Immunoengineering

Instructions:
1. Complete what are the main **functions** for each cell and specifics for **how** each cell acomplishes its functions/interacts with the rest of the immune system
2. You can add the analogy if this is helpful. This is not meant to be stressful, but as a resource for your study guide for the midterm exam later.
3. The Macrophages is filled in for an example of how much detail you should provide
4. When finished save as a pdf and upload with your other problems.
5. If you do not want to fill in the excel sheet, please write each major category with functions in bullet point below.

Adaptive Immune System

A.K.A. Learned or Specific system

Immune Cell	Analogy	Function	How
B cells + Plasma B cells		Produce antibodies	With or without the help of T cells (CD40L on helper T cell bind to CD40 proteins on B cells)
		Identification of antigens	B cells's receptors (BCRs) recognize its cognate antigen
		Proliferation	Activation by T-cells or antigen independent of BCR (mithogen)
		Class switching	B cell can change the class of antibody it produces
		Somatic hypermutation	Genes of the BCR can mutate to increase the affinity of BCR
		Mutation	B cell can become a plasma B cell or a memory B cell
		Regulatory	B cells cam prime CD4+ T cells, or reduce T-cell immune response (Tregs)
CD4+ T cells (helper)	government	B cell activation	Antigen recognised by the surface IgM of the B cell is internalised and rexepressed on the MHC class II molecule of the B cell which, in turn is identified by a T cell. Further interactions happen with the binding of CD40 on B cells with CD40 ligand on T cells
		T cell proliferation	Th1 cells produce Interleukin 2 (IL2). IL2 stimulates CD8+ T cell division and cytoxicity.
		Macrophage activation to kill intracellular pathogens	Interferon ɣ from th1 activates macrophages to kill intracellular pathogens
		Promotes antibody production	Th2 produces IL4, IL5, IL6 and IL13. IL-5, for example, encourages B cells to produce IgA antibodies
		Antigen recognition	CD4+ cells rcognize antigen presented with MHC class II
CD8+ T cells (cytotoxic)		Cytoxic activity	CD8+ T cells recognize antigens presented by class I MHC molecules on the target cell.
		Production of cytokines	Produce variaous cytokiens; such as IFN-gamma and TNF-alpha which can have direct antiviral effects and can activate macrophages or NK cells.
		Memory Formation	CD8+ T cells can develop into memory T cells
		Immune monitoirng	They interact with class I MHC molecules on the surface of APCs and target cells.
		Regulation of Immune response	Through their cytotoxic activity, CD8+ T cells play a role in the magnitude and duration of the immune response

Innate Immune System

A.K.A. Unlearned or Generic system

Immune Cell	Analogy	Function	How
Mac	Sentinels Marines	Recruit other immune cells: macrophages/ neutrophils	When activated secretes cytokines and chemokines
		Function as antigen presenting	Toll-like receptors (TLRs) recognize pathogen patterns (PAMPs) and are activated
		Phagocytosis	Microbes are coated with proteins of the complement system and recognized by specific complement receptors on macrophages
Neutrophils	foot soldier	Phagocytosis	Microbes are coated with proteins of the complement system and recognized by specific complement receptors on neutrophils. Dying neutrophils release neutrophil extracellular traps (NETs) which can trap or kill bacteria, viruses, fungi or parasites.
		Alert immune system cells	They produce different cytokines, chemokines, and other substances to recruit other immune cells, and promote inflammatory process.
		Clearance of cellular debirs	Neutrophils can phagocytose and clear cellular debris, including dead cells.
Dendritic Cells	spies	Collect antigens	Antigenes are loaded on class II MHC molecules at the surface of the DC
		Bridge between innate and adaptive immne responses	DC are imprinted with the special characteristics of an antigen presenting cells (APC) , the DC travels to a lymph node and produce IL-12 to a naive helper T cell which become a helper T cell producing Th1 cytokines
		Co-stimulatory signals	DCS provide co-stimulatory signals through the interaction of surface molecules such as CD80/CD86 (on DCs) with CD28 (on T cells)
		Differentiation of Th0 cells	IL-4 directs the differentiation of Th0 cells into Th2 cell IL-6 and TGF-Beta can induce the differentiation of Th0 into Th17 cells TGF-Beta can also promote the differentiation into Treg
		Migration	DC can influence the localization of the immune response by presenting antigens and activating T cells in specific lymph nodes
		Anigen processing	Once DCs have captured antigens, they break them down into smaller fragments, exposing many facettes of the antigens. The fragments are them presented to T cells with MCH molecules.
Natural Killer Cells	CIA	Destroy virus-infected cells, bacteria, parasites, and fungi	NK cells use perforing proteins to deliver "suicide" enzymes; such as granzyme B, into a target cell. On other cases, Fas ligand on the NK cell surface interacts with a Fas protein on the surface of the target cell.
		Production of cytokines	NK cells produce cytokines, such as IFN-gamma which can activate macrophages, and enhance anitgen presentation
		Cell recognition	NK cells are equipped with inhibitor and activating receptors to allow them to distinguish between healthy cells and cells not expressing low levels of class I MHC molecules
F Den		Display antigen to B cells	Follicular DCs capture opsonized antigens and display these antigens to B cells to be activated. The follicle become a center of B cell proliferation.
		B cell activation	FDCs release factors, such as profiferation-inducing ligand (APRIL) or B-cell activating factor (BAFF) which co-stimulate B cells.
		Formation of germinal centers (GCs)	FDCs play a critical role in the formation and maintenance of GCs where B cells expand, mature and differentaite into plasma cells.

Innate Immune System

A.K.A. Unlearned or Generic system

Other Defense Factors	Analogy	Function	How
Skin & Mucus		Acts a barrier	The skin has tigth epithelial cells which protect naturally against external pathogens and if they enter the body , a sticky mucus captures them and clears them out
		Acts as a sensory organ	Several skin receptors detect touch, pressure, vibrational changes, pain and temperature changes
		Reduces UV radiation	UV rays activate melanin in the skin which absorbs the UV rays
		Helps in detecting infection	Keratinocytes, the predominant cells in the epidermis; express Tool-like receptors (TLRs) which are pattern-recognition receptors (PRRs) triggering an infrlammatory response
		Helps regulate temperatur	Skin particiopates in thermal regulation by conserving or releasing heat
		Prevents loss of moisture	The skin maintains the body's water and homeostatic balance (using tight cell junctions, sebaceous glands, sweat glands, moisturinzing factors)
Complement Proteins		Membrane attack complex	Certain complement proteins (c3b, C5b, C6, C7, C8) can form MAC on the surface of a bacterium that opens up a hole in the surface of the pathogen
		Chemoattractants	Certain complement proteins , such as C3a and C5b stimulate the recruitment of immune cells like macrophages
		Enhancement of adaptive immune system	Complement activation can increase antibody-dependent cellular cytotoxicity (ADCC) and complement dependent cytotoxicity (DCC)
		Clearance of immune complexes	Complement protein assist in the clearnace of antigen-antibody complexes in tissues, apoptotic cells and cellular debris by opsonizing them
		Stimulation of B cells	Complement activation via CR1/2/CD19/TAPA-1 can participate to the costimulation of B cells enhancing clonal expansion and germinal center formation
Toll-like Receptors		Recognition of class of invaders	TLRs are pattern-recognition receptors designed to recognize microbial attacks; among them TLR4 is used by macropages to sense the presence of lipopolysaccharide (LPS); TLR7 detects single-stranded RNA of viruses whereas TLR9 recognized double-stranded DNA of bacteria and simple viruses
		Activation of immune responses	TLRs initiate a signaling cascade that leads to the activation of immune responses.
		Enhanced antige-presentation	The recognition of invading microbes by TLRS enhance antigen presentation to naïve T cells.
		Cytokine production	TLR signaling can induce the production of cytokines such as IL-12 and TNF-alpha in DCs; recruiting immune cells to the site of infection and activate them
Antibodies	missiles	Neutralisation	IgM antibodies can neutralize viruses by binding to them preventing them from infecting cells.
		Antibody-dependent cellular cytotoxicity (ADCC)	Antibodies recognize specific antigens (IgG antibodies). The Fc region of the bound antibodies interact with Fc receptors on the surface of the NK cells. This activation primes the NL cells for cytotoxic activity.
		Complement-mediated lysis of pathogens or infected cells	Complement mediated can cause the lysis of bacterial cells through the formation of a menbrane attack Complex (MAC) which makes holes in the targeted cell, causing its deaths.
Lymph Nodes/ Spleen		Immune monitoring	Filtering of foreign substances and pathogens: T and B cells, and antigen-presenting cells (APCs) are present within lymph nodes to detect antigens
		Production of memory cells	Memory T or B cells are generated within lymph nodes
		Activation of B or T cells	These lymphocytes can become activated in lymph nodes
		Immune response coordination	Lymph nodes are hubs where various immune cells communicate and coordinate to build the immune response
Lymphatic system/ Circulation		Drainig the lymph from the tissues	The lymphatic system drains the lymph from the body tissues and returns it to the blood system preventing tissue swelling
		Transport of immune cells	Dendrictic cells leave the tissues and travel through the lymphatic system to the nearest lymph node to activate naïve T cells. Lymphatic vessels transport immune cells and APCs between lymph nodes and tissues.