2027 Anatomy & Physiology (B & C)

Disclaimer

- This presentation was prepared using draft rules.
- There may be some changes in the final copy of the rules.
- Final copies of the rules will be released at soinc.org.
- These rules will be the official rules for the 2027 Season.

Event Rules – 2027

BE SURE TO CHECK THE 2027 EVENT RULES FOR EVENT PARAMETERS AND TOPICS FOR EACH COMPETITION LEVEL

ROTATION SCHEME

Year 1	Skeletal	Muscular	Integumentary	(2025)
Year 2	Nervous	Sense Organs	Endocrine	(2026)
Year 3	Respiratory	Digestive	Immune	(2027)
Year 4	Cardiovascular	Lymphatic	Excretory	(2028)

ANATOMY & PHYSIOLOGY

Event Content*: *2027 – YEAR 3 OF 4 YR ROTATION

- **BASIC ANATOMY AND PHYSIOLOGY**
  - ❖ Respiratory System
  - ❖ Digestive Organs
  - ❖ Immune System
  - ❖ Major disorders
  - ❖ Treatment and prevention of disorders
- **PROCESS SKILLS -** observations, inferences, predictions, calculations, data analysis, and conclusions.

TRAINING MATERIALS

Training Power Point – content overview

Training Handouts – General and 3 Systems

Sample Tournament – sample problems with key

Event Supervisor Guide – prep tips, event needs, and scoring tips

Internet Resource & Training PDF's – on the Science Olympiad website at www.soinc.org under Event Information

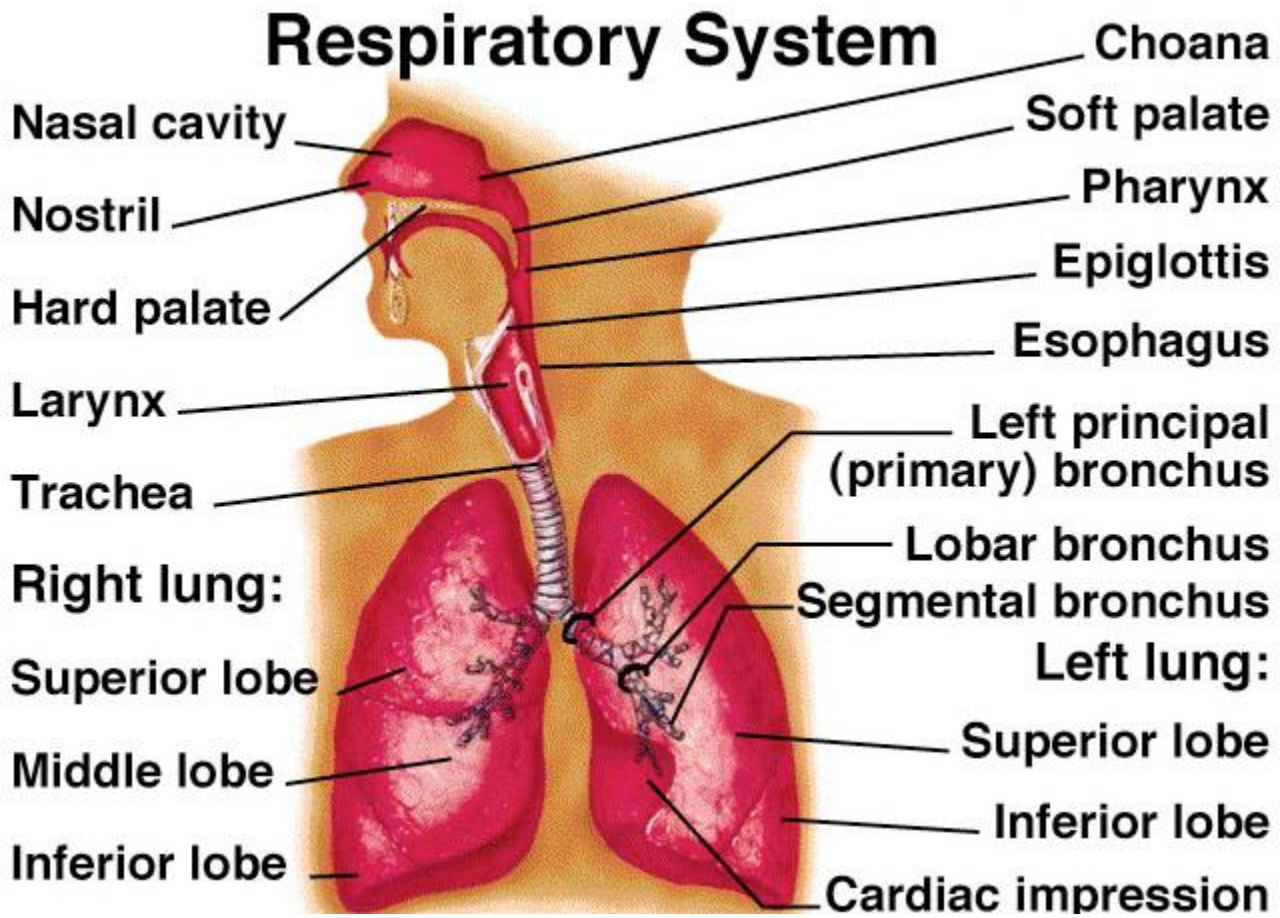
RESPIRATORY SYSTEM

Respiratory System – Functions

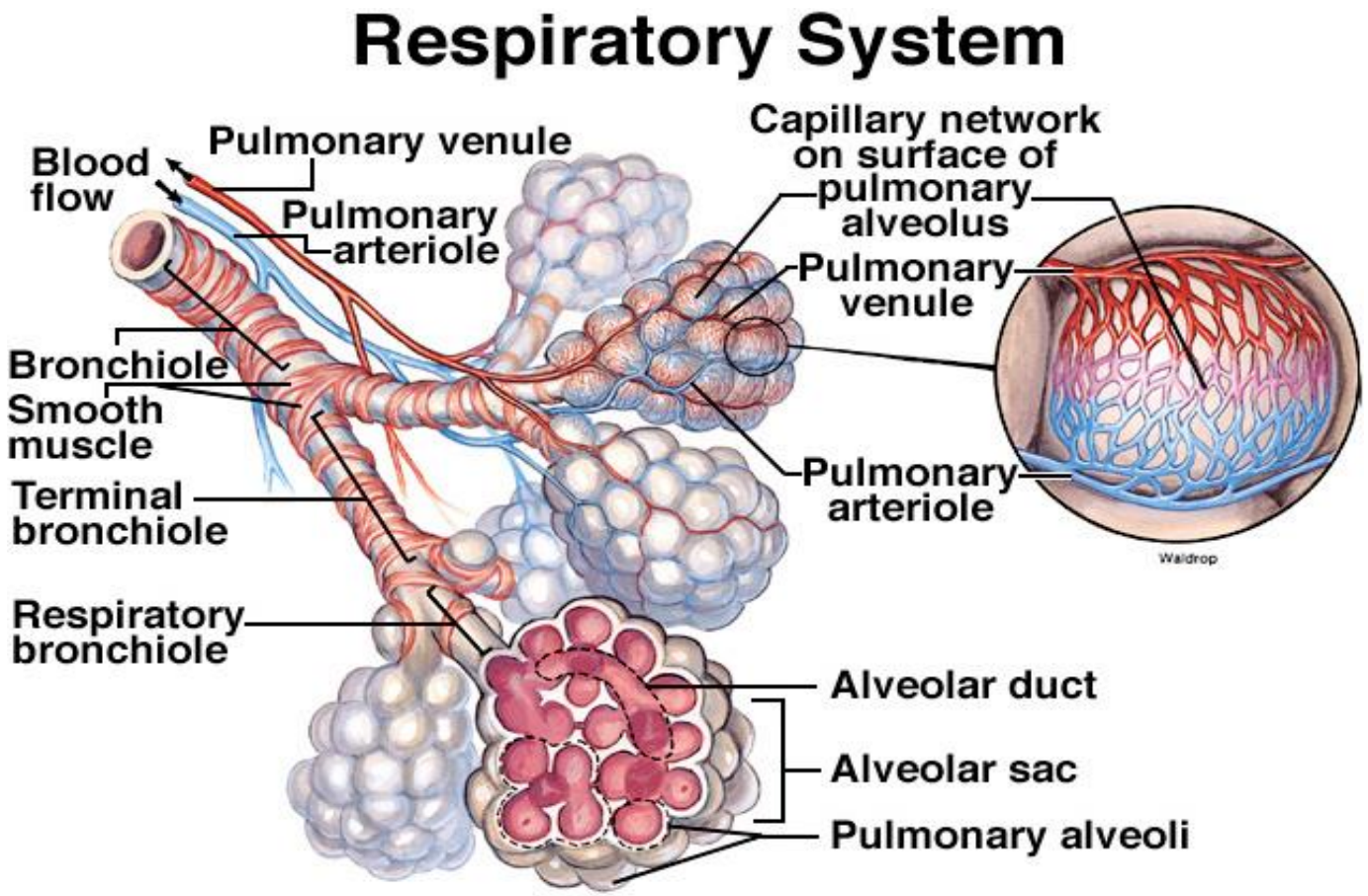
Basic functions of the respiratory system are:

1. provides oxygen to the blood stream and removes carbon dioxide
2. enables sound production or vocalization as expired air passes over the vocal chords
3. enables protective and reflexive non-breathing air movements such as coughing and sneezing, to keep the air passages clear
4. control of Acid-Base balance
5. control of blood pH

Respiratory System - Principal Organs



Respiratory System – Lungs



Non-respiratory Air Movements

Table 17.5 Nonrespiratory Air Movements

Air Movement	Mechanism	Comments
Coughing	Deep inspiration followed by a closure of of the glottis. The forceful expiration that results abruptly opens the glottis, sending a blast of air through the upper respiratory tract.	Reflexive or voluntary. Stimulus may be foreign material irritating the larynx or trachea.
Sneezing	Similar to a cough, except that the forceful expired air is directed primarily through the nasal cavity. The eyelids close reflexively during a sneeze.	Reflexive response to irritating stimulus of the nasal mucosa. Sneezing clears the upper respiratory passages.
Sighing	Deep, prolonged inspiration followed by a rapid, forceful expiration.	Reflexive or voluntary, usually in response to boredom or sadness.
Yawning	Deep inspiration through a widely opened mouth. The inspired air is usually held for a short period before sudden expiration.	Usually reflexive in response to drowsiness, fatigue, or boredom, but exact stimulus-receptor cause is unknown.
Laughing	Deep inspiration followed by a rapid convulsive expiration. Air movements are accompanied by expressive facial distortions.	Reflexive; may be voluntary to express emotions.
Crying	Similar to laughing, but the glottis remains open during entire expiration and different facial muscles are involved.	Somewhat reflexive but under voluntary control.
Hiccuping	Spasmodic contraction of the diaphragm while the glottis is closed, producing a sharp inspiratory sound.	Reflexive; serves no known function.

Respiration Process

A collective term for the following processes:

Pulmonary Ventilation

- Movement of air into the lungs (inspiration)
- Movement of air out of the lungs (expiration)

External Respiration

- Movement of oxygen from the lungs to the blood
- Movement of carbon dioxide from the blood to the lungs

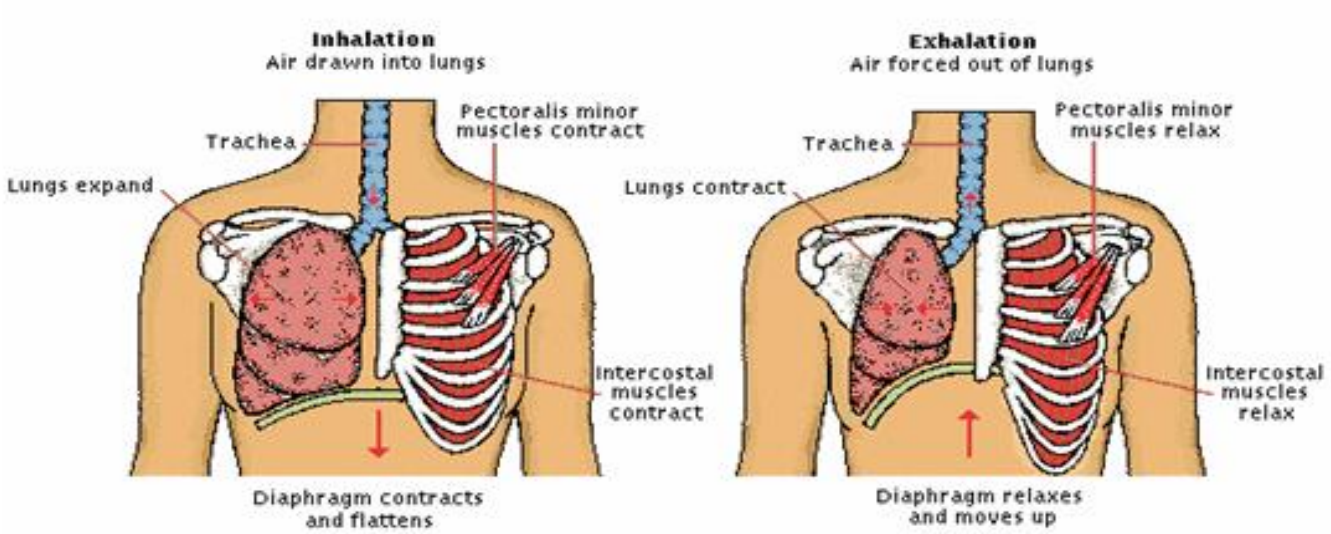
Transport of Respiratory Gases

- Transport of oxygen from the lungs to the tissues
- Transport of carbon dioxide from the tissues to the lungs

Internal Respiration

- Movement of oxygen from blood to the tissue cells
- Movement of carbon dioxide from tissue cells to blood

Pulmonary Ventilation



The intercostal muscles and the diaphragm work together

Inspiration, or inhalation – a very active process that requires input of energy
Air flows into the lungs when the thoracic pressure falls below atmospheric pressure. The diaphragm moves downward and flattens while the intercostal muscles contract.

Expiration, or exhalation – a passive process that takes advantage of the recoil properties of elastic fibers Air is forced out of the lungs when the thoracic pressure rises above atmospheric pressure. The diaphragm and expiratory muscles relax.

Patterns of Breathing

Apnea – temporary cessation of breathing (one or more skipped breaths)

Dyspnea – labored, gasping breathing; shortness of breath

Eupnea – normal, relaxed, quiet breathing

Hyperpnea – increased rate and depth of breathing in response to exercise, pain, or other conditions

Hyperventilation – increased pulmonary ventilation in excess of metabolic demand

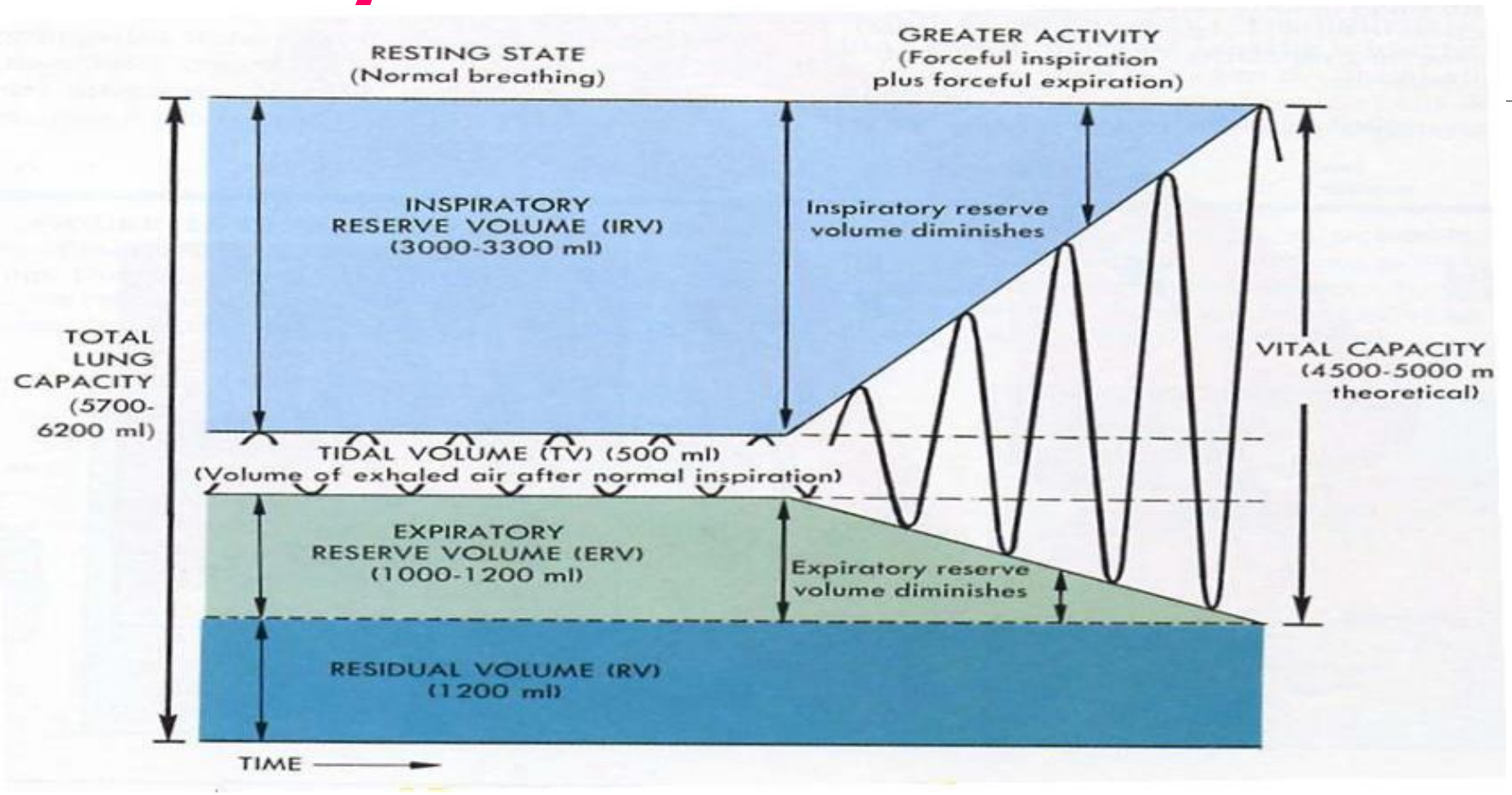
Hypoventilation – reduced pulmonary ventilation

Orthopnea – Dyspnea that occurs when a person is lying down

Respiratory arrest – permanent cessation of breathing

Tachypnea – accelerated respiration

Pulmonary Ventilation - Volumes



Measures of Pulmonary Ventilation

Respiratory volumes – values determined by using a spirometer

- **Tidal Volume (TV)** – amount of air inhaled or exhaled with each breath under resting conditions
- **Inspiratory Reserve Volume (IRV)** – amount of air that can be inhaled during forced breathing in addition to resting tidal volume
- **Expiratory Reserve Volume (ERV)** – amount of air that can be exhaled during forced breathing in addition to tidal volume
- **Residual Volume (RV)** – Amount of air remaining in the lungs after a forced exhalation.

Formulas – Capacities

Vital Capacity – maximum amount of air that can be expired after taking the deepest breath possible (**VC = TV + IRV + ERV**)

Inspiratory Capacity – maximum volume of air that can be inhaled following exhalation of resting tidal volume (**IC = TV + IRV**)

Functional Residual Capacity – volume of air remaining in the lungs following exhalation of resting volume (**FRC = ERV + RV**)

Total Lung Capacity – total volume of air that the lungs can hold (**TLC = VC + RV**)

Control of Respiratory System

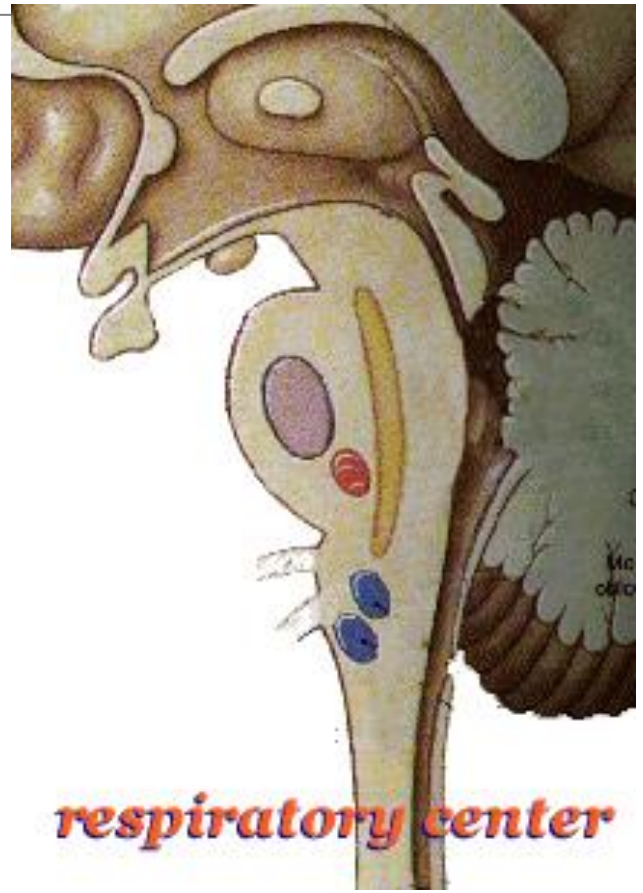
Respiratory control centers – found in the pons and the medulla oblongata

Control breathing

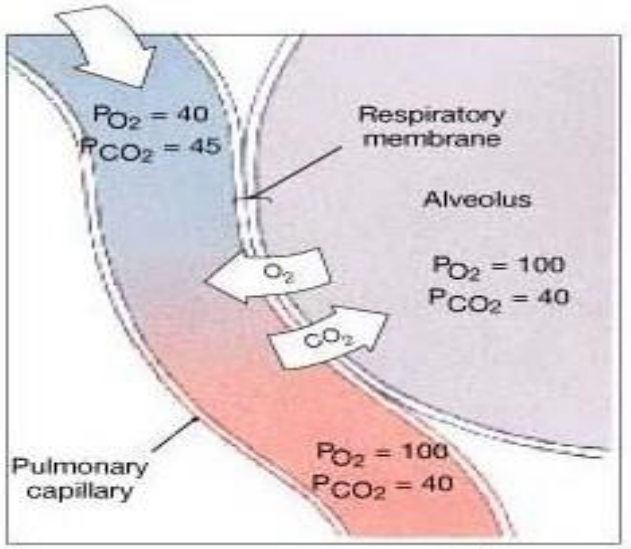
Adjusts the rate and depth of breathing according to oxygen and carbon dioxide levels

Afferent connections to the brainstem

Hypothalmus and limbic system send signals to respiratory control centers



Gas Exchange and Transport

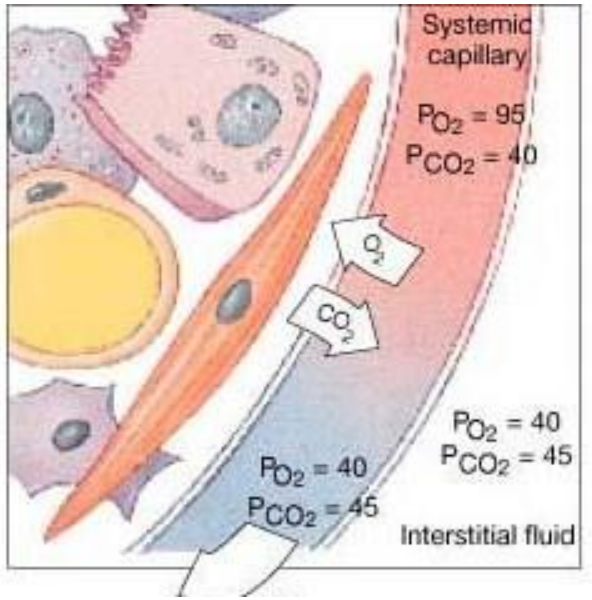


- **Alveolar Gas Exchange** – the loading of oxygen and the unloading of carbon dioxide in the lungs
- **Oxygen is carried** in the blood bound to hemoglobin (98.5%) and dissolved in plasma (1.5%)

Carbon dioxide is transported in three forms

- **Carbonic acid** – 90% of carbon dioxide reacts with water to form **carbonic acid**
- **Carboamino compounds** – 5% binds to plasma proteins and hemoglobin
- **Dissolved gas** – 5% carried in the blood as dissolved gas

Systemic Gas Exchange



Carbon dioxide loading -The Haldane Effect – the lower the partial pressure of oxygen and saturation of it in hemoglobin, the more carbon dioxide can be carried in the blood

Oxygen unloading from hemoglobin molecules

Blood Chemistry & Respiratory Rhythm

Hydrogen ion concentrations -strongly influence respiration

Carbon dioxide concentrations - strongly influence respiration

Oxygen concentrations - have little effect on respiration

Effects of Exercise on Respiratory System

During exercise

The muscle cells use up more oxygen and produce increased amounts of carbon dioxide.

The lungs and heart have to work harder to supply the extra oxygen and remove the carbon dioxide.

Your breathing rate increases and you breathe more deeply. Heart rate also increases in order to transport the oxygenated blood to the muscles.

Muscle cell respiration increases - more oxygen is used up and levels of carbon dioxide rise.

The brain detects increasing levels of carbon dioxide - a signal is sent to the lungs to increase breathing.

Breathing rate and the volume of air in each breath increase - This means that more gaseous exchange takes place.

The brain also tells the heart to beat faster so that more blood is pumped to the lungs for gaseous exchange.

More oxygenated blood is gets to the muscles and more carbon dioxide is removed.

Disorders of the Respiratory System

Chronic obstructive pulmonary diseases – long-term obstruction of airflow and a substantial reduction in pulmonary ventilation

- **Chronic bronchitis** – cilia are immobilized and reduced in number; goblet cells increase their production of mucus → mucus clogs the airways and breeds infection
- **Emphysema** – alveolar walls break down and the surface area of the lungs is reduced
- **Asthma** – allergens trigger the release of histamine and other inflammatory chemicals that cause intense bronchoconstriction

Lung Cancer – cancer of the lung

Pneumonia – lower respiratory infection that causes fluid build up in the lungs

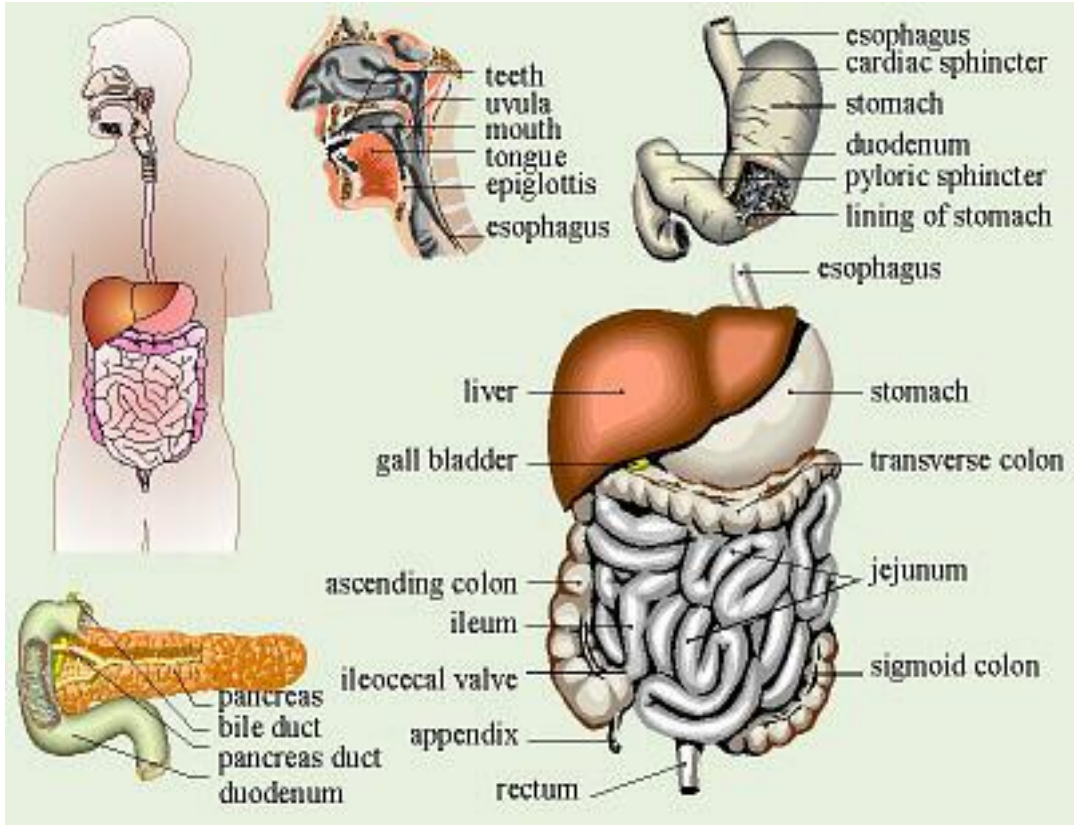
Sleep Apnea – Cessation of breathing for 10 seconds or longer during sleep

Tuberculosis – pulmonary infection with Mycobacterium tuberculosis; reduces lung compliance

DIGESTIVE SYSTEM

DIGESTIVE SYSTEM – digest foods

extracellular (outside of cell) in digestive canal



BASIC PROCESSES OF THE DIGESTIVE SYSTEM

INGESTION -- intake of food

DIGESTION – breakdown of food

- **Mechanical Digestion** – physical breakdown
- **Chemical Digestion** – chemical breakdown of macromolecules to monomers

Absorption -- Transport of the products of digestion into the blood

Defecation -- Elimination of undigested waste

ORGANS OF DIGESTIVE TRACT (mouth to anus)

Mouth - Chewing, Digestion begins

Pharynx - Swallowing

Esophagus - Transports food to stomach

Stomach - Storage of food, Digestion of protein

Small Intestine - Majority of digestion and absorption of food

Large Intestines - Absorption of water, Waste storage

Anus - Elimination of waste

ASCESSORY ORGANS

SECRETE FLUIDS INTO DIGESTIVE TRACT

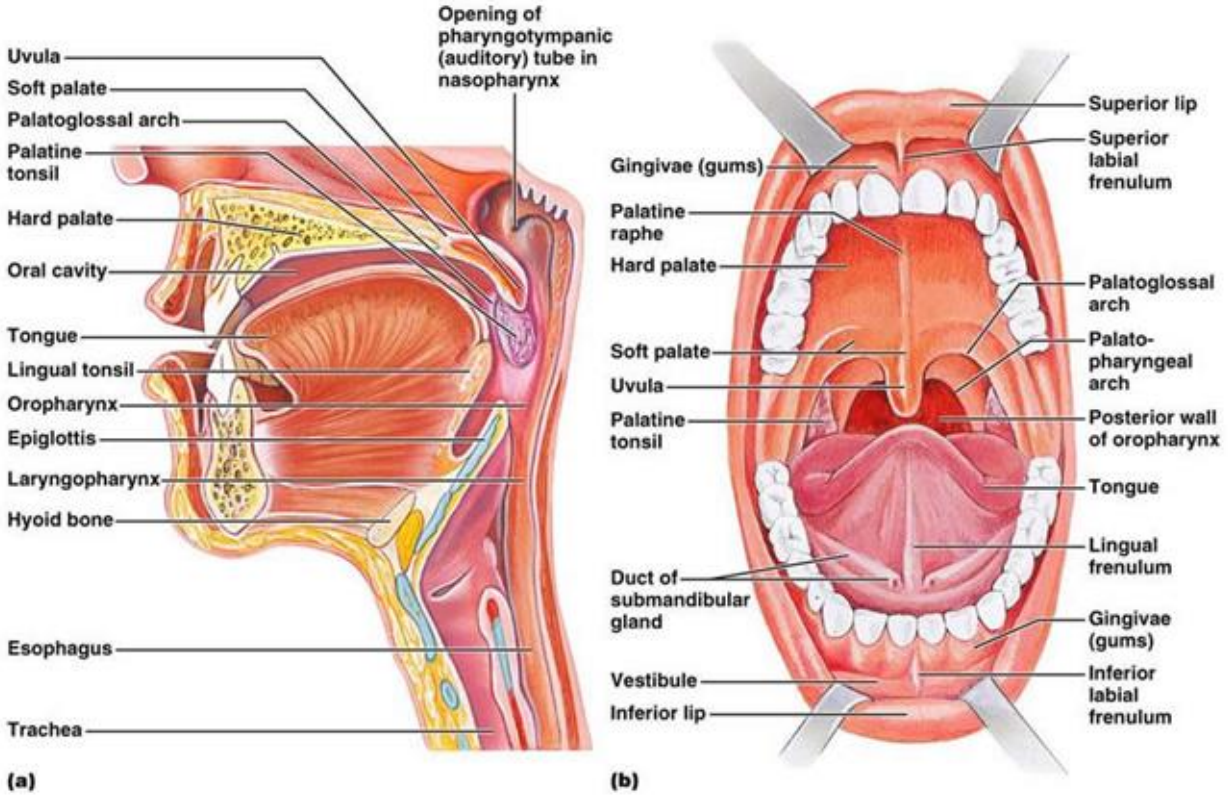
Salivary Glands - Secrete salivary amylase

Liver - Produces bile

Gallbladder - Storage of bile

Pancreas - Secretes pancreatic amylase and other digestive enzymes

MOUTH



Opens to outside to facilitate feeding

Aids in preparation of food for digestion

Foods are broken down mechanically by chewing

Saliva is added as a lubricant from the auxiliary saliva glands

Saliva contains amylase, an enzyme that digests starch

Serves as an organ for speech and pleasure

Includes cheeks, lips, tongue, palate, teeth – primary & secondary

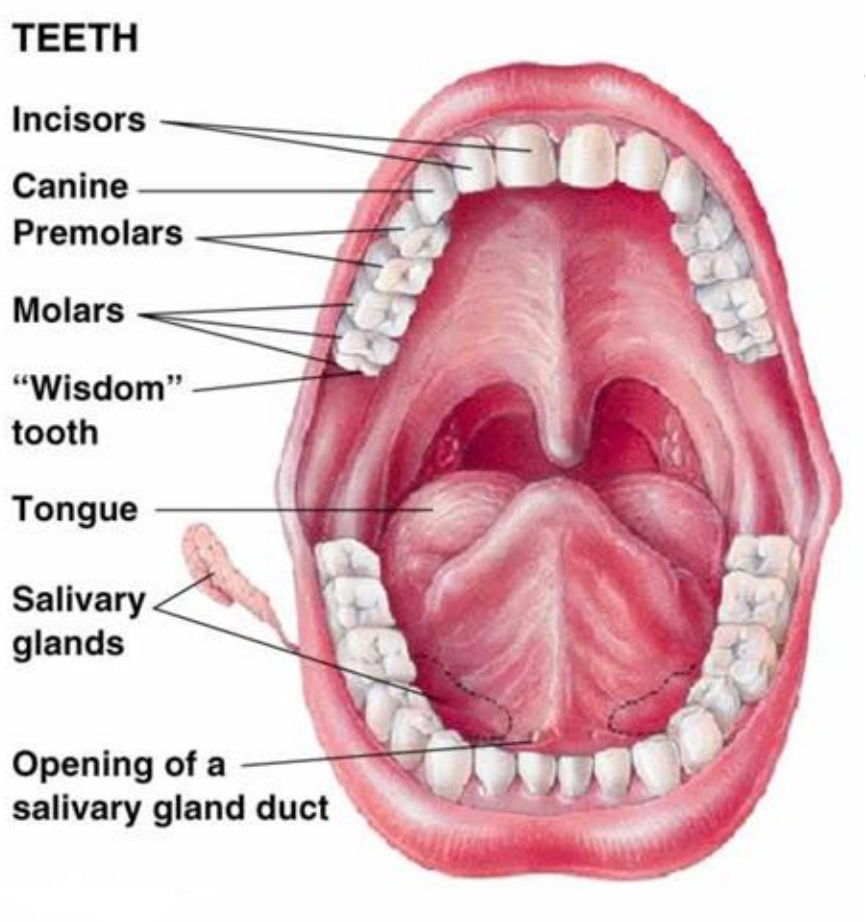
TEETH

Incisors (8) – for biting food

Canines (4) - for grasping and tearing food

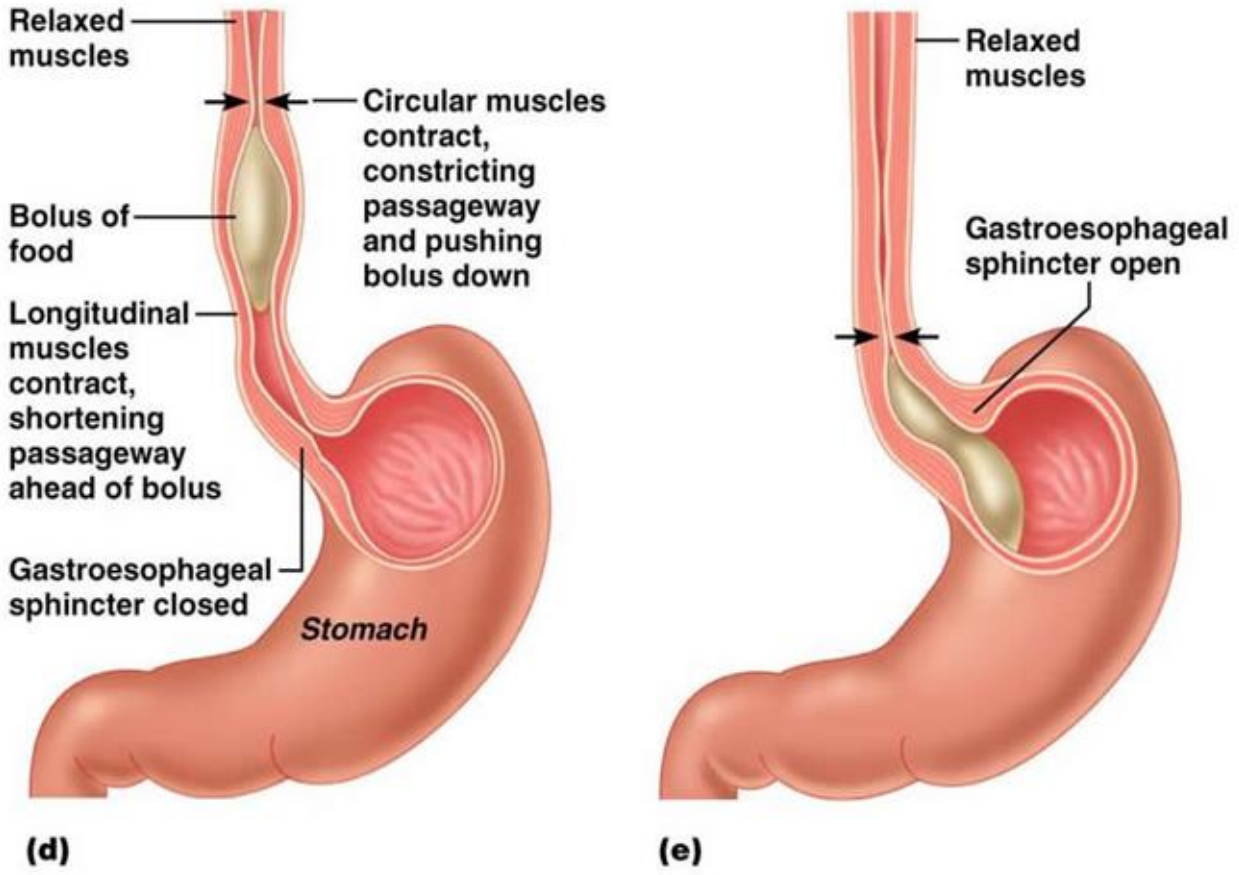
Bicuspids (8) – for grinding and crushing food

Molars (12) – for grinding food

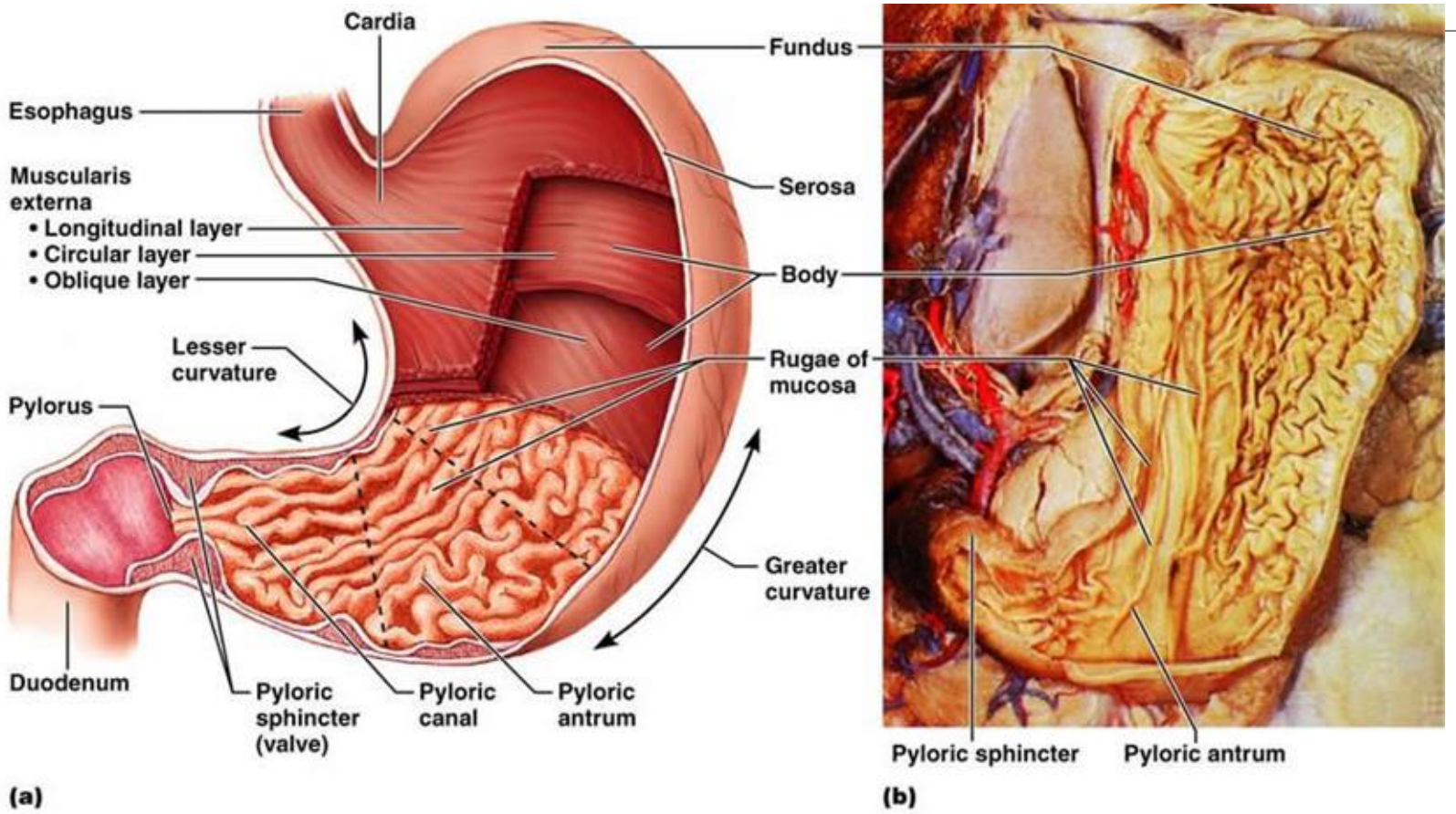


ESOPHAGUS

a simple tube between the mouth and stomach – peristalsis aides in swallowing



STOMACH


Cardia
Fundus
Esophagus
Serosa
Muscularis externa
• Longitudinal layer
• Circular layer
• Oblique layer
Body
Lesser curvature
Rugae of mucosa
Pylorus
Greater curvature
Duodenum
Pyloric sphincter (valve)
Pyloric canal
Pyloric antrum
(a)
Pyloric sphincter
Pyloric antrum
(b)

STOMACH

Enzyme digestion of proteins initiated

Foods reduced to a liquid form

Walls lined with millions of gastric glands

Several kinds of cells in gastric glands

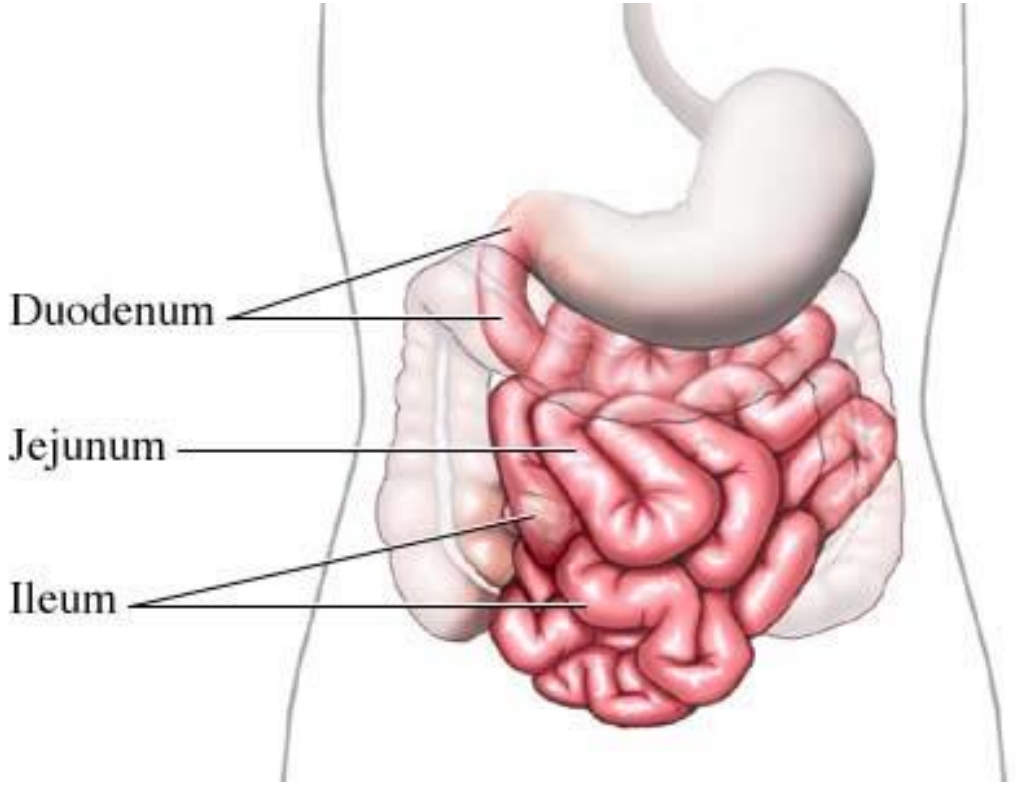
Very little absorption from stomach – some water, ethanol, drugs as aspirin, and certain ions

SMALL INTESTINE

most of chemical enzymatic digestion occur

almost all nutrients are absorbed

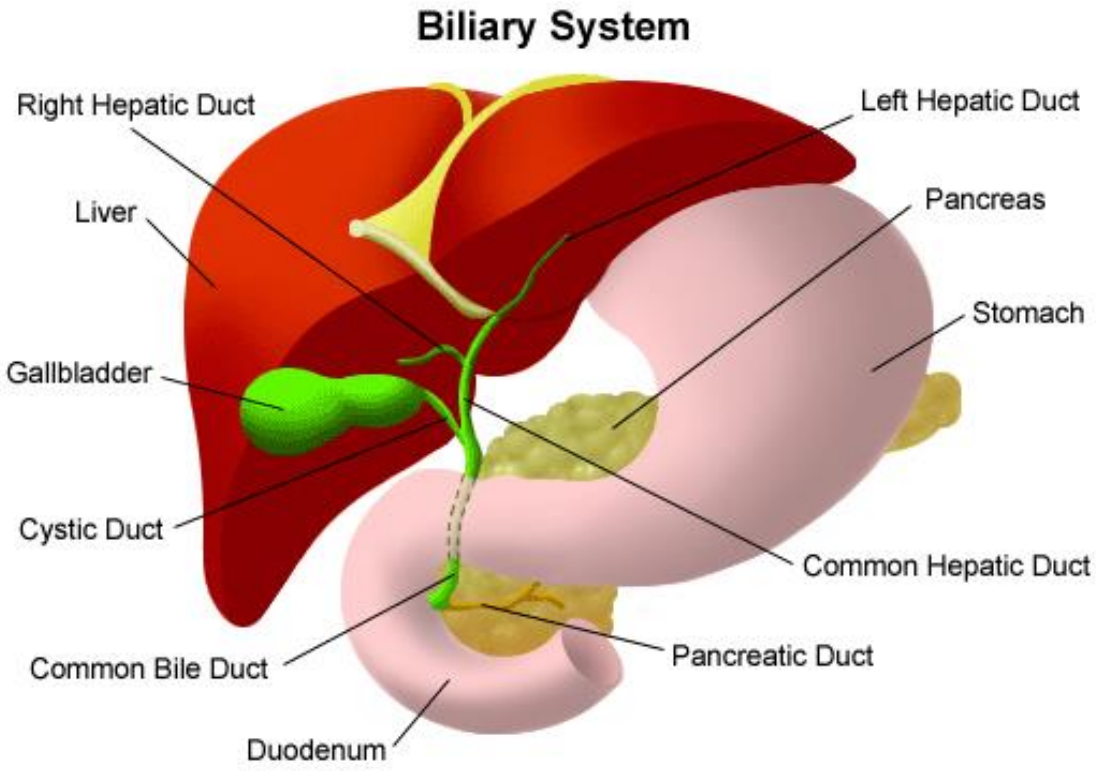
Accessory glands – liver, gall bladder, and pancreas provide secretions to assist with chemical enzymatic digestion



LIVER and GALL BLADDER

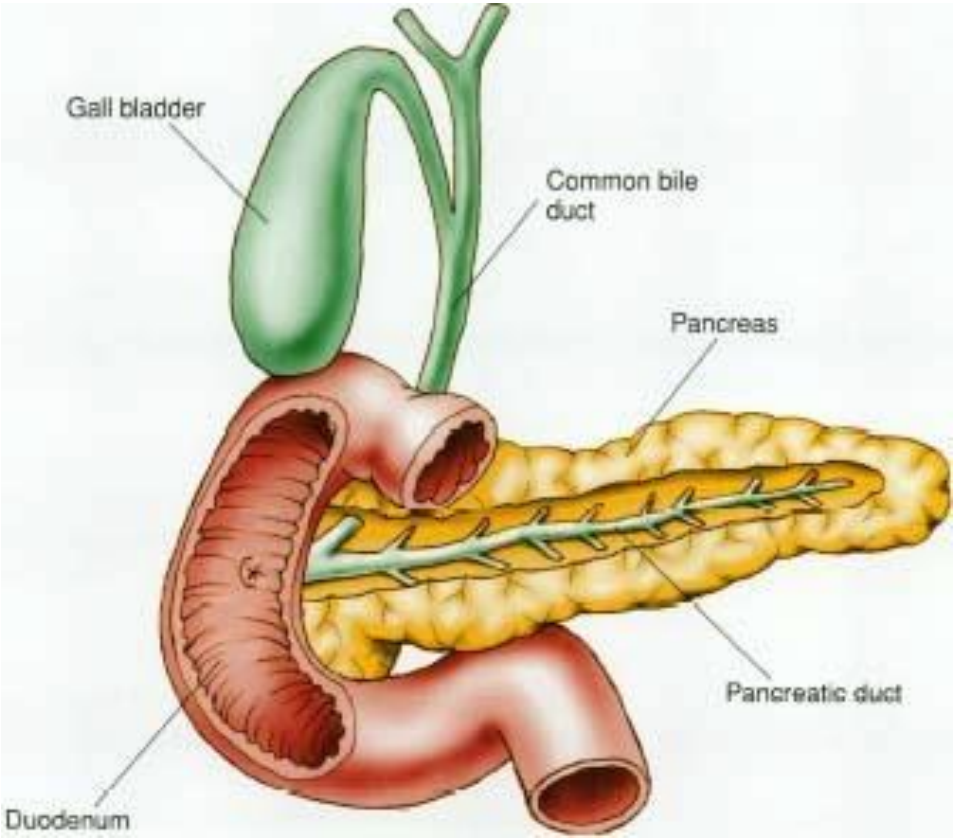
Liver: - provides bile salts to the small intestine, which are critical for digestion and absorption of fats.

Gallbladder – stores bile



PANCREAS

Pancreas: - provides digestive enzymes to the small intestine which are critical for digestion of fats, carbohydrates and protein.



LARGE INTESTINES

Colon:

liquid residue – mainly water with undigested materal

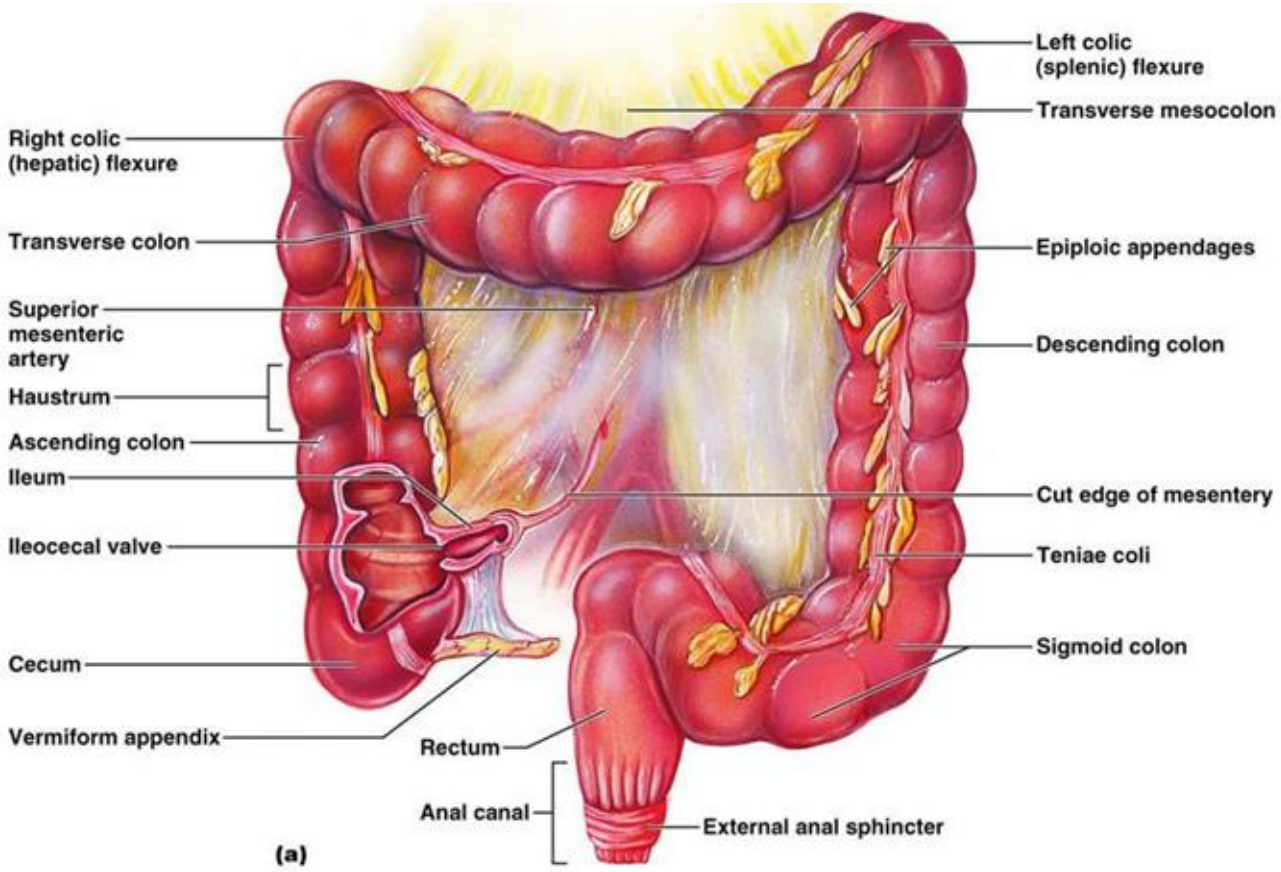
water is absorbed,

bacterial fermentation takes place

feces are formed.

Rectum: collects undigested waste

Anus: expels undigested waste – muscles to control exit and prevent leakage.



DIGESTIVE PROCESS

Ingestion – intake of food

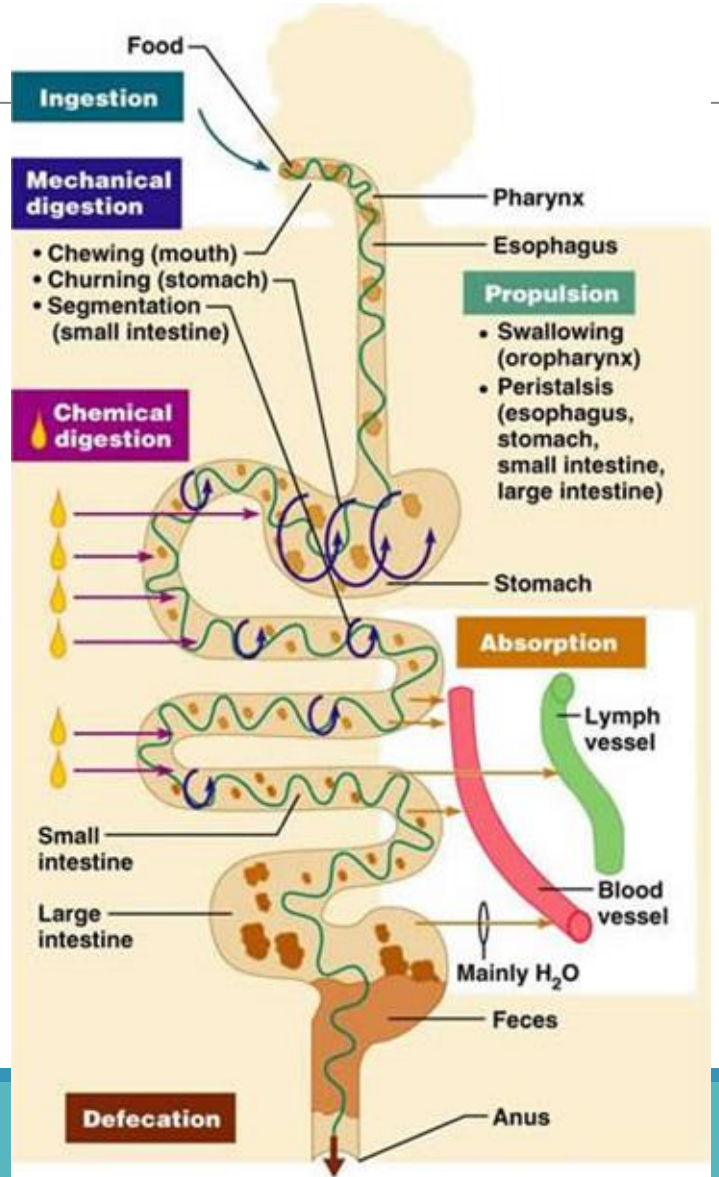
Digestion – breakdown of food bit by bit into molecules small enough to be absorbed

Mechanical Digestion – physical breakdown of food

Chemical Digestion – chemical breakdown of macromolecules to monomers

Absorption – transport of productions into the blood

Elimination (Defecation) - elimination of undigested waste



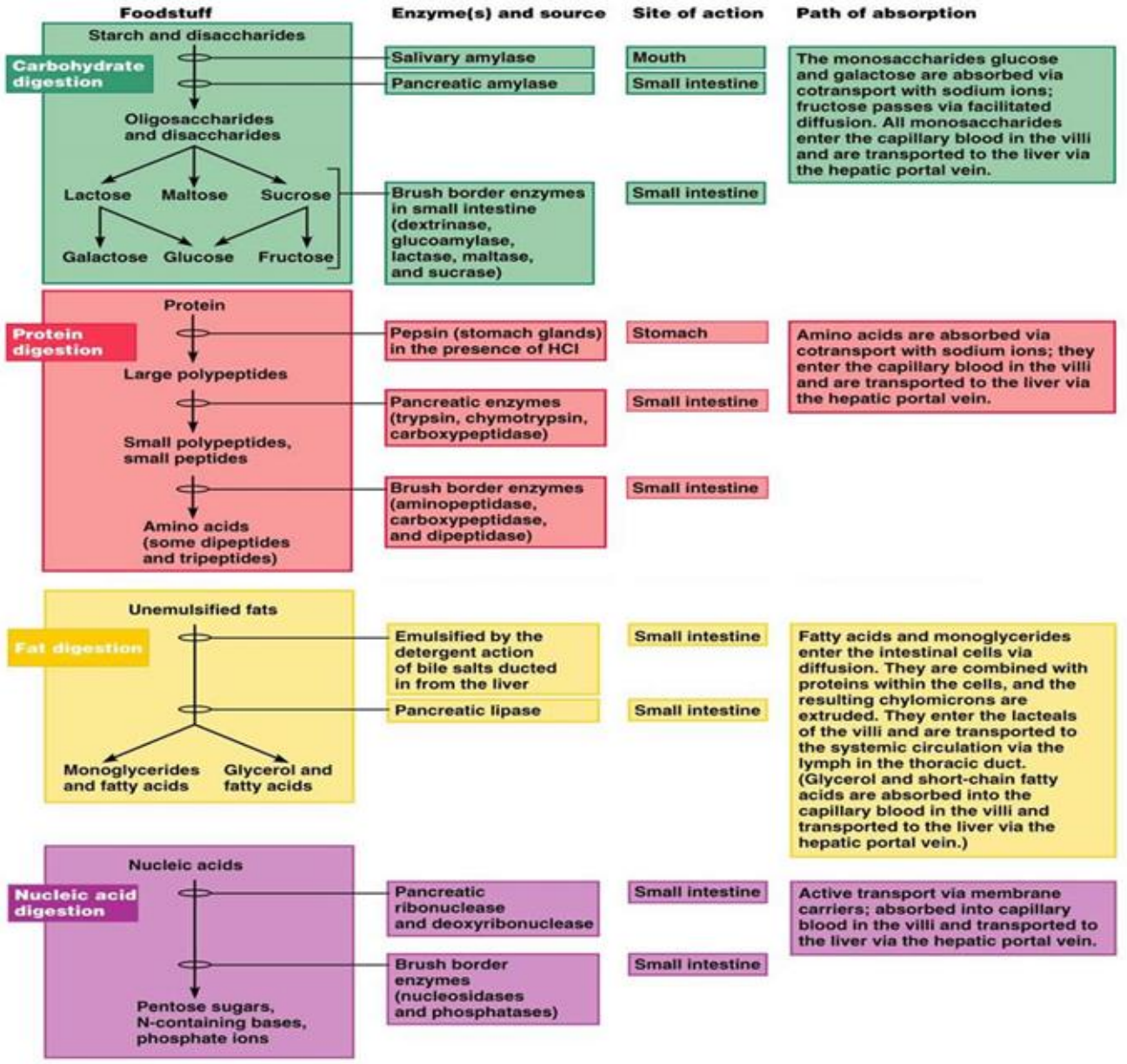
CHEMICAL DIGESTION

CARBOHYDRATES

PROTEIN

FATS

NUCLEIC ACIDS



Disorders of the Digestive System

- Peptic ulcer disease
- Lactose Intolerance
- Appendicitis
- Crohn’s Disease
- GERD
- Diverticular Disease
- Celiac Disease

Role of Fiber in Digestion

Fiber is found mostly in plant

There are two types **– insoluble fiber and soluble fiber**

Insoluble fiber is a type of fiber which cannot be dissolved in water

Insoluble fiber draws water to the intestine, increasing the bulk and softness of waste products

Soluble fiber which can be dissolved in water

Soluble fiber can be digested slowly and it slows the digestive process and keeps the stomach fuller longer leaving the body feeling full for a longer period of time

Digestion and absorption of carbohydrates are slower so that glucose (sugar) in food enters the bloodstream more slowly, which keeps blood sugar on a more even level

The slow absorption of sugar gives the body an opportunity to regulate blood sugar levels

New Food Group Pyramid

2000 calorie diet

Grains – 6 oz daily

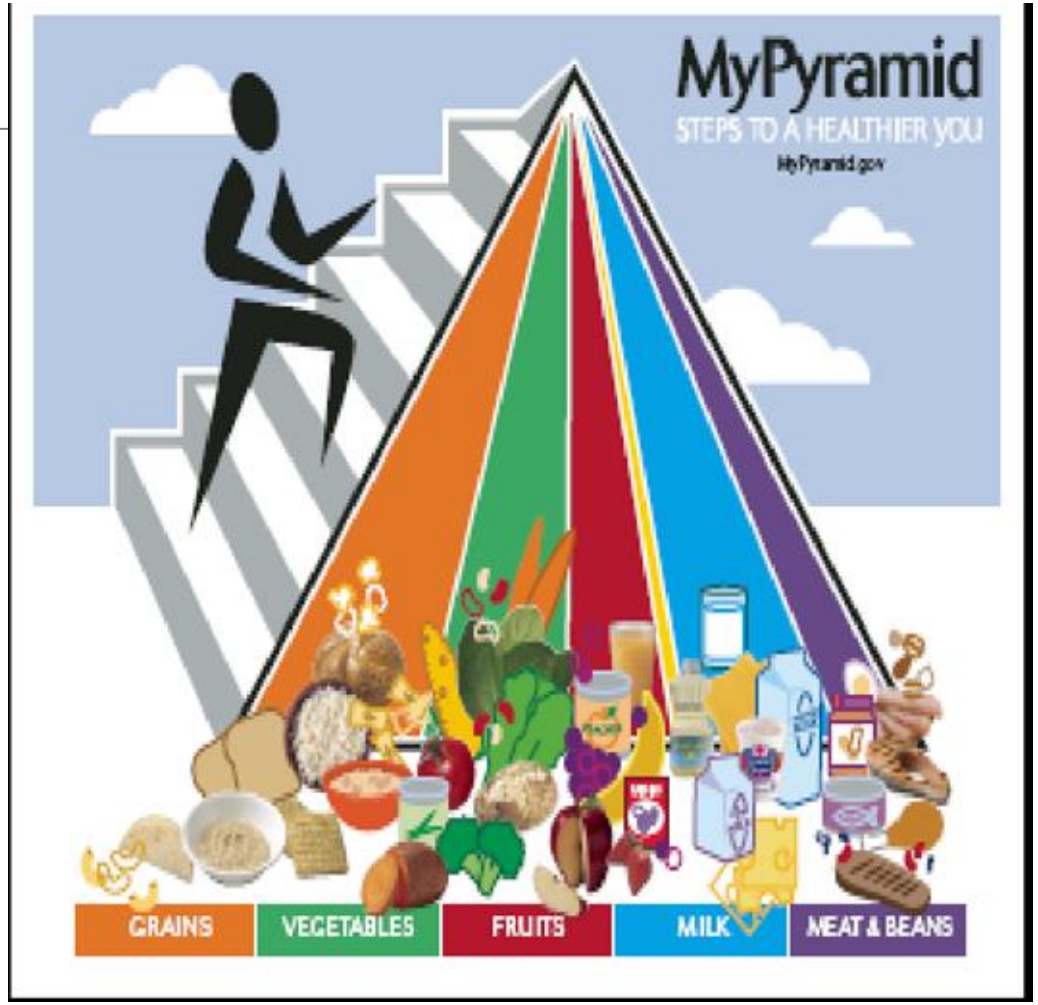
Vegetables – 2 ½ cups daily

Fruits – 2 cups daily

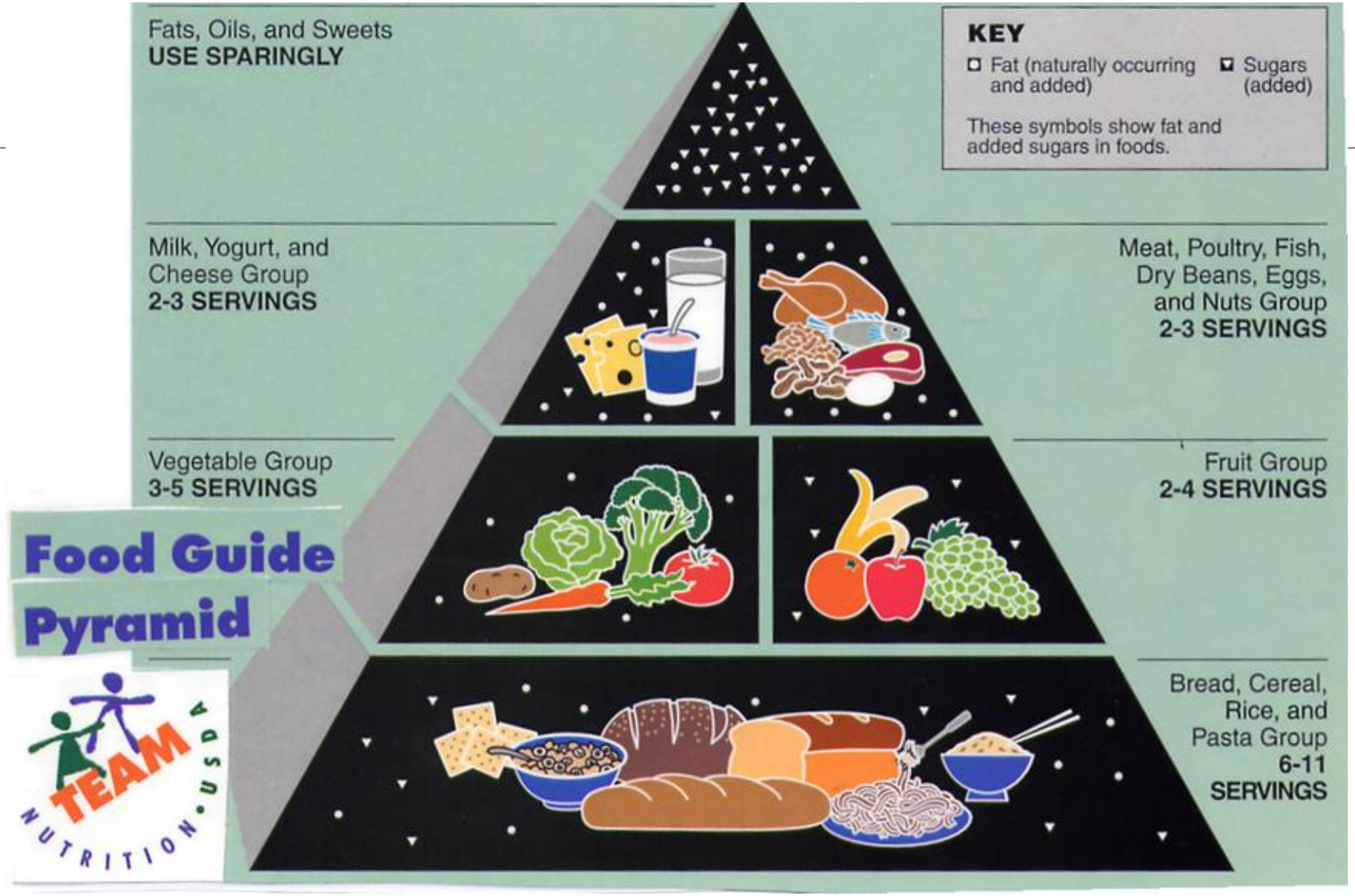
Milk – 3 cups daily

Meats and Beans –

5 ½ oz daily



Old Food Group Pyramid



Food Labels

Serving Size

Serving per container

Calories

Nutrients – g and % Daily values

Vitamins and Minerals-

% Daily Values

2000 calorie diet

Sample label for
Macaroni & Cheese

Nutrition Facts

Serving Size 1 cup (228g)
Serving Per Container 2

Amount Per Serving

Calories 250 Calories from Fat 110

% Daily Value*

Total Fat 12g	**18%**
Saturated Fat 3g	**15%**
Cholesterol 30mg	**10%**
Sodium 470mg	**20%**
Total Carbohydrate 31g	**10%**
Dietary Fiber 0g	**0%**
Sugars 5g	
Protein 5g	
Vitamin A	4%
Vitamin C	2%
Calcium	20%
Iron	4%

* Percent Daily Values are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs:

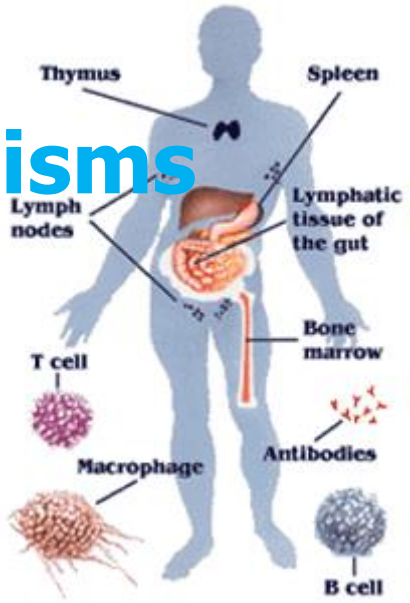
	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

IMMUNE SYSTEM

Immune System

The body's defense against:

- **disease causing organisms**
- **malfunctioning cells**
- **foreign particles**



Basic Immunology

Depends on the ability of the immune system to distinguish between ***self*** and ***non-self*** molecules

Self molecules are those components of an organism's body that can be distinguished from foreign substances by the immune system

- ***Autoimmunity*** is an immune reaction against self molecules (causes various diseases)

Non-self molecules are those recognized as foreign molecules

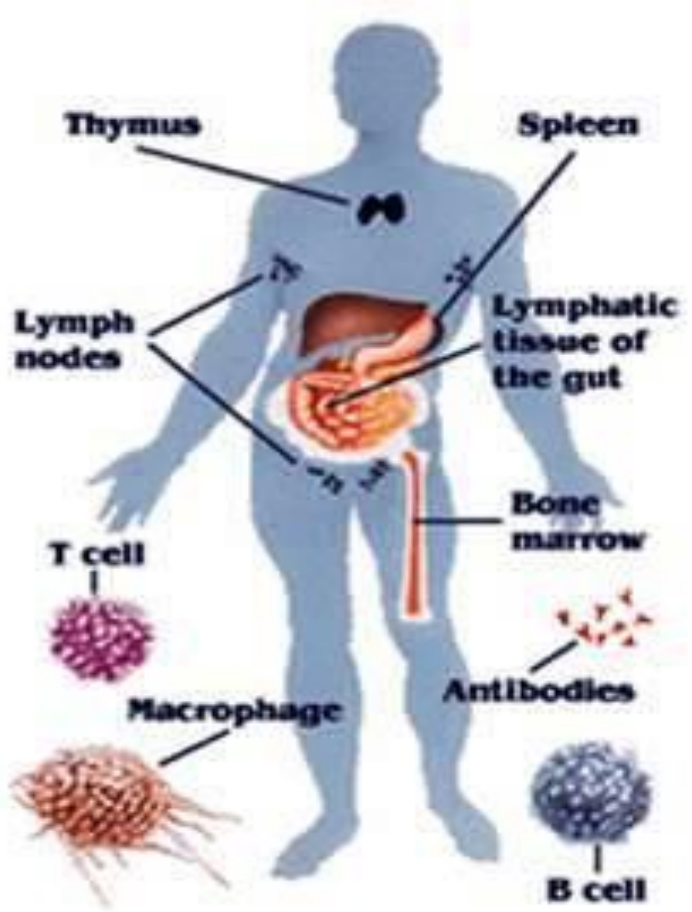
- One class of non-self molecules are called **antigens** (short **for *anti*body *gen*erators**) and are defined as substances that bind to specific immune receptors and elicit an immune response

Immune System Components

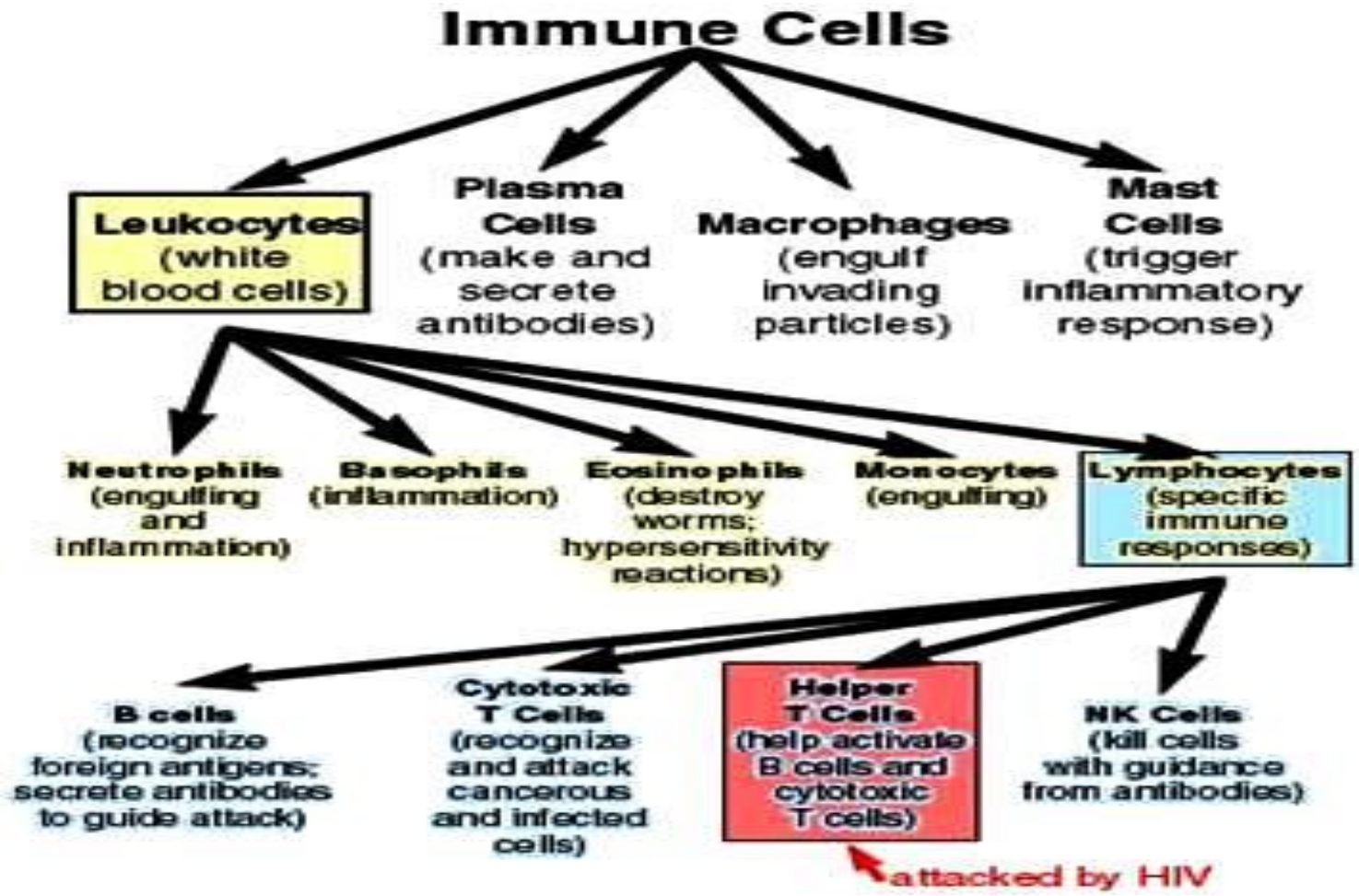
specific cells - lymphocytes, macrophages, etc., originate from precursor cells in the bone marrow and patrol tissues by circulating in either the blood or lymphatics, migrating into connective tissue or collecting in immune organs

lymphatic organs- thymus, spleen, tonsils, lymph nodes

diffuse lymphatic tissue -collections of lymphocytes and other immune cells dispersed in the lining of the digestive and respiratory tracts and in the skin

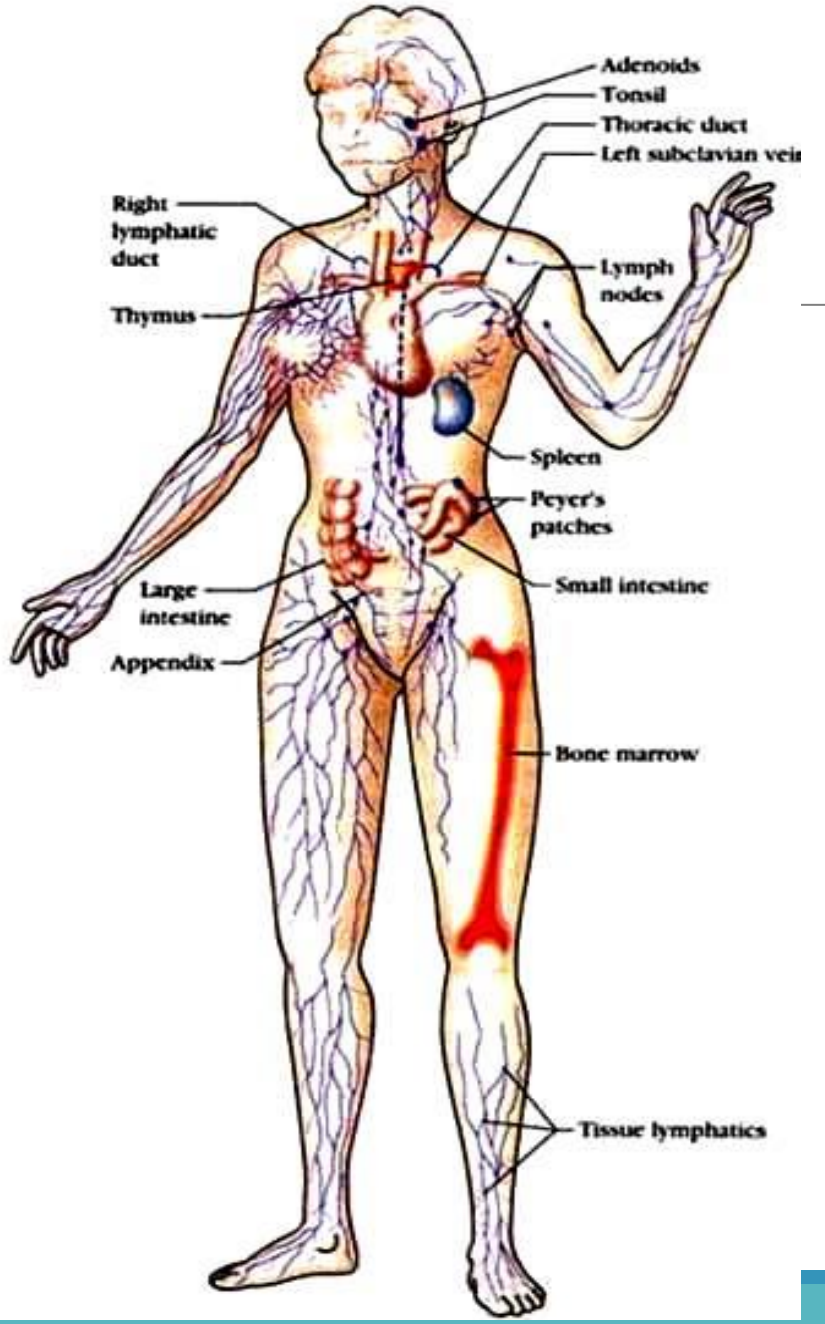


Types of Cells



Lymphatic Organs

- Lymph Nodes
- Spleen
- Thymus
- Red Bone Marrow
- Immune Tissue in Organs – GALT, MALT, SALT



Plan of Protection

Immunity **is the ability to defend against infectious agents, foreign cells and abnormal cells eg. cancerous cells**

1st Line of defense – Block entry

2nd Line of Defense – Fight Local Infections

3rd Line of Defense – Combat Major Infections

Nonspecific Response

Responds quickly, fights all invaders and consists of:

First line of defense – intact skin and mucosae and secretions of skin and mucous membranes prevent entry of microorganisms

Second line of defense – phagocytic white blood cells, antimicrobial proteins, and other cells

Inflammatory response process is key

Inhibit invaders from spreading throughout the body

First line of Defense

Non specific barriers to block entry

Skin – **physical & chemical barrier**

Mucous membranes

Nasal hairs and microscopic cilia

Gastric juice, vaginal secretions & urine

Natural flora

Tears, saliva and sweat glands

Cerumen or Ear Wax

Second Line of Defense

Fight local infection with Inflammation Process

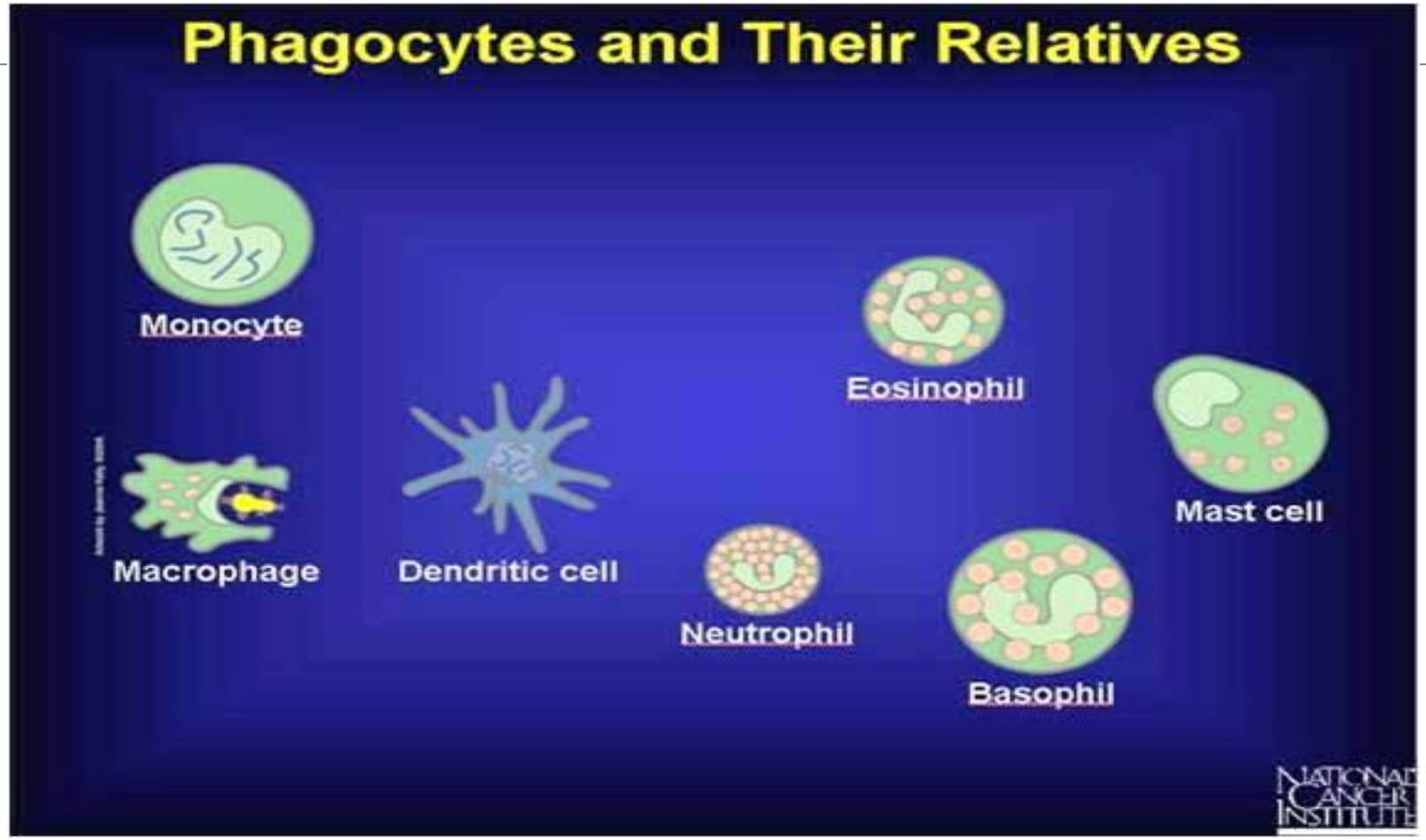
Response is a non-specific, immediate, maximal response

Consists of phagocytosis, complement protein response

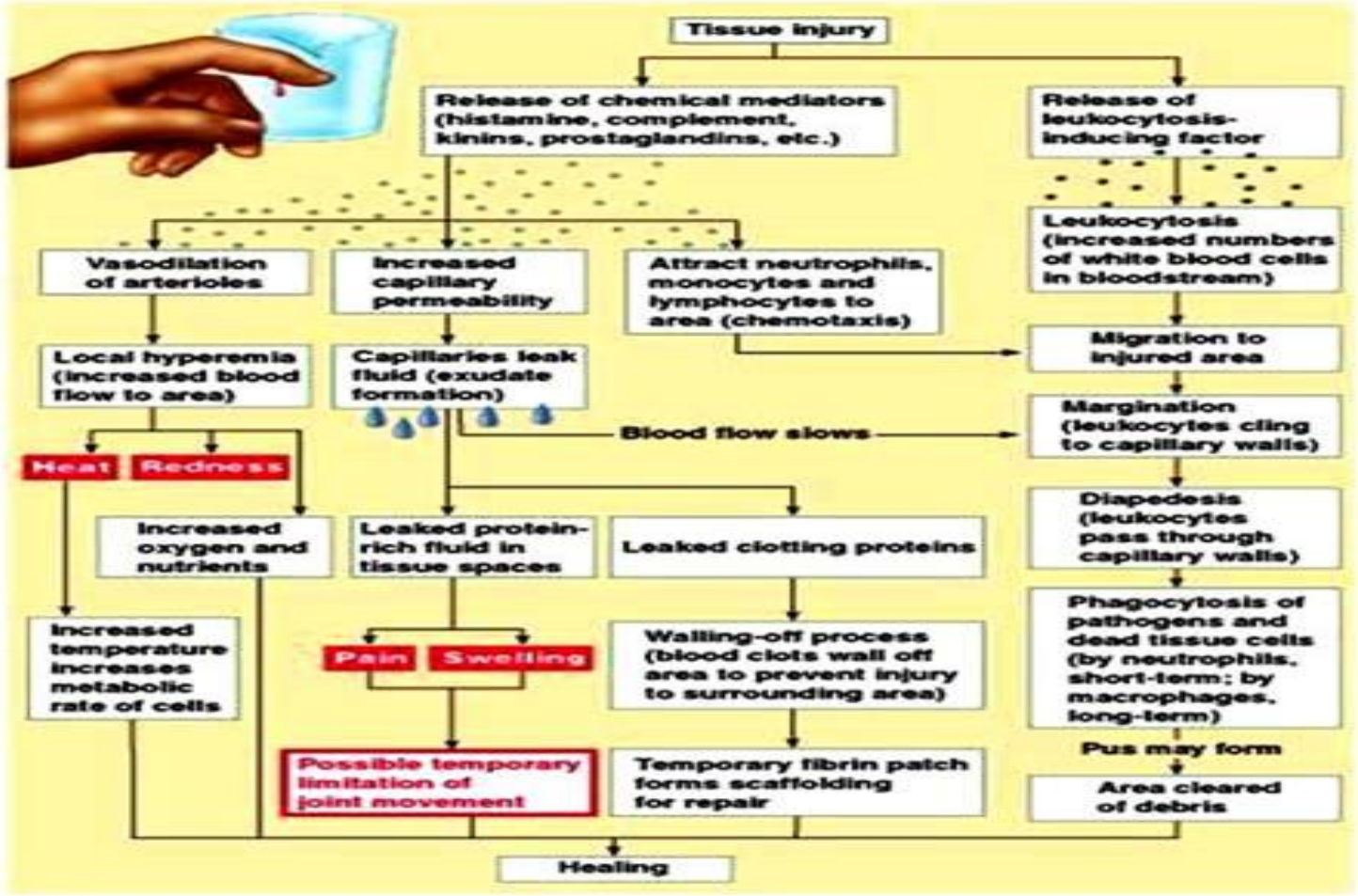
Involve the Inflammation Process



Phagocytes and Their Relatives



Inflammation Process



Third Line of Defense

Specific Response

takes longer to react

work on specific types of invaders which it identifies and targets for destruction

not restricted to initial site of invasion/infection – whole body protection

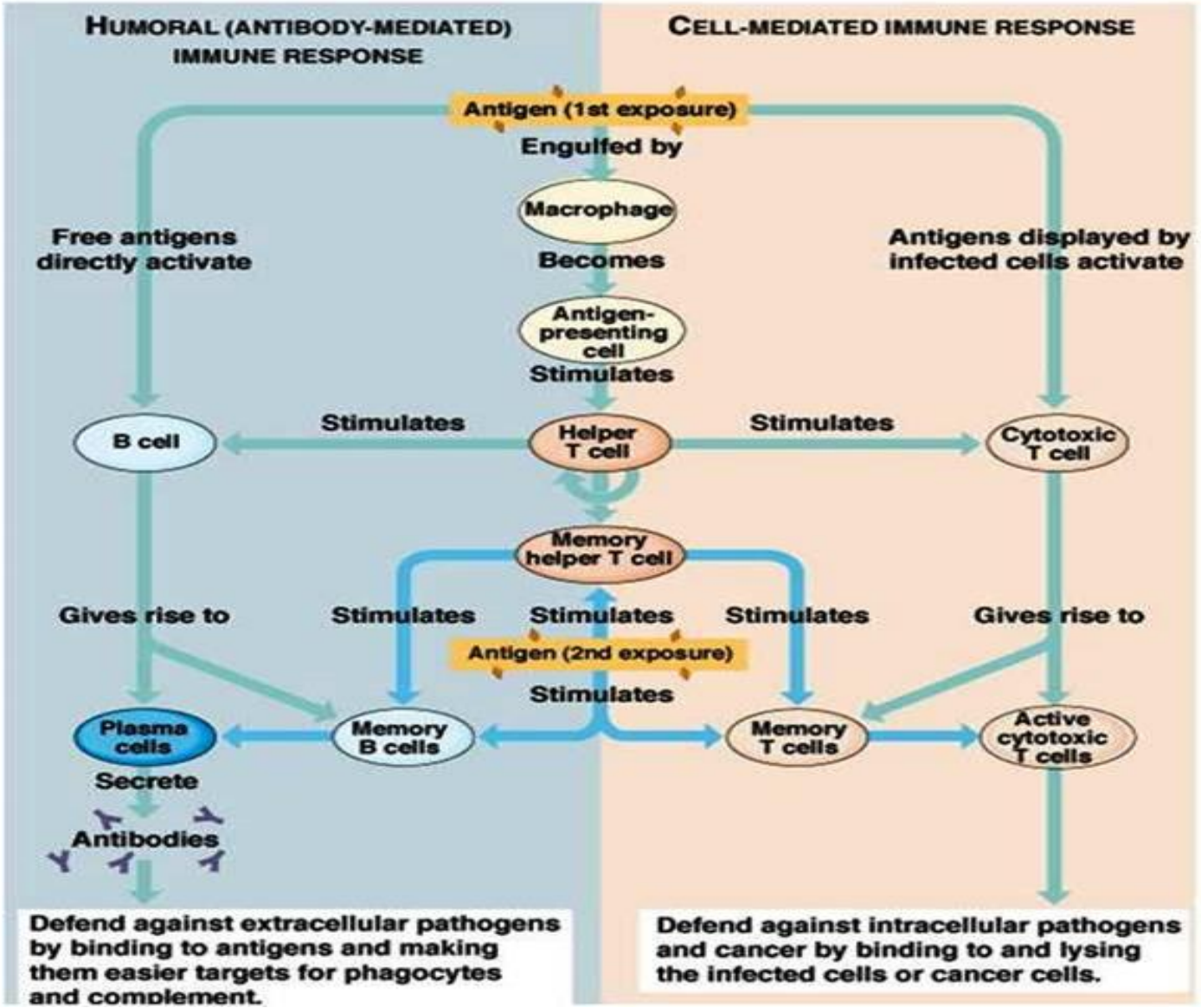
a stronger immune response as well as immunological memory

Antigens

Antigens are proteins or carbohydrate chain of a glycoprotein within a plasma membrane which the body recognizes as **“nonself”**

antigen presentation - specific immune response is antigen-specific and requires the recognition of specific “non-self” antigens

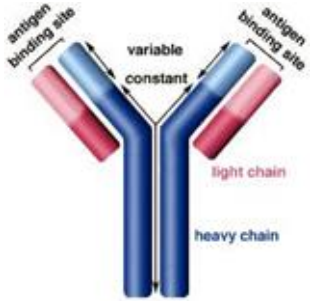
Specific Defense



Humoral – Antibody (Extracellular Response)

B cells

Plasma Cells -produce antibodies

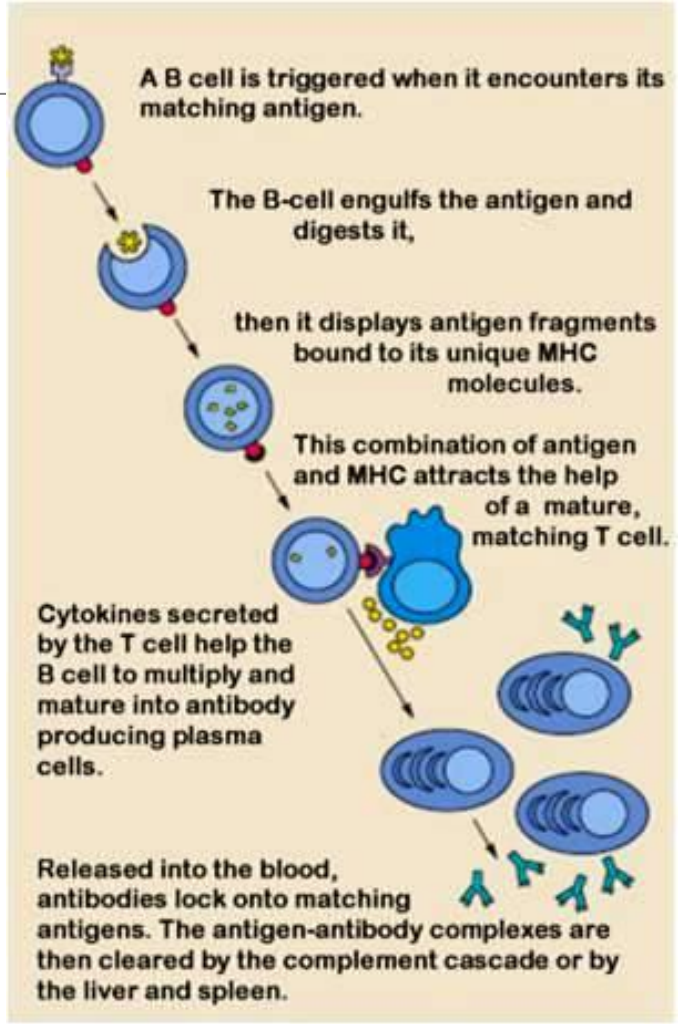




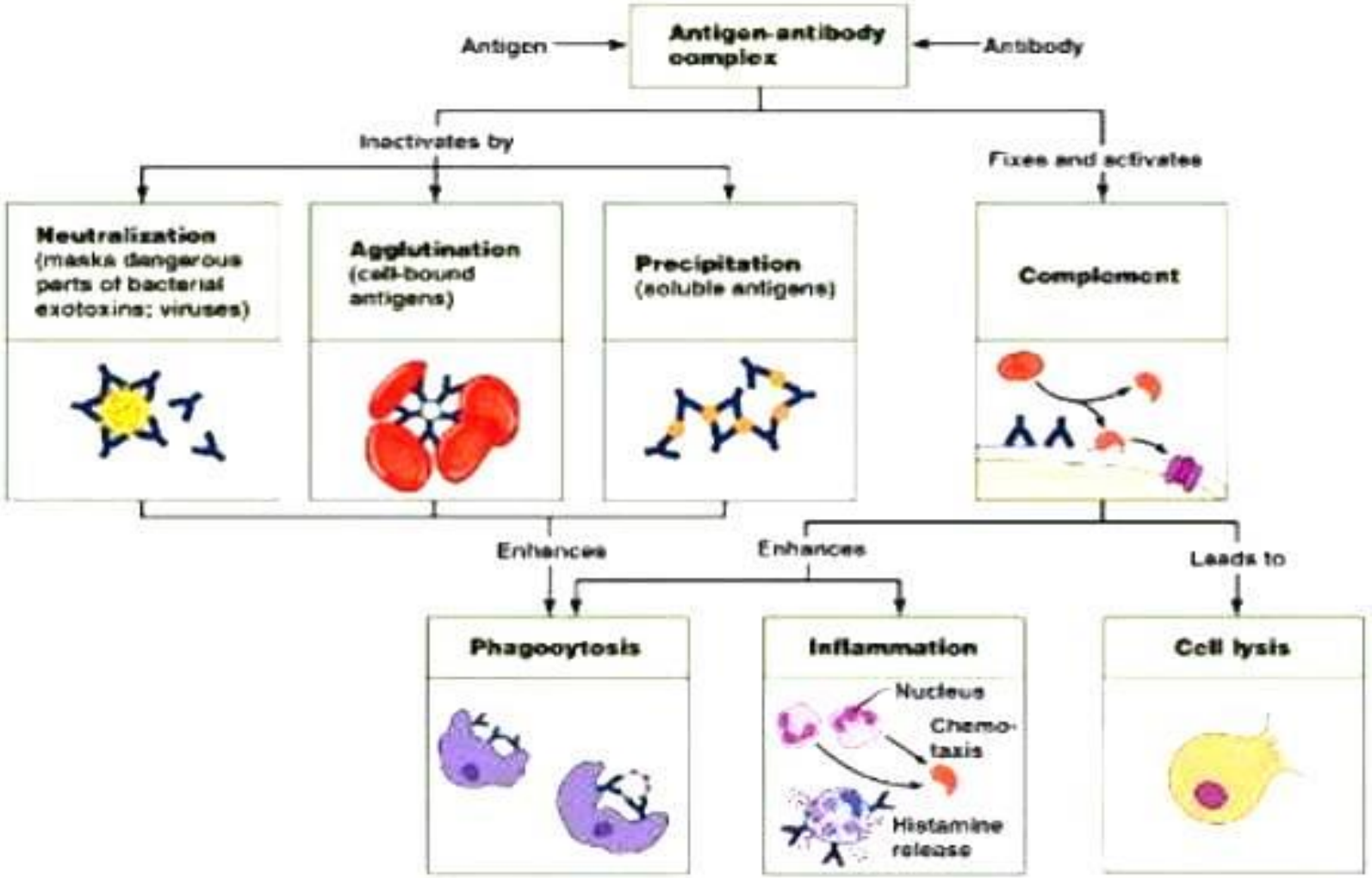
Antibody-antigen Complex

Helper T Cells

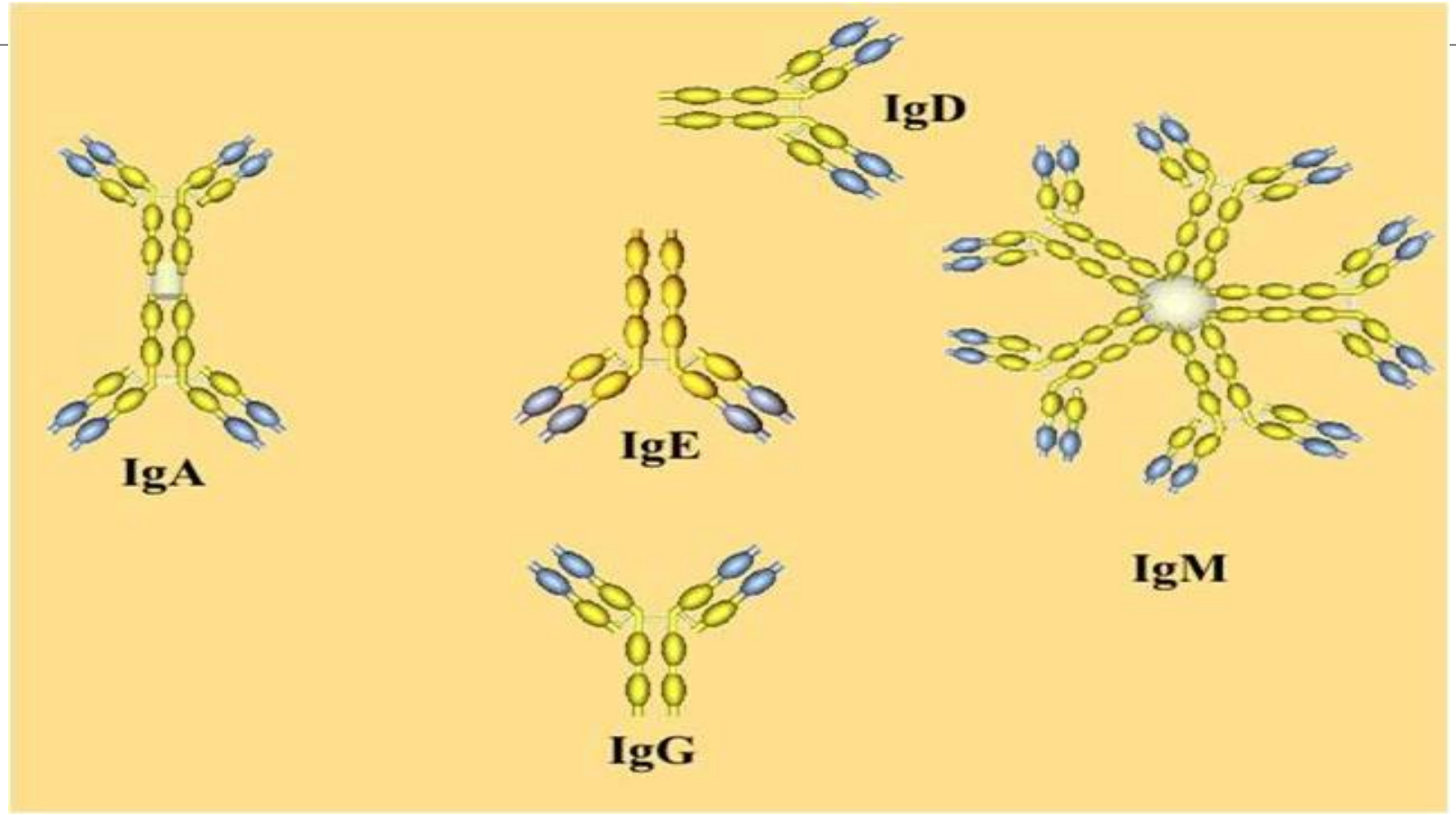
Memory Cells



Antigen-Antibody Complex Functions



Classes of Antibodies



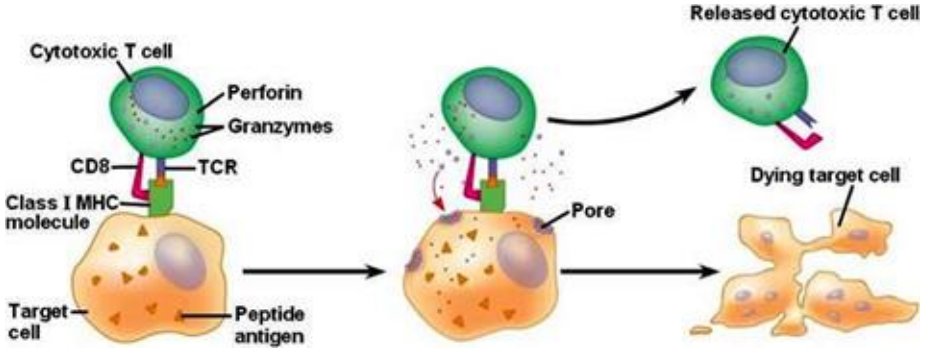
Classes of Antibodies

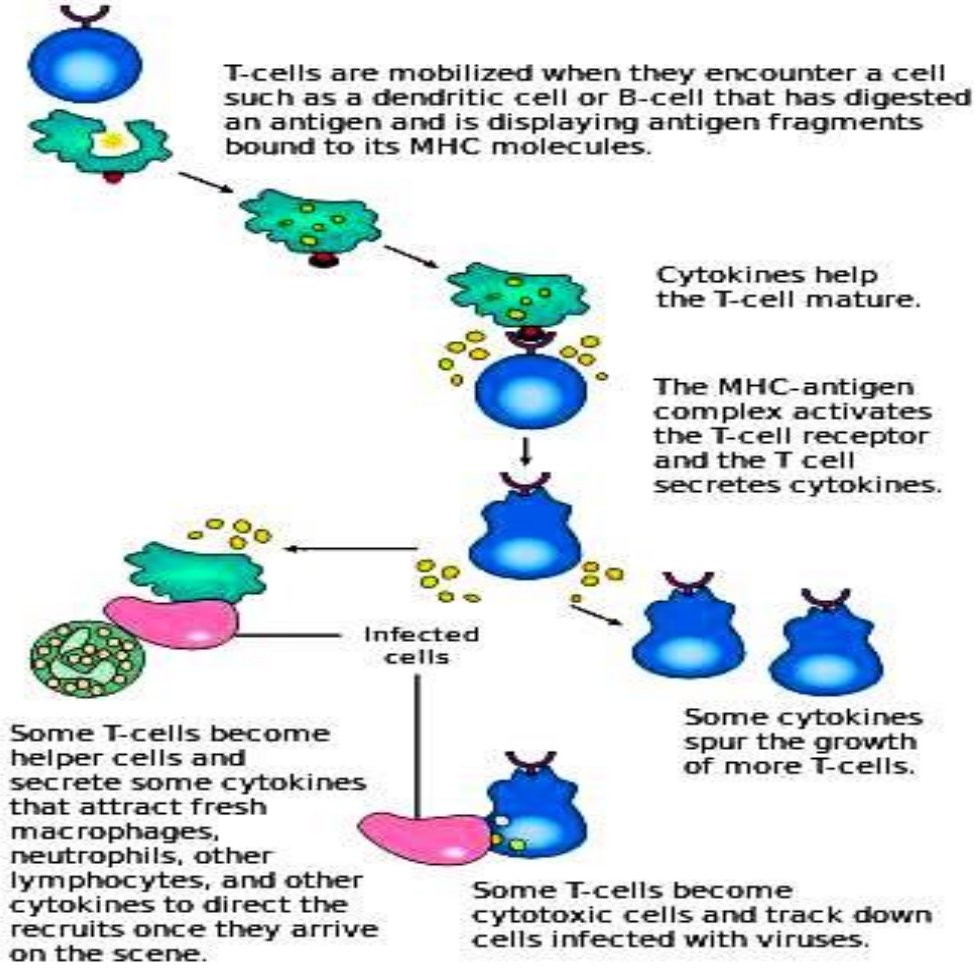
IgA	Antibodies are dimmers – contain two Y shaped structures. Found in mucosal areas, such as the gut, respiratory tract and urogenital tract. Also found in saliva, tears, and breast milk. They attack microbes and prevents colonization by pathogens before they reach the blood stream so it is most important antibody in local immunity
IgD	Functions mainly as an antigen receptor on B cells that have not been exposed to antigens. It has been shown to activate basophils and mast cells to produce antimicrobial factors.
IgG	In its four forms, provides the majority of antibody-based immunity against invading pathogens. It makes up about 75 % of all human antibodies and is the body's major defense against bacteria. The only antibody capable of crossing the placenta to give passive immunity to fetus. It is the most versatile of antibodies because it carries out functions of the other antibodies as well.
IgE	Binds to allergens and triggers histamine release from mast cells and basophils, and is involved in allergy. Also protects against parasitic worms.
IgM	Expressed on the surface of B cells and in a secreted form with very high avidity. Eliminates pathogens in the early stages of B cell mediated (humoral) immunity before there is sufficient IgG.

Cell-mediated immune response

Within the cell

involves the activation of phagocytes, antigen-specific cytotoxic T-lymphocytes, and the release of various cytokines in response to an antigen

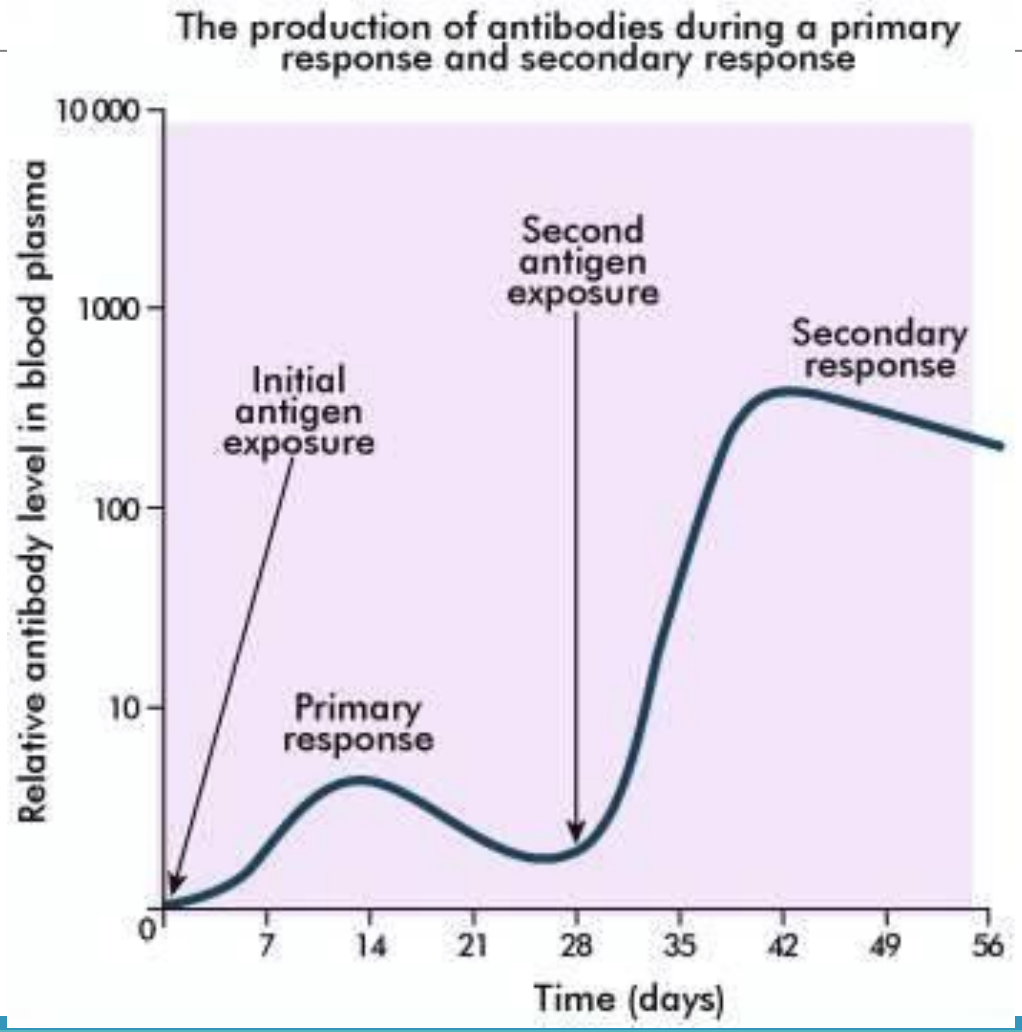




Memory B & T Cells

Should a pathogen infect the body more than once, these specific **memory cells** are used to *quickly* eliminate

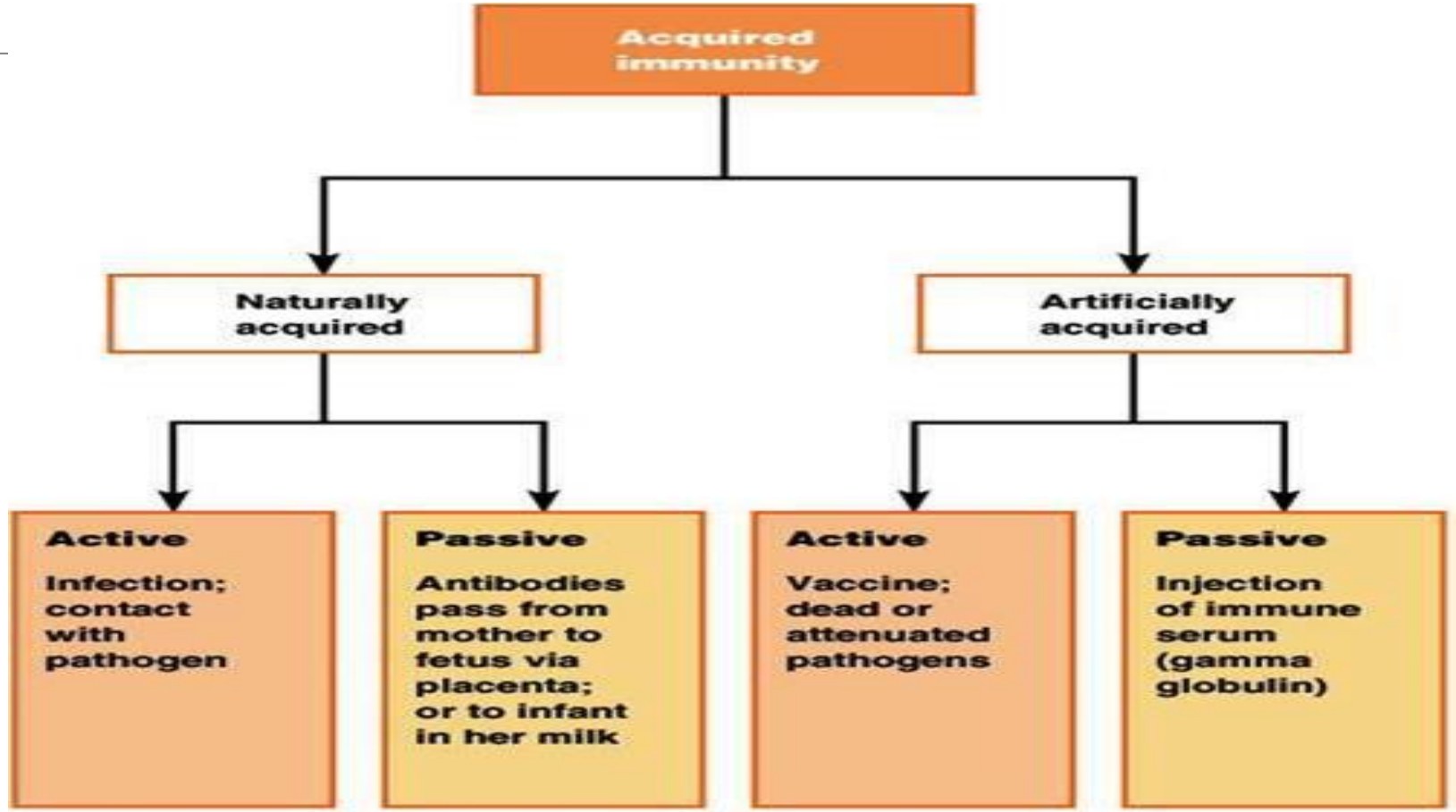
Primary & Secondary Immunity



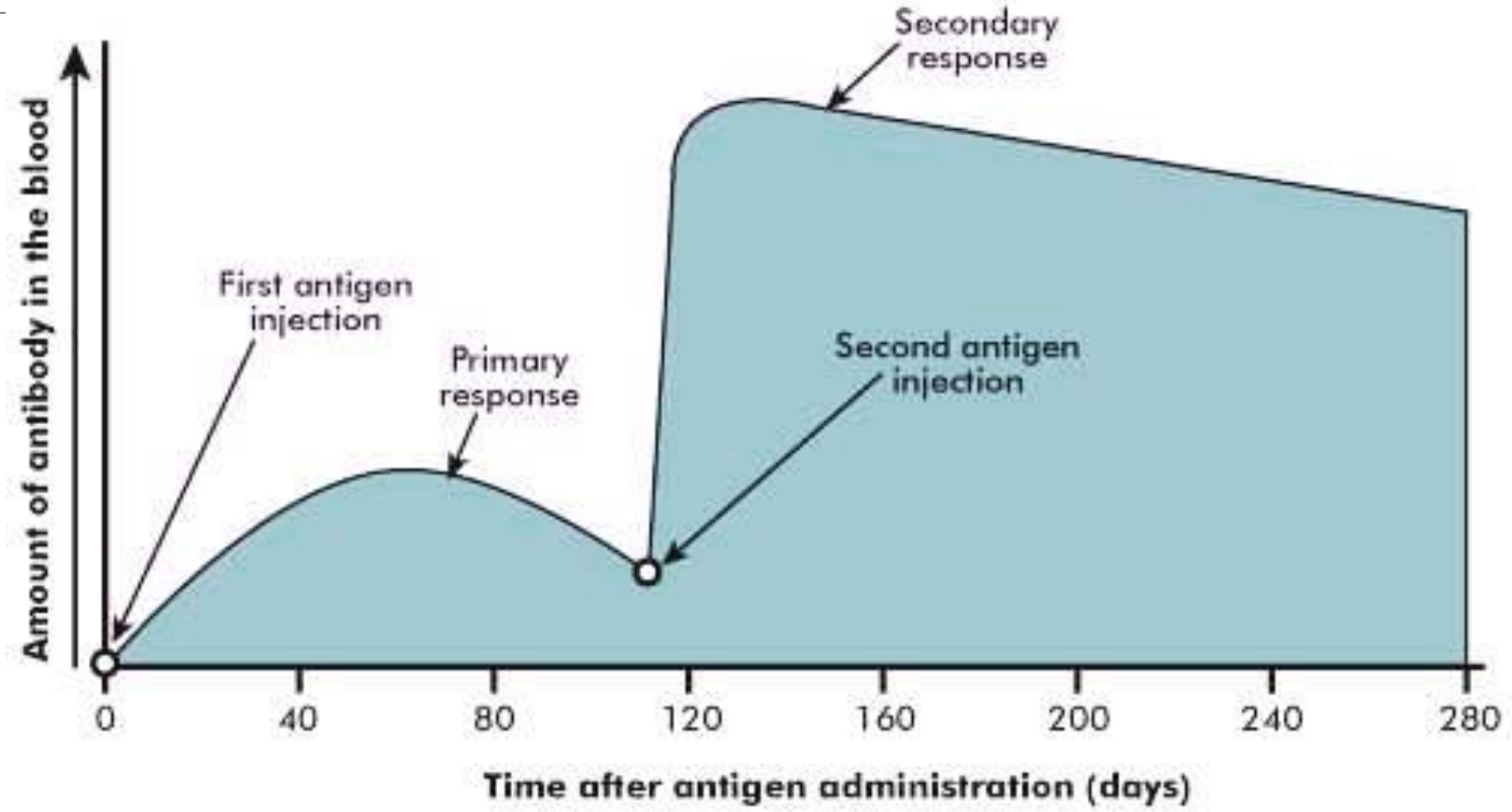
Sources of Specific Immunity
Inborn & Acquired

Inborn Immunity – immunity for certain diseases is inherited

Acquired Immunity – immunity can be acquired through infection or artificially by medical intervention



Immunization



Antibiotics and Antivirals

Antibiotics or antibacterials – group of medications used to kill bacteria by preventing them from dividing

There is concern about the extensive use of antibiotics resulting in resistant forms of bacteria and "superbugs"

Antivirals – group of medications used to treat viral infections but they cannot destroy the virus. Rather they inhibit the virus from reproducing and developing.

Cultured Antibodies

Monoclonal antibodies – cloning of many copies of the same antibody which can be useful in fighting diseases because they can be designed specifically to only target a certain antigen, such as one that is found on cancer cells.

Allergies



Hypersensitivity of the immune system to relatively harmless environmental antigens - the immune system reacts to an outside substance that it normally would ignore

Allergy types (food, dust, mold, seasonal), symptoms and **signs** (skin rash, itching, red bumps, sneezing).

AIDS -HIV

AIDS - (acquired immune deficiency syndrome) is the final stage of HIV disease, which causes severe damage to the immune system-caused by infection with **human immunodeficiency virus (HIV)-** HIV infects vital cells in the human immune system such as helper T cells, macrophages, and dendrite cells

Autoimmune Disorders

Condition that occurs when the immune system mistakenly attacks and destroys healthy body tissue

The immune system can't tell the difference between healthy body tissue and antigens. The result is an immune response that destroys normal body tissues

More than 80 different types – **Multiple sclerosis, Rheumatoid arthritis, Hashimoto thyroiditis, Graves' disease**