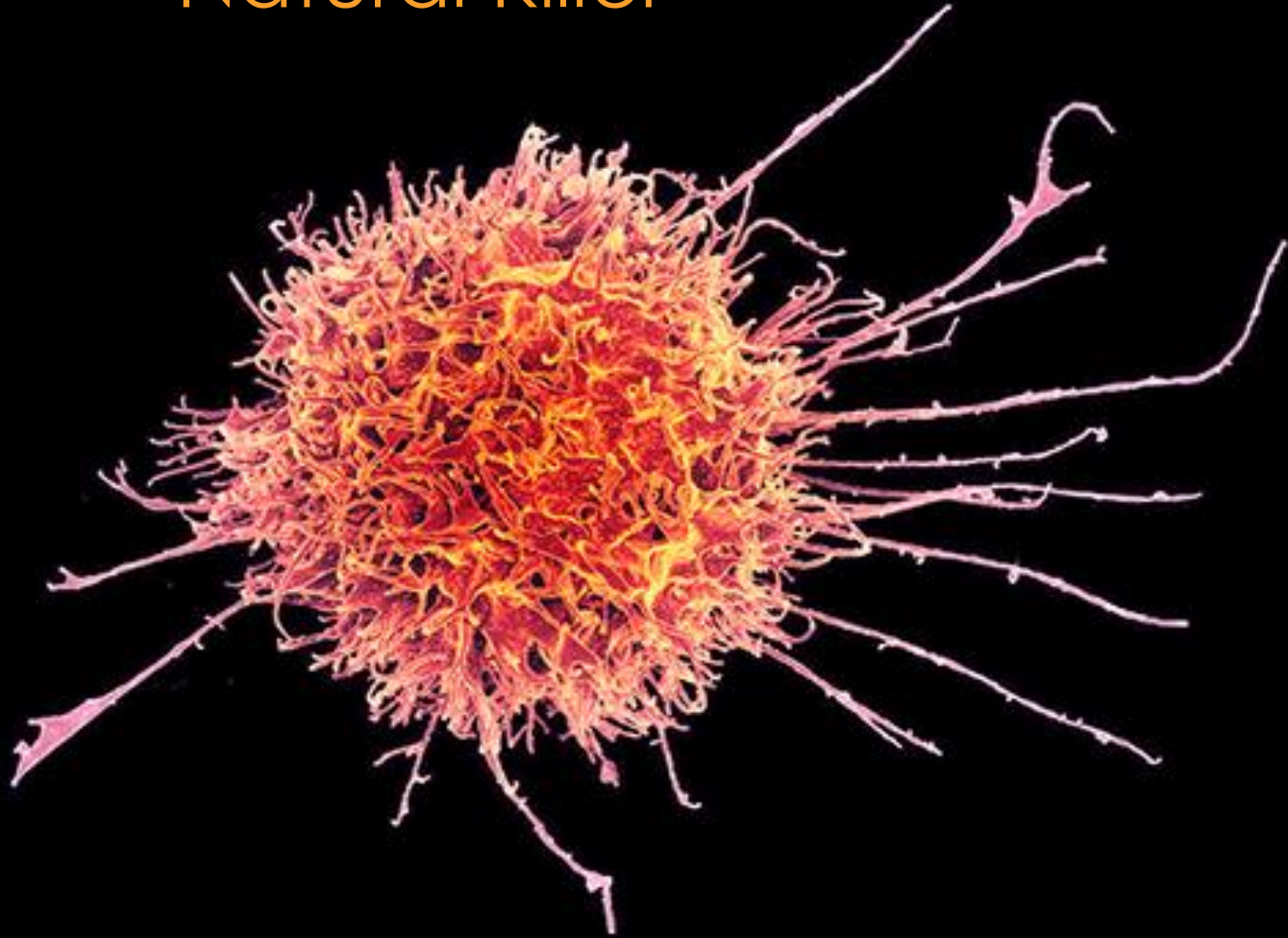
Lymphocyte T



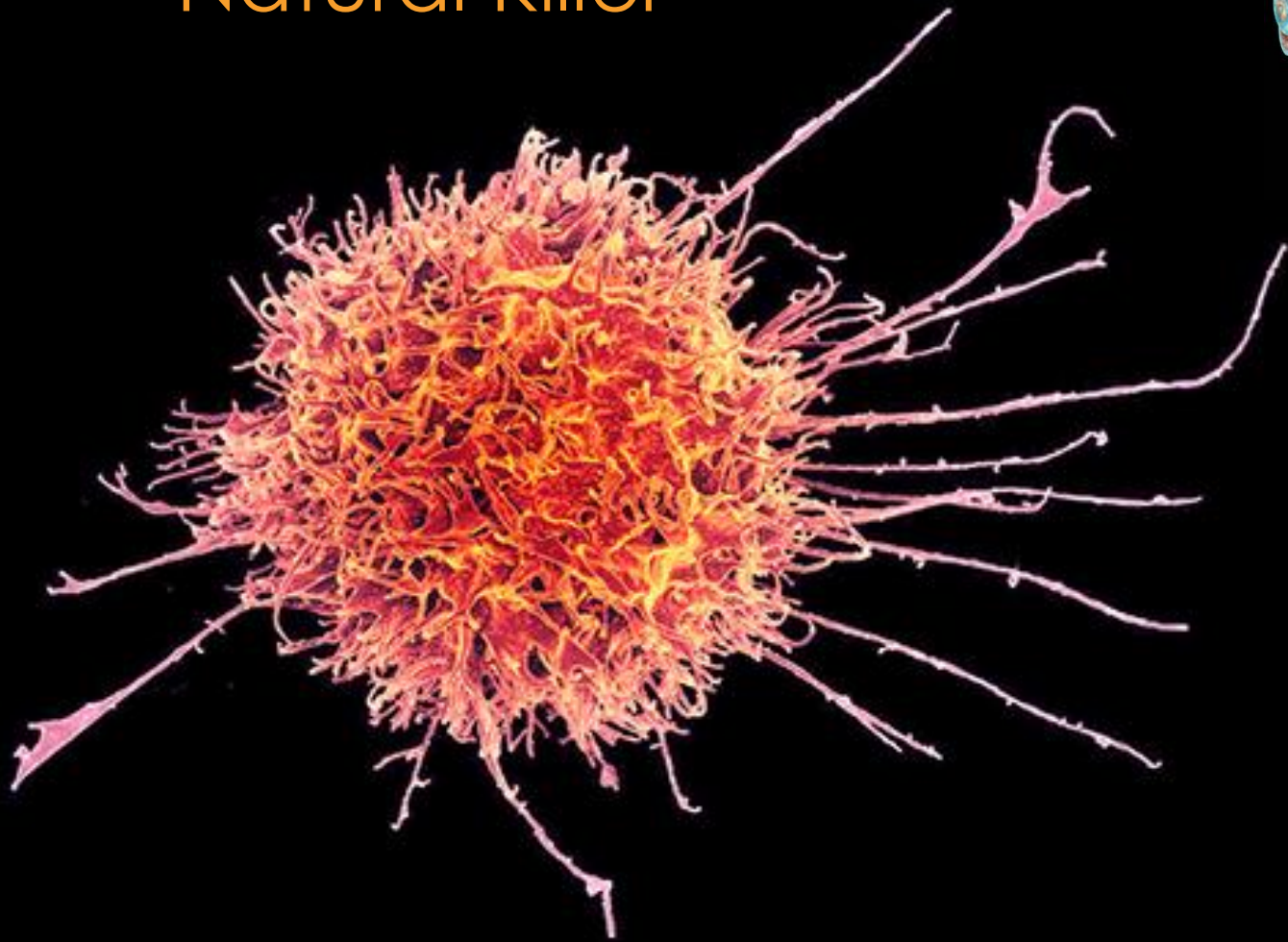
Lymphocyte T



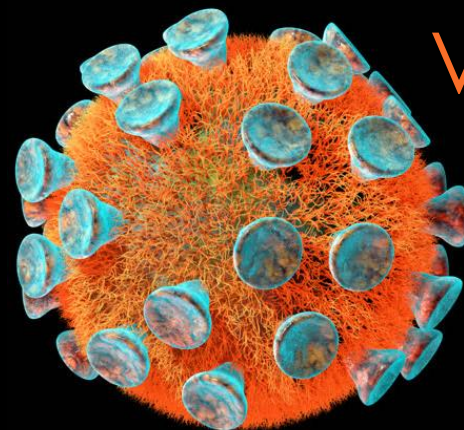
# Natural Killer



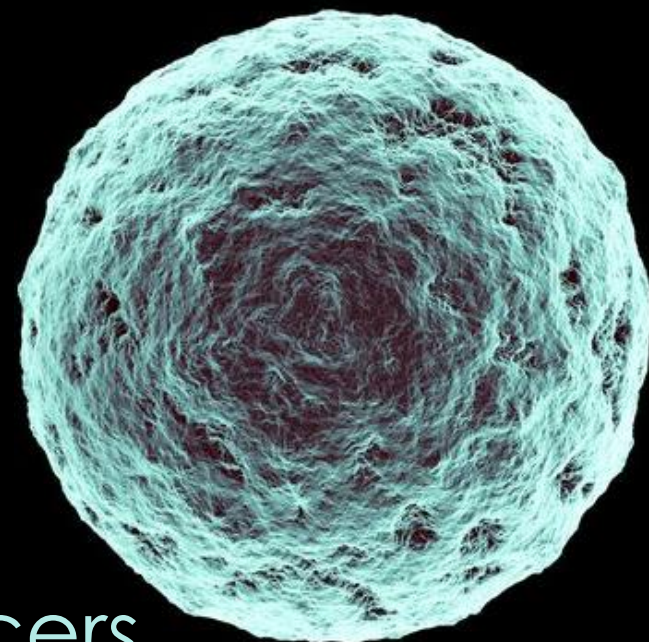
Natural Killer



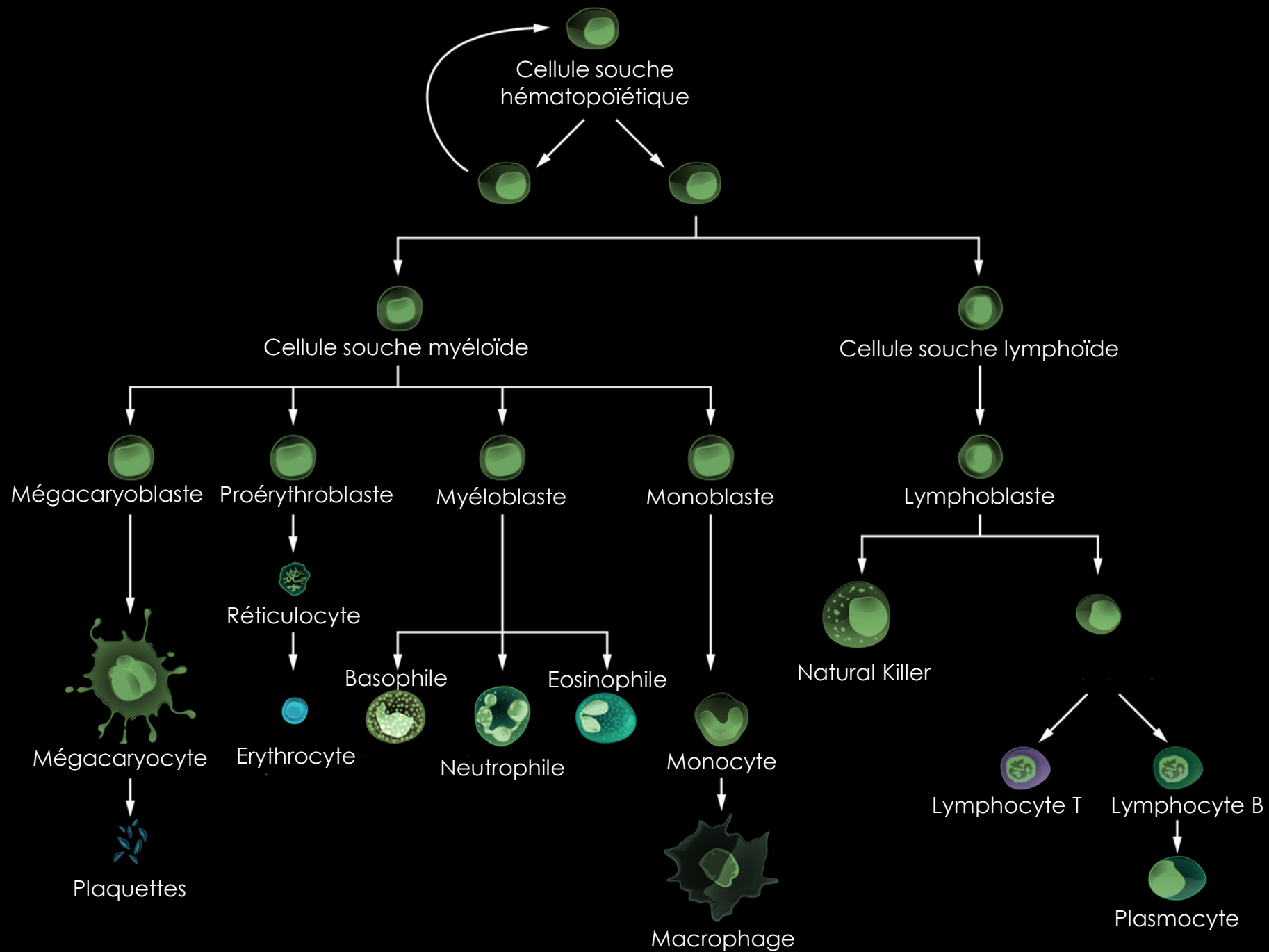
Virus



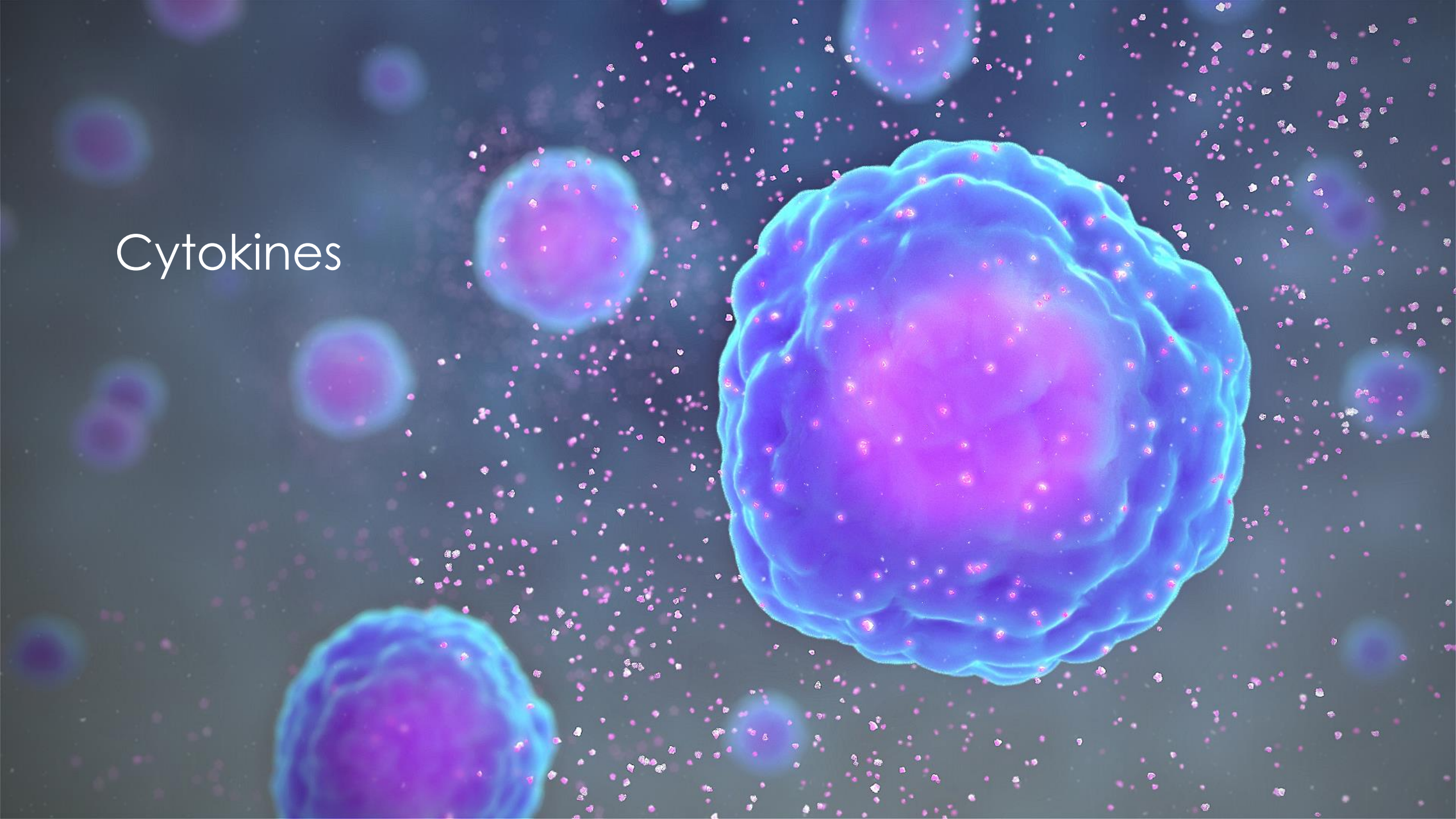
Cancers





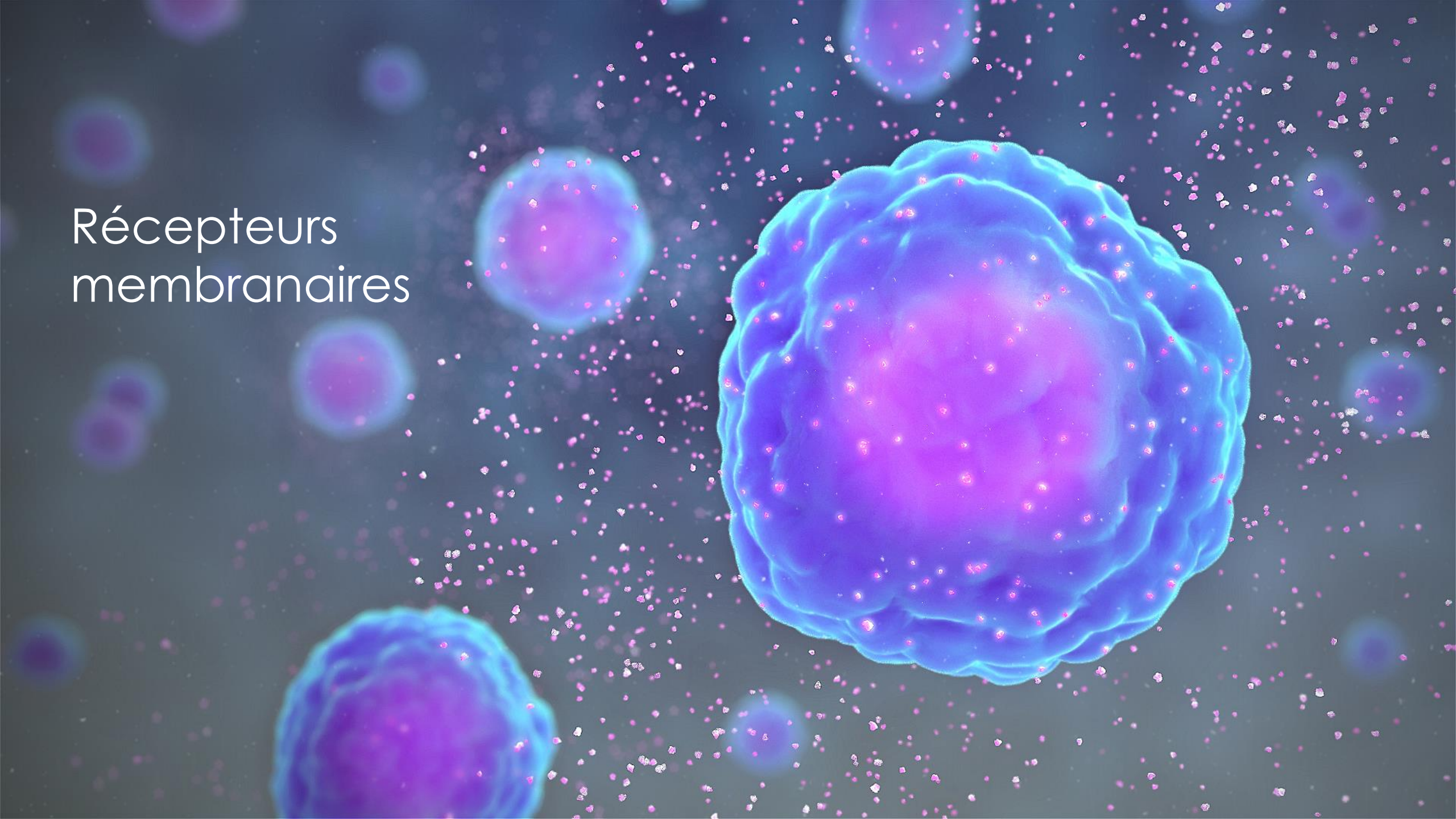


Cytokines



	Cytokine	Main sources	Target cell	Major function
<b>Interleukins</b>	<b>IL-1</b>	Macrophages, B cells, DCs	B cells, NK cells, T-cells	Pyrogenic, pro-inflammatory, proliferation and differentiation, BM cell proliferation
	<b>IL-2</b>	T cells	Activated T and B cells, NK cells	Proliferation and activation
	<b>IL-3</b>	T cells, NK cells	Stem cells	Hematopoietic precursor proliferation and differentiation
	<b>IL-4</b>	Th cells	B cells, T cells, macrophages	Proliferation of B and cytotoxic T cells, enhances MHC class II expression, stimulates IgG and IgE production
	<b>IL-5</b>	Th cells	Eosinophils, B-cells	Proliferation and maturation, stimulates IgA and IgM production
	<b>IL-6</b>	Th cells, macrophages, fibroblasts	Activated B-cells, plasma cells	Differentiation into plasma cells, IgG production
	<b>IL-7</b>	BM stromal cells, epithelial cells	Stem cells	B and T cell growth factor
	<b>IL-8</b>	Macrophages	Neutrophils	Chemotaxis, pro-inflammatory
	<b>IL-9</b>	T cell	T cell	Growth and proliferation
	<b>IL-10</b>	T cell	B cells, macrophages	Inhibits cytokine production and mononuclear cell function, anti-inflammatory
	<b>IL-11</b>	BM stromal cells	B cells	Differentiation, induces acute phase proteins
	<b>IL-12</b>	T cells	NK cells	Activates NK cells
<b>Tumour necrosis factors</b>	<b>TNF-<math>\alpha</math></b>	Macrophages	Macrophages	Phagocyte cell activation, endotoxic shock
	<b>TNF-<math>\beta</math></b>	Monocytes T-cells	Tumour cells Phagocytes, tumour cells	Tumour cytotoxicity, cachexia Chemotactic, phagocytosis, oncostatic, induces other cytokines
<b>Interferons</b>	<b>IFN-<math>\alpha</math></b>	Leukocytes	Various	Anti-viral
	<b>IFN-<math>\beta</math></b>	Fibroblasts	Various	Anti-viral, anti-proliferative
	<b>IFN-<math>\gamma</math></b>	T-cells	Various	Anti-viral, macrophage activation, increases neutrophil and monocyte function, MHC-I and -II expression on cells
<b>Colony stimulating factors</b>	<b>G-CSF</b>	Fibroblasts, endothelium	Stem cells in BM	Granulocyte production
	<b>GM-CSF</b>	T cells, macrophages, fibroblasts	Stem cells	Granulocyte, monocyte, eosinophil production
	<b>M-CSF</b>	Fibroblast, endothelium	Stem cells	Monocyte production and activation
	<b>Erythropoietin</b>	Endothelium	Stem cells	Red blood cell production
<b>Others</b>	<b>TGF-<math>\beta</math></b>	T cells and B cells	Activated T and B cells	Inhibit T and B cell proliferation, inhibit haematopoiesis, promote wound healing

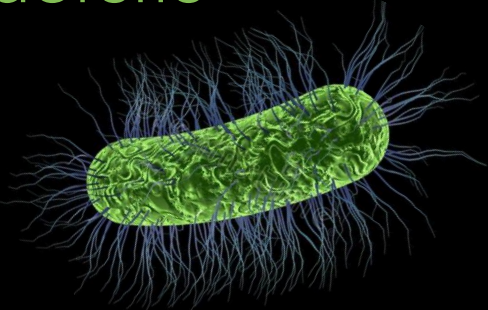
# Récepteurs membranaires



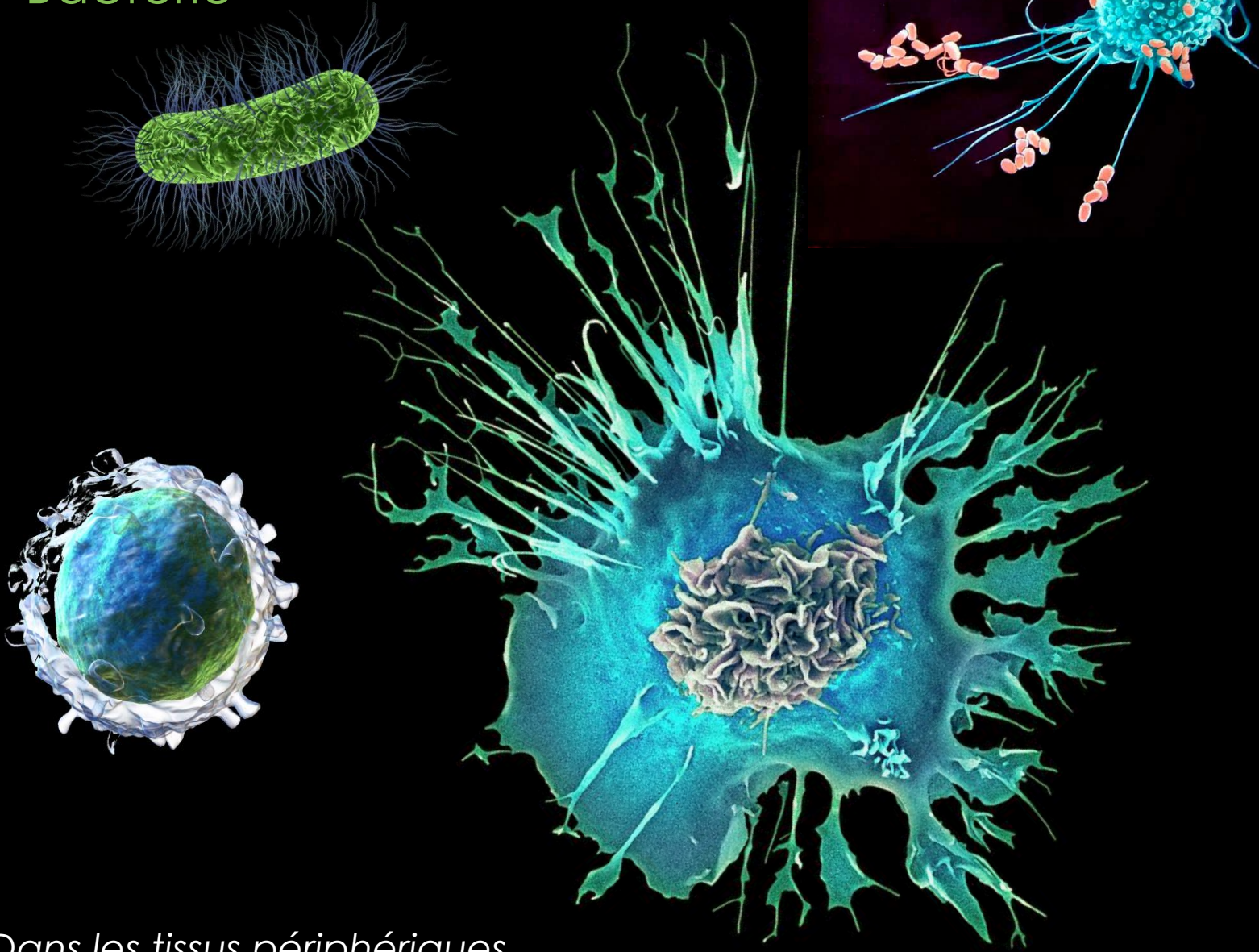
CD	Expression	Functions
CD1	IDC, B subset	Presents glycolipid and other nonpeptide antigens to T-cells
CD2	T, NK	Receptor for CD58 (LFA-3) co-stimulator
CD3	T	Transducing elements of T-cell receptor
CD4	MHC class II restricted T, IDC, Mo, M $\phi$	Receptor for MHC class II
CD5	T, B subset	Involved in antigen receptor signaling
CD8	MHC class I restricted T	Receptor for MHC class I
CD14	G, Mo, M $\phi$	Receptor for LPS/LBP complex
CD16	G, NK, B, M $\phi$ , IDC	Fc $\gamma$ RIII (medium-affinity IgG receptor)
CD19	B, FDC	Part of B-cell antigen receptor complex
CD20	B	Provides signals for B cell activation and proliferation
CD21	B, FDC	CR2. Receptor for C3d and Epstein-Barr virus. Part of B-cell antigen receptor complex
CD23	B, Mo, FDC	Fc $\epsilon$ RII (low affinity IgE receptor)
CD25	*T, *B, *Mo, *M $\phi$	IL-2 receptor $\alpha$ chain
CD28	T, *B	Receptor for CD80/CD86 (B7.1 and B7.2) co-stimulators
CD32	Mo, M $\phi$ , IDC, FDC, G, NK, B	Fc $\gamma$ RII (low-affinity IgG receptor)
CD34	Progenitors	Adhesion molecule. Stem cell marker
CD40	B, M $\phi$ , IDC, FDC	Receptor for CD154 (CD40L) co-stimulator
CD45RA	Resting/Naive T-cells, B, G, Mo, NK	Phosphatase, cell activation
CD45RO	Effector T-cell, Mo, M $\phi$ , IDC	Phosphatase, cell activation
CD64	Mo, M $\phi$ , DC	Fc $\gamma$ RI (high-affinity IgG receptor)
CD79a/CD79b	B	Ig $\alpha$ /Ig $\beta$ -transducing elements of B-cell receptor
CD80	*B, *T, M $\phi$ , DC	B7.1 receptor for CD28 co-stimulator and for CTLA4 inhibitory signal
CD86	B, IDC, Mo	B7.2 receptor for CD28 co-stimulator and for CTLA4 inhibitory signal
CD95	Widespread	Fas receptor for FasL (CD178). Transmits apoptotic signals

# *Réponses immunitaires*

Bactérie



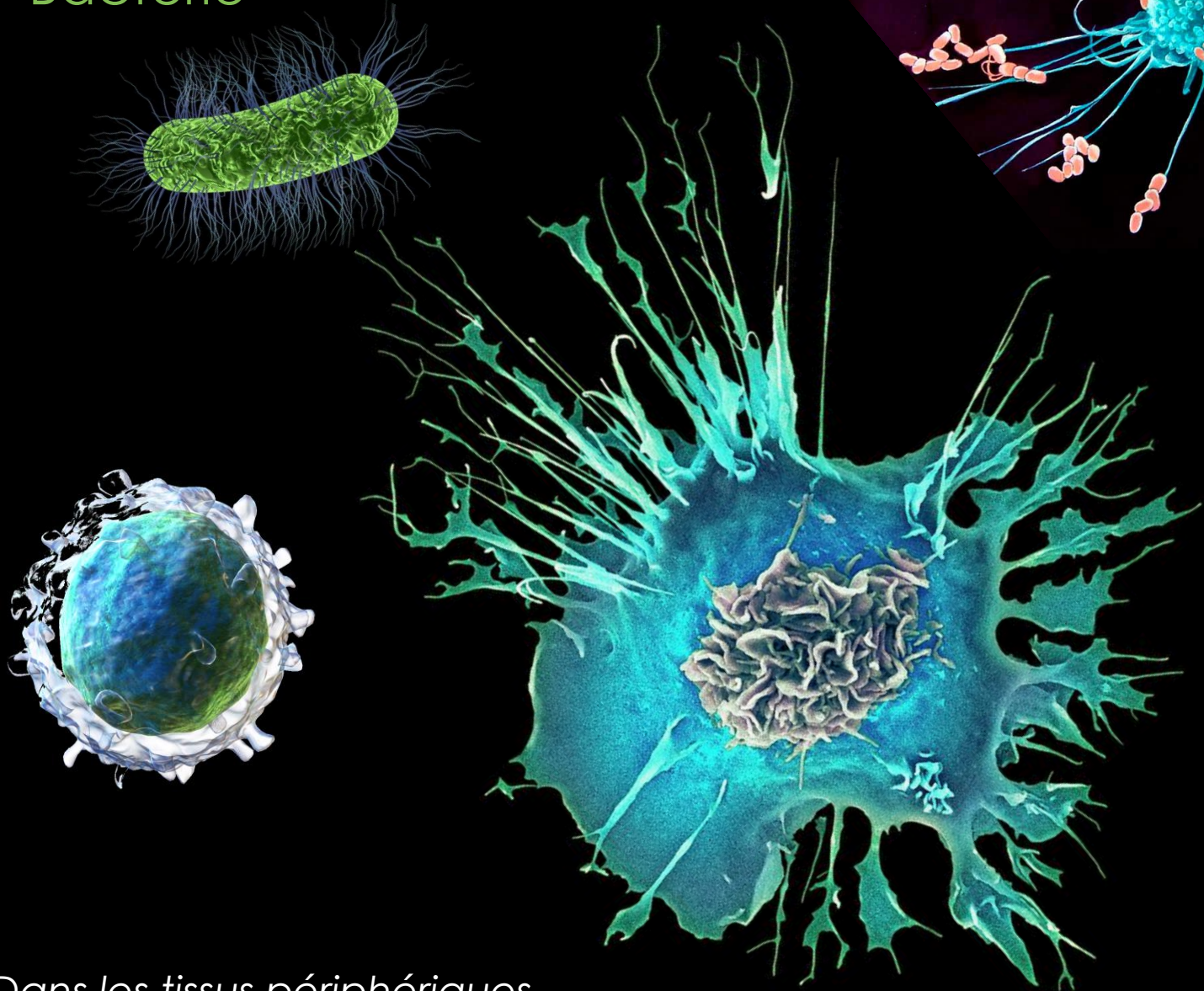
Bactérie



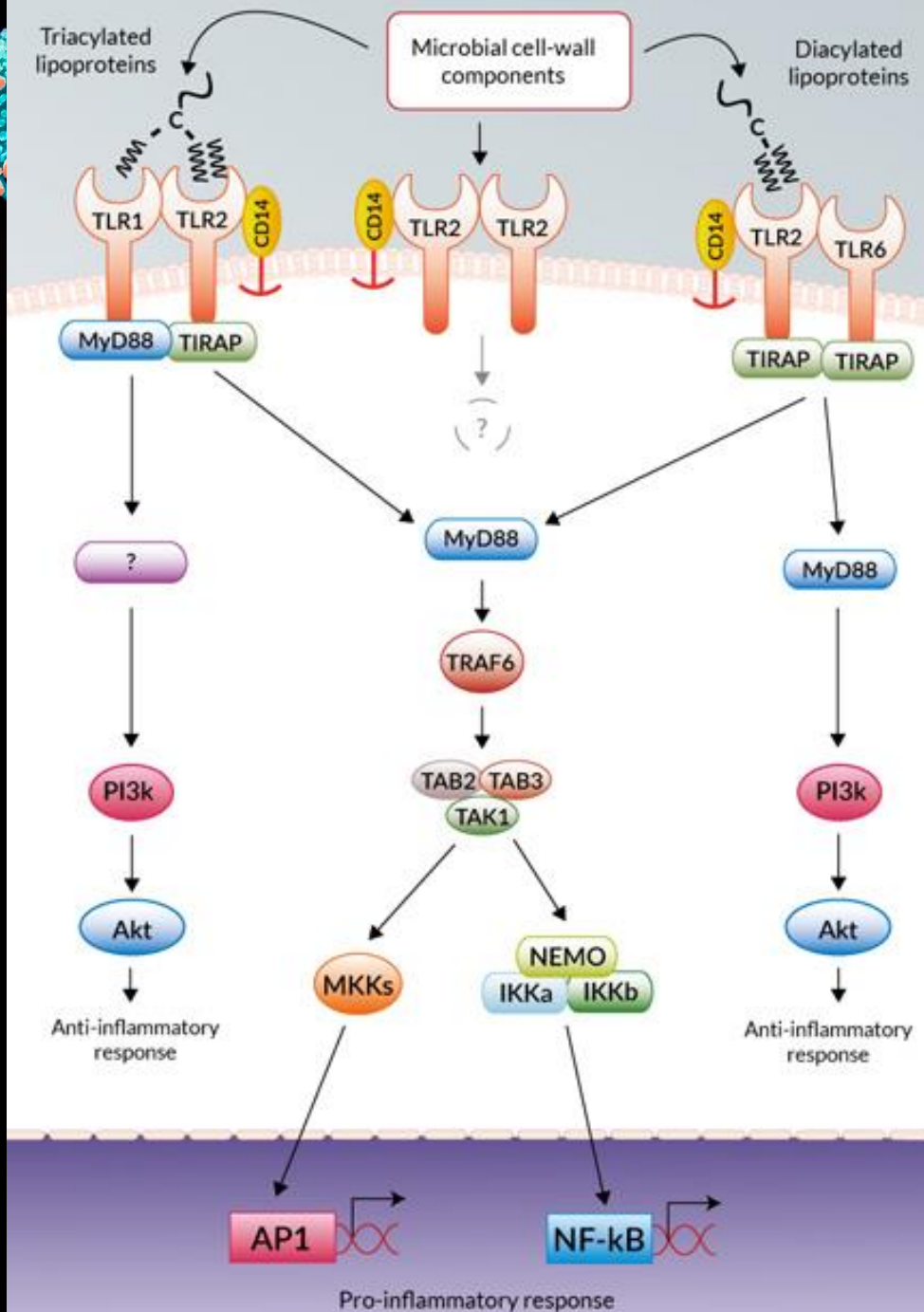
*Dans les tissus périphériques*



Bactérie



Dans les tissus périphériques



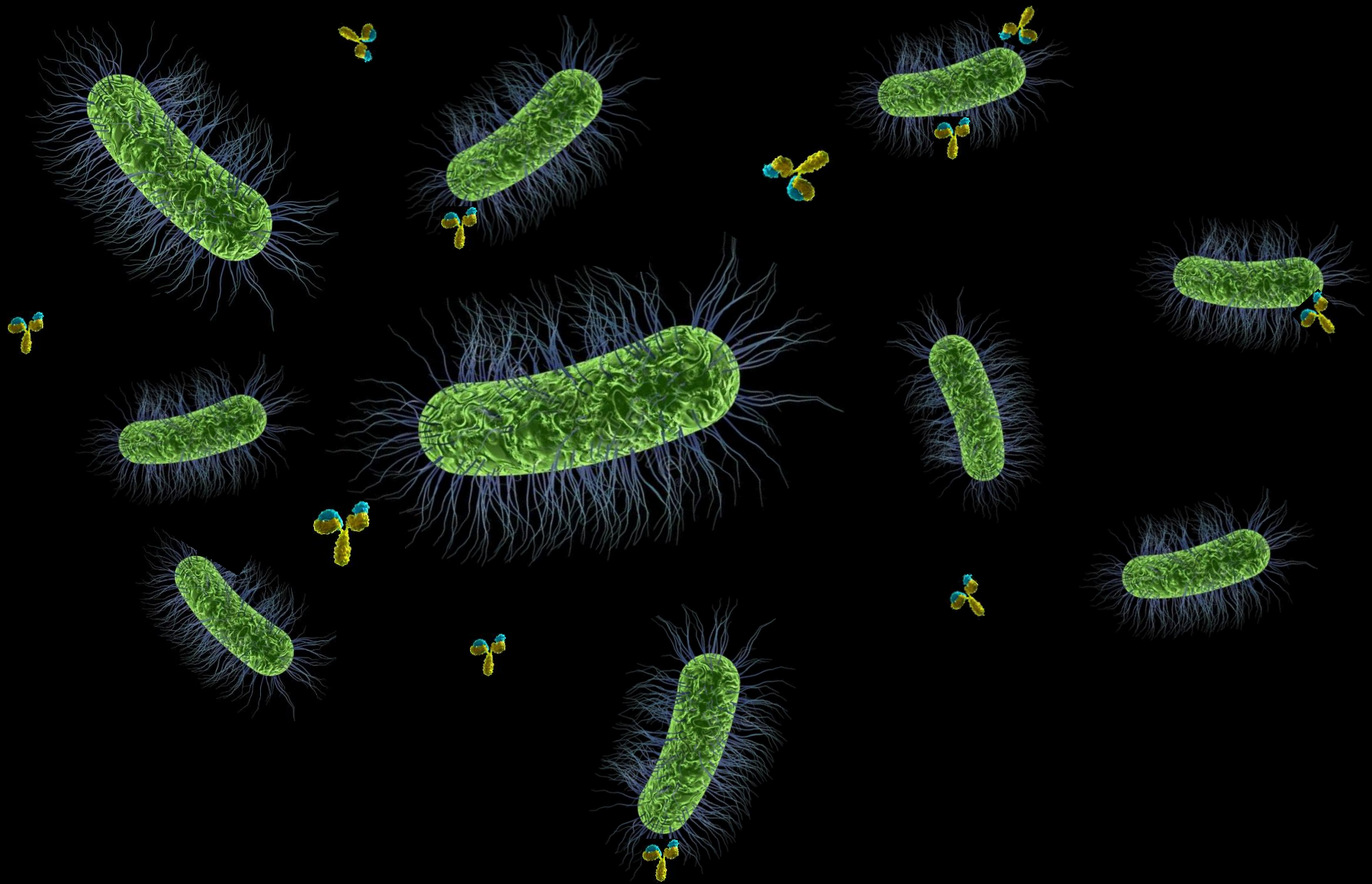


Cellule  
dendritique

Lymphocyte T CD4 « auxiliaire »

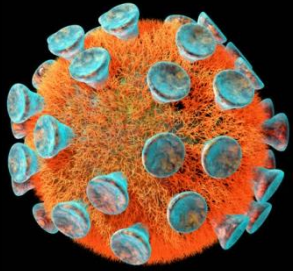
Lymphocyte B > Plasmocyte

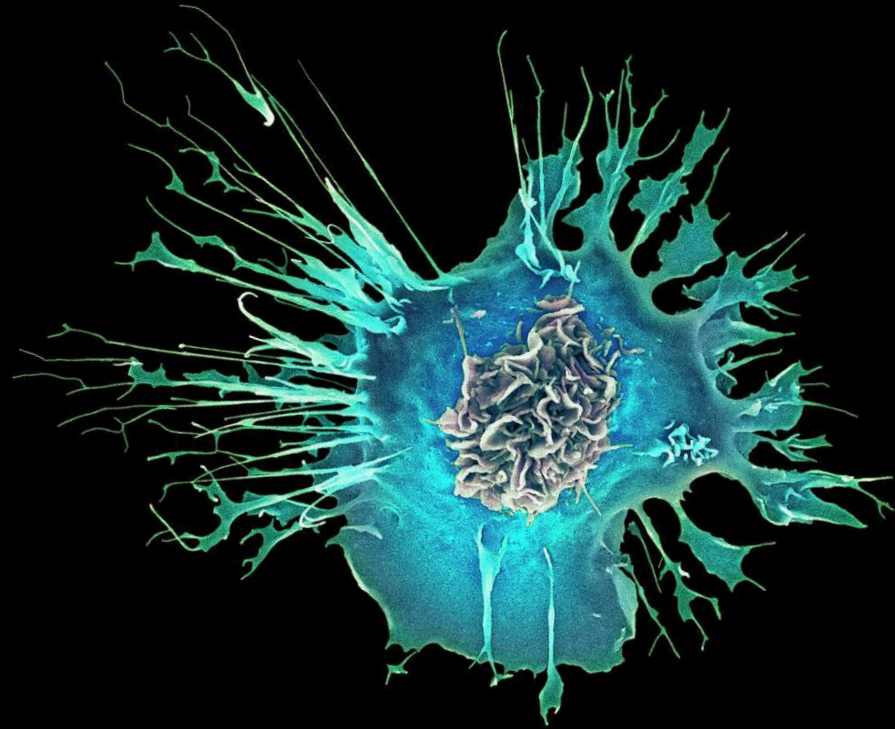
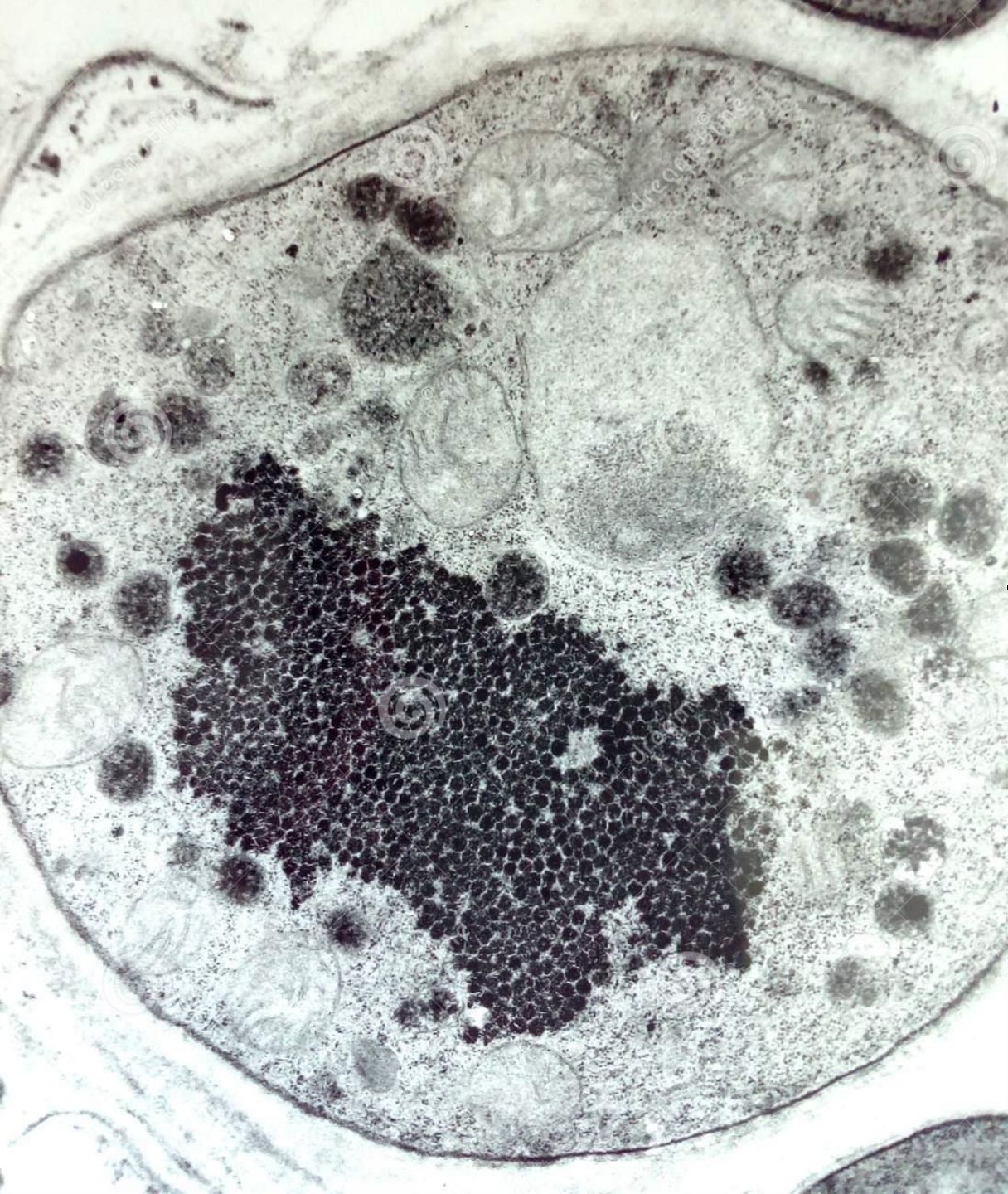
*Dans les organes lymphoïdes secondaires*



*Dans tout l'organisme*

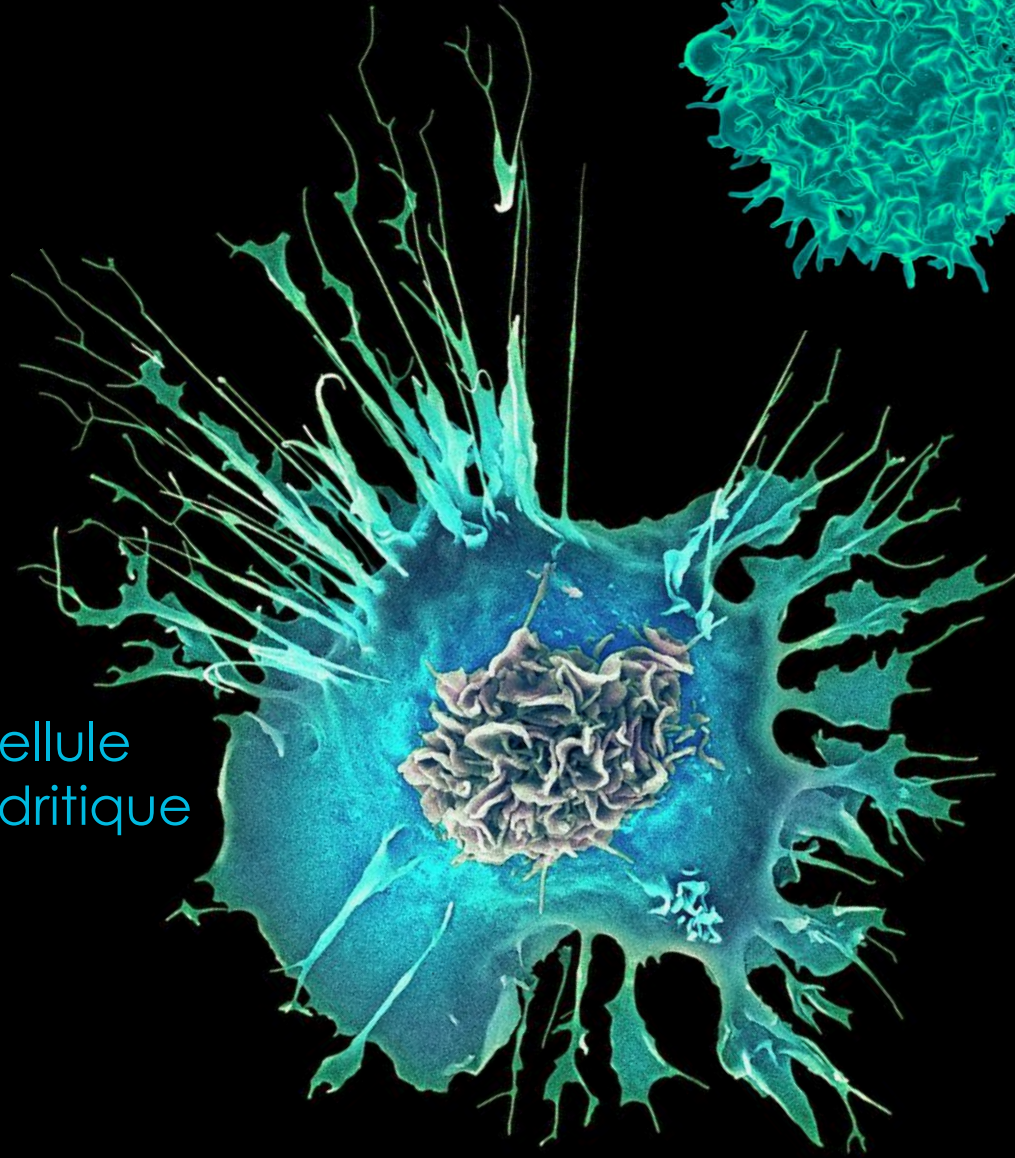
Virus



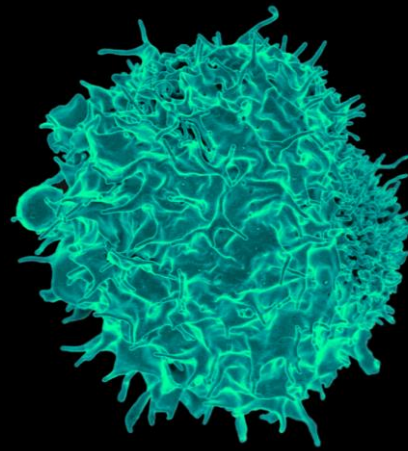


*Dans les tissus périphériques*

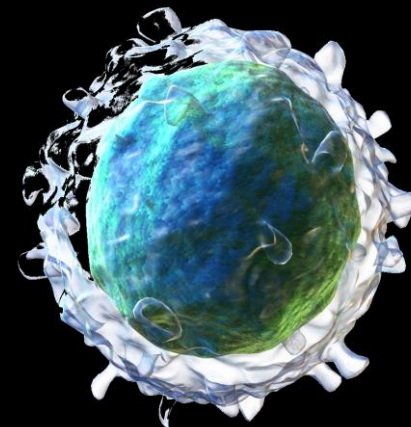
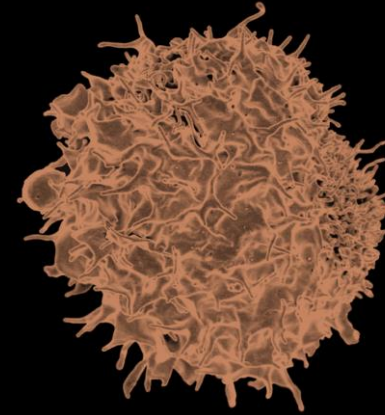
Cellule  
dendritique



Lymphocyte T CD4 « auxiliaire »

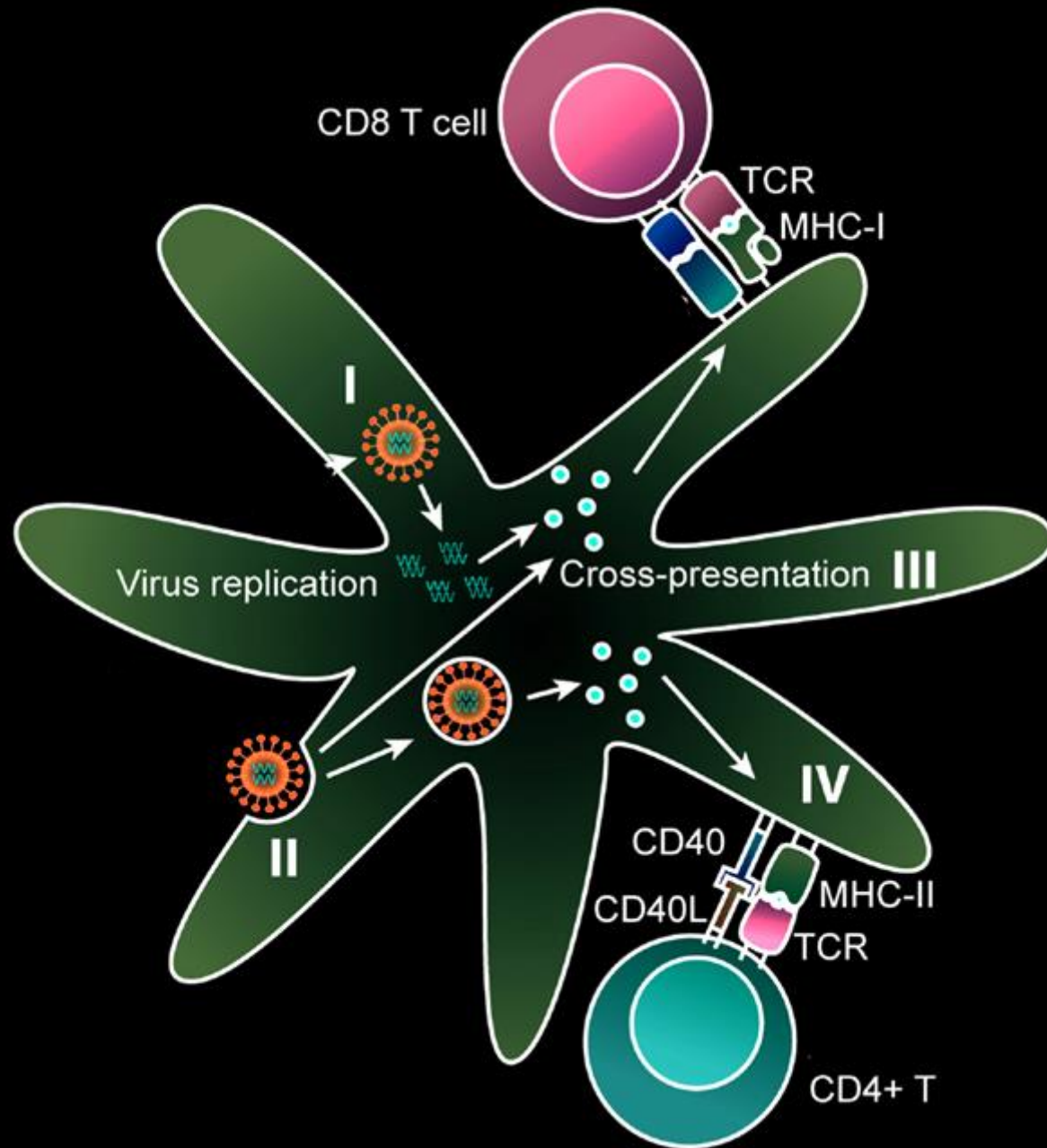


Lymphocyte T CD8 « tueur »

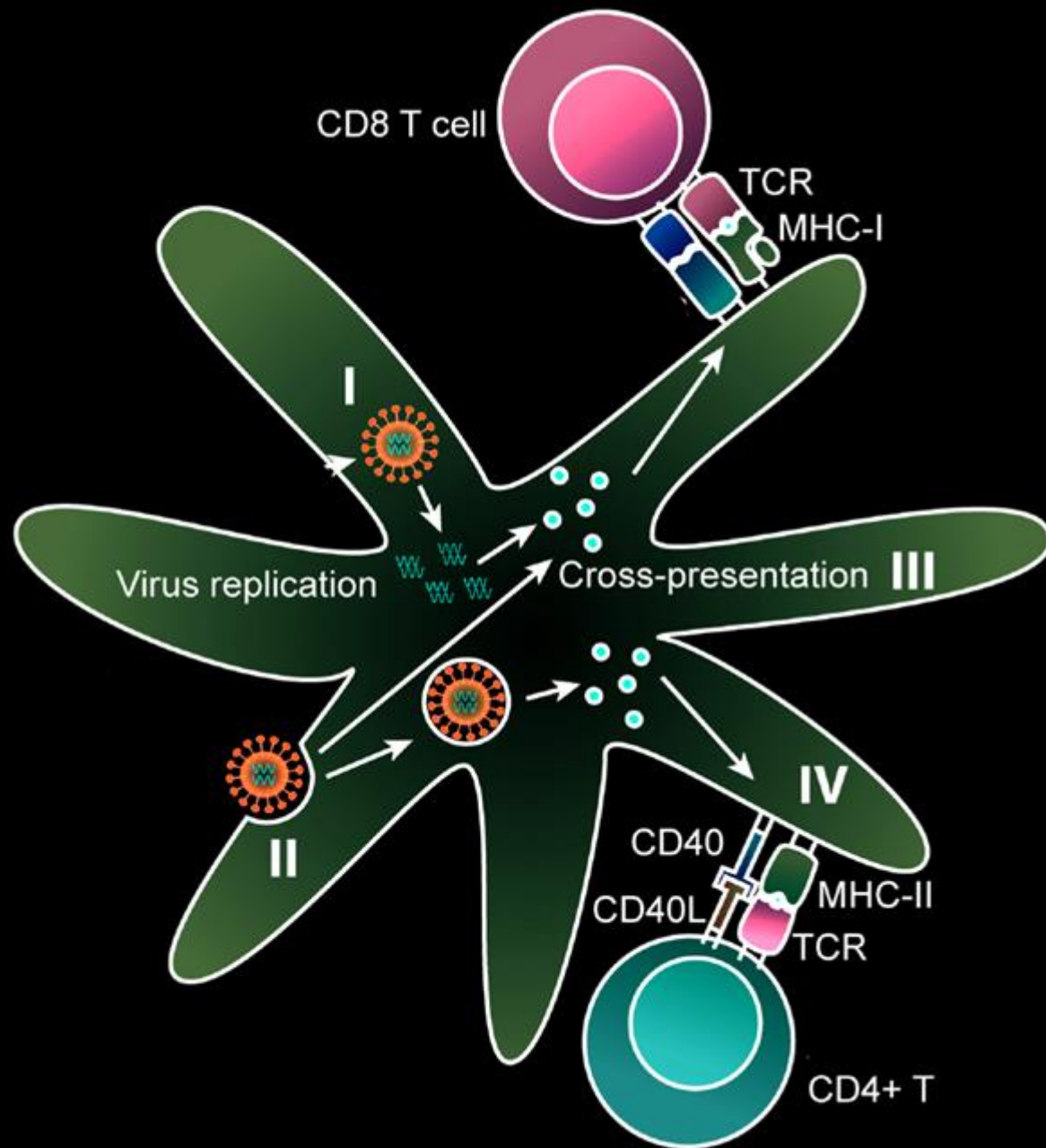


Lymphocyte B > Plasmocyte

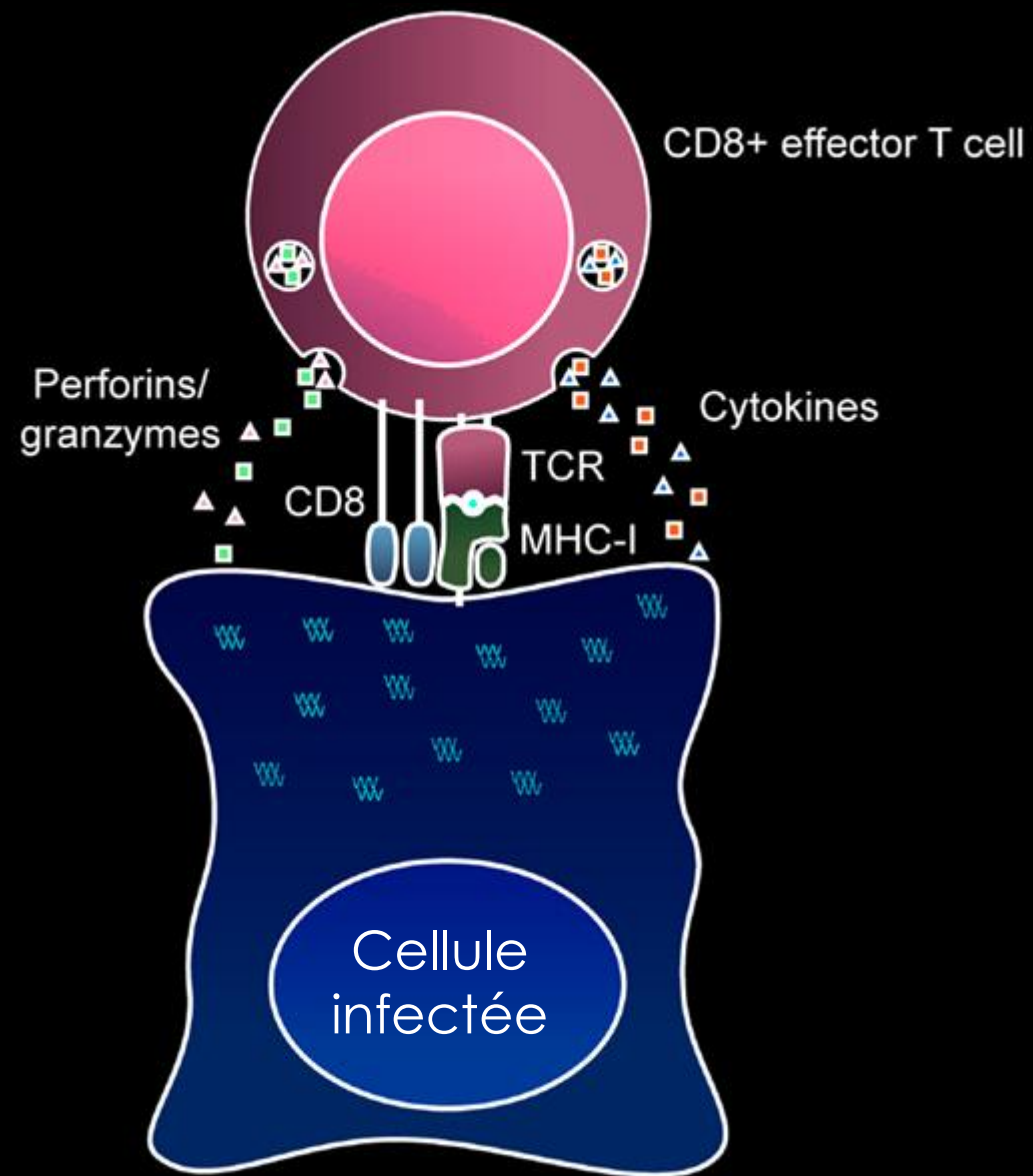
Dans les organes lymphoïdes secondaires



*Dans les organes lymphoïdes secondaires*



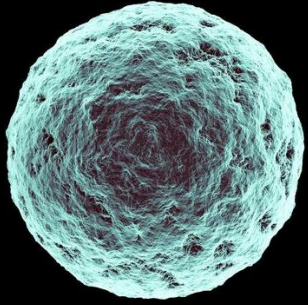
*Dans les organes lymphoïdes secondaires*

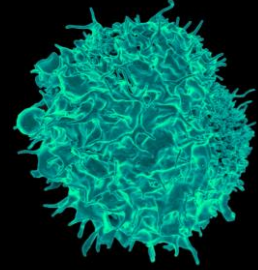


*Dans les tissus périphériques*

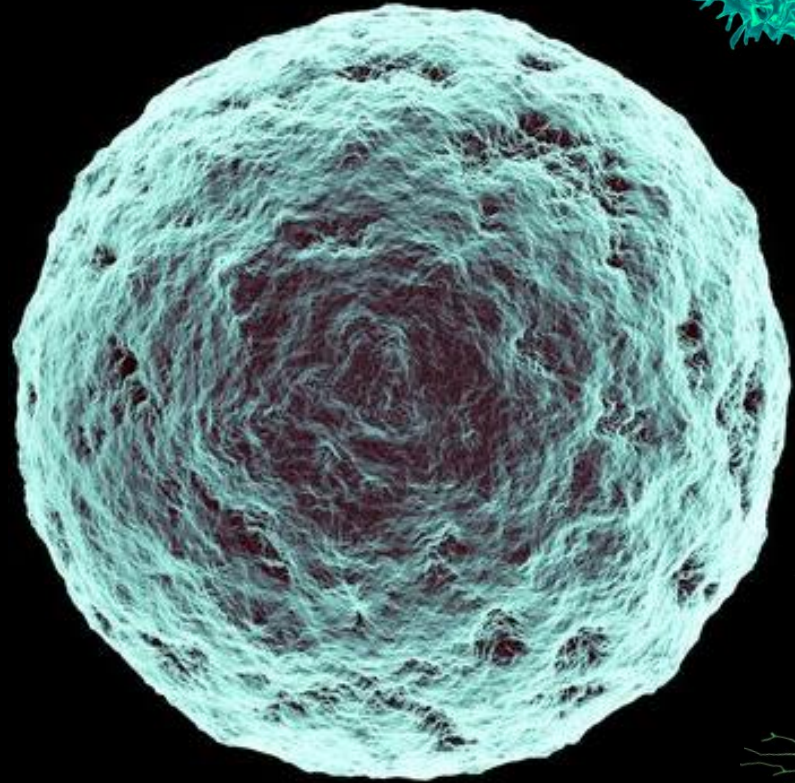


Cancer

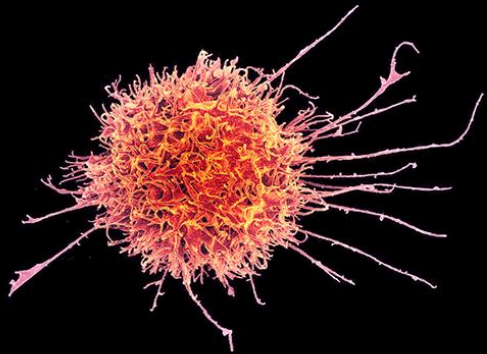




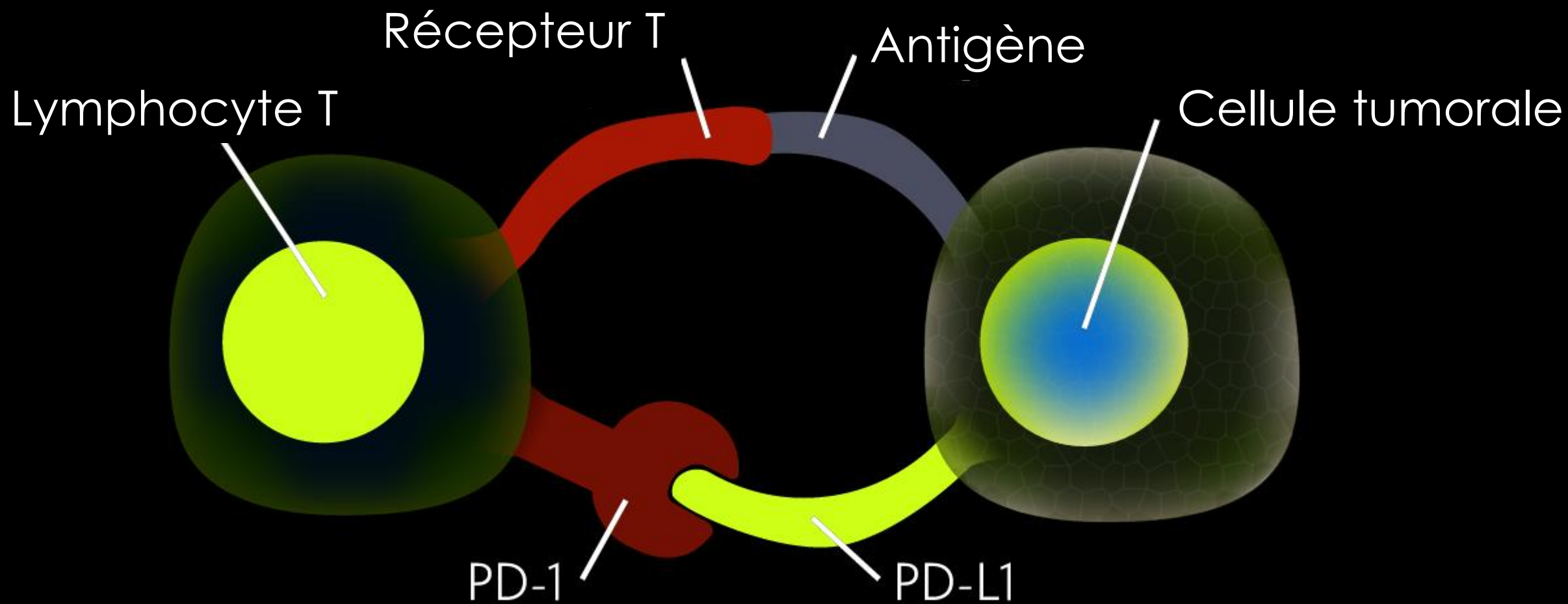
Lymphocyte T « tueur »



Cellule dendritique

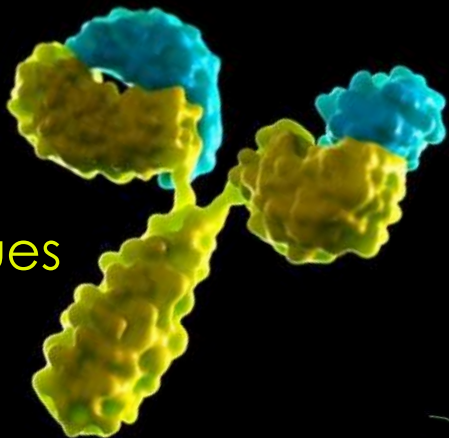


Natural Killer

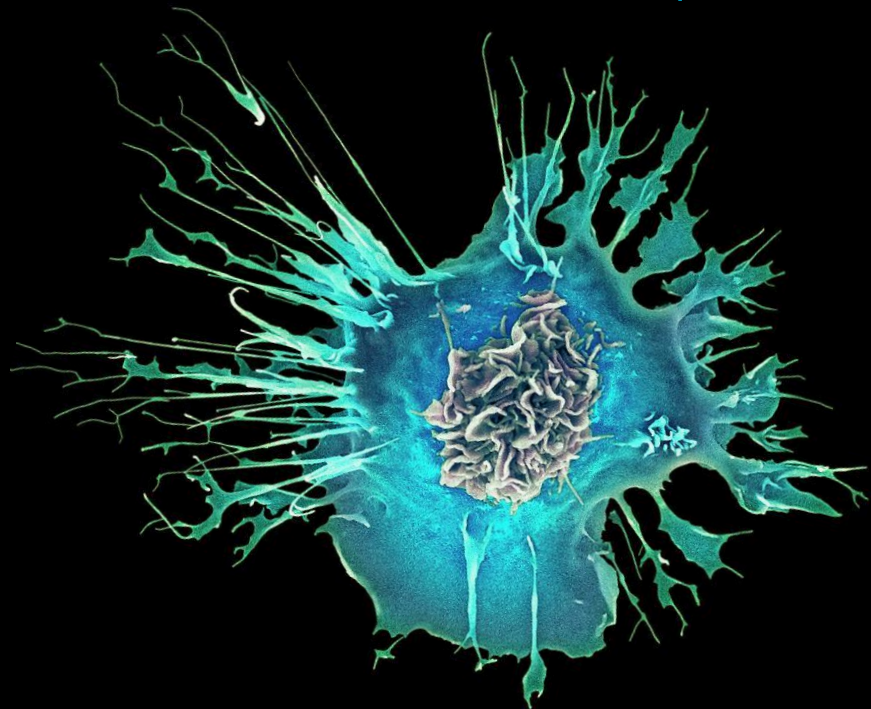


# *L'immunothérapie*

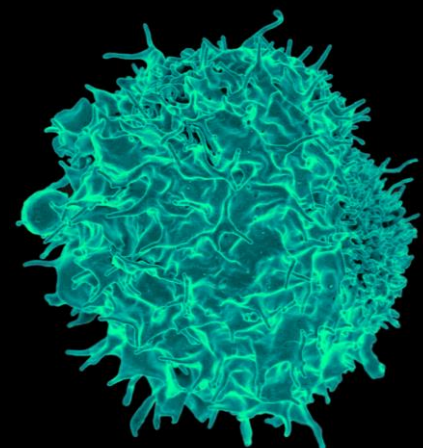
Anticorps  
thérapeutiques



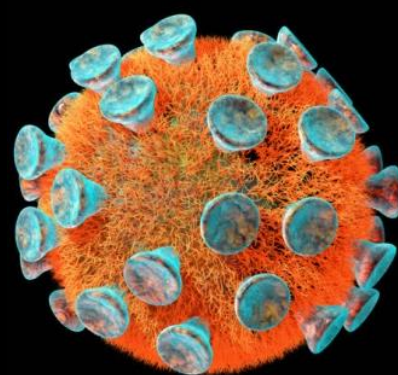
Cellule dendritique



Cellules « CAR T »



Virus oncolytiques



**Tumor**

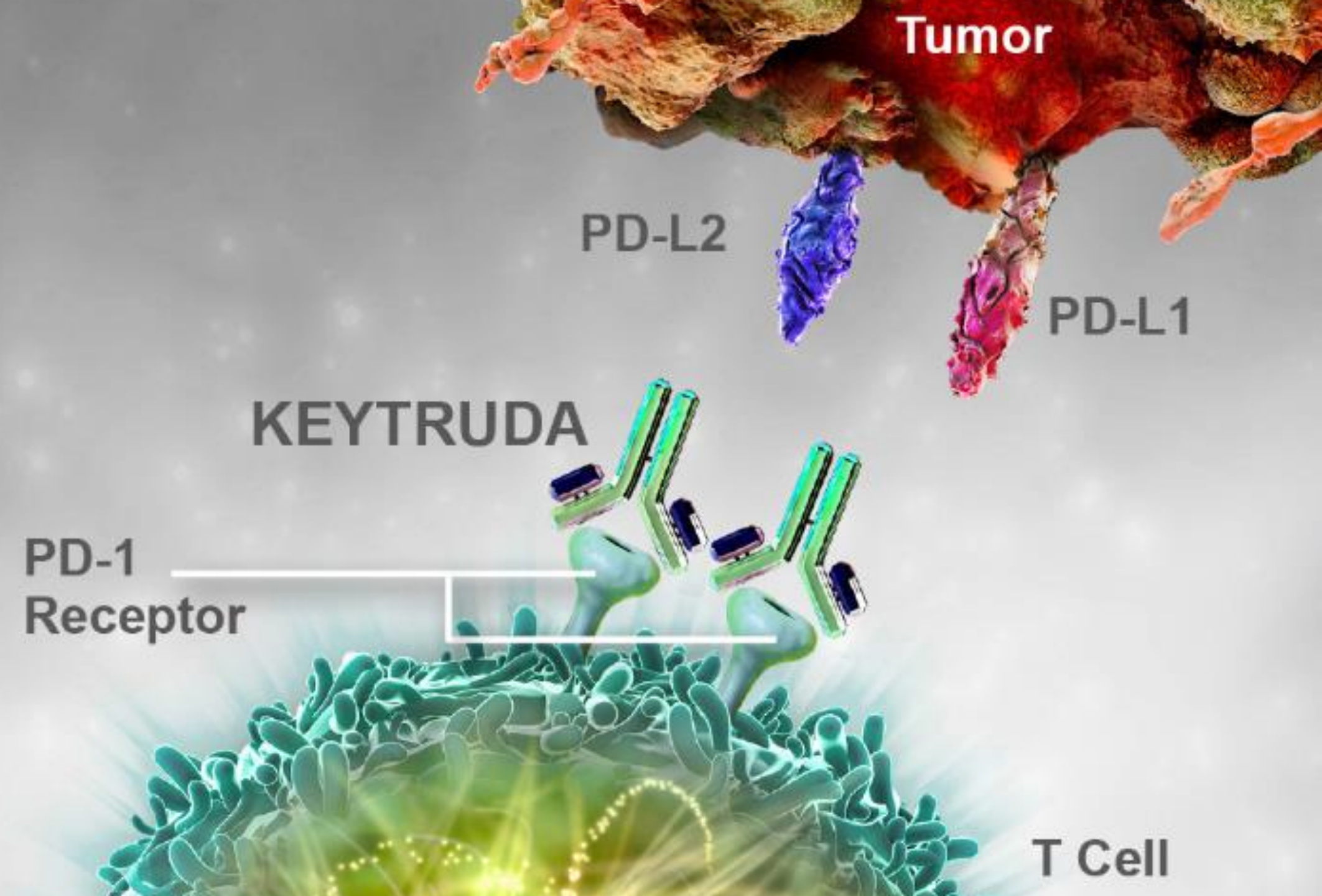
PD-L2

PD-L1

**KEYTRUDA**

PD-1  
Receptor

**T Cell**



*En résumé...*

# Equipe 1



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