Colour vision
for
second year MBBS students

DR RIFFAT SULTANA

Agenda

- What is colour vision?
- Perception of colour
- Types of Colours
- Types of Vision
- History and theories
- Conclusion

What is color vision ???

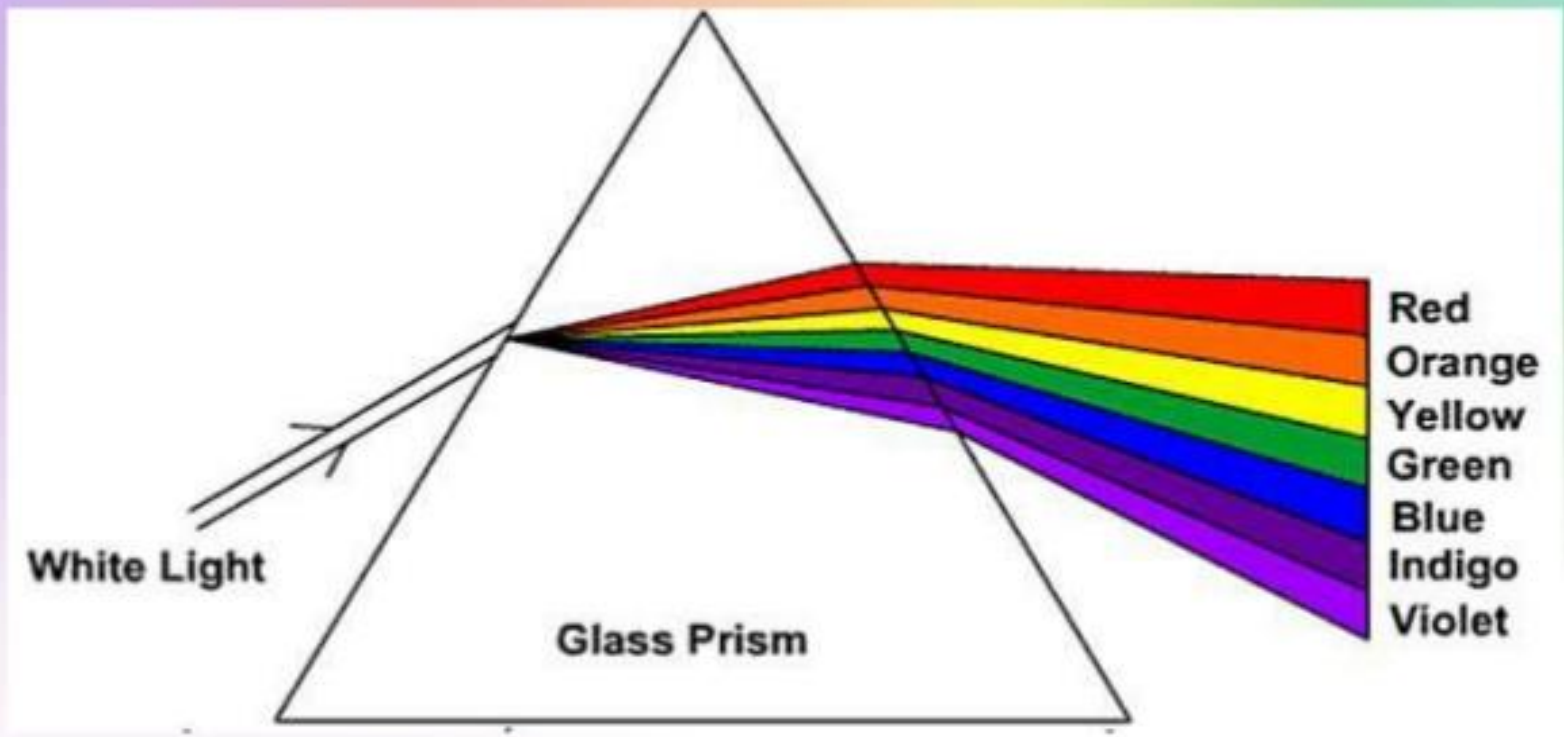
- Color vision is the capacity of an organism or machine to distinguish objects based on the wavelengths (or frequencies) of the light they: reflect, emit, transmit .

Perception of colour

- Colour vision is a function of cones
- Better appreciated in phototopic conditions
- Scotopic vision- all colors seen as gray-Purkinje shift
- Perception of colour depends upon
  - spectral composition of light
  - coming from an object &
  - emanating from surrounding
  - State of light adaptation of subject

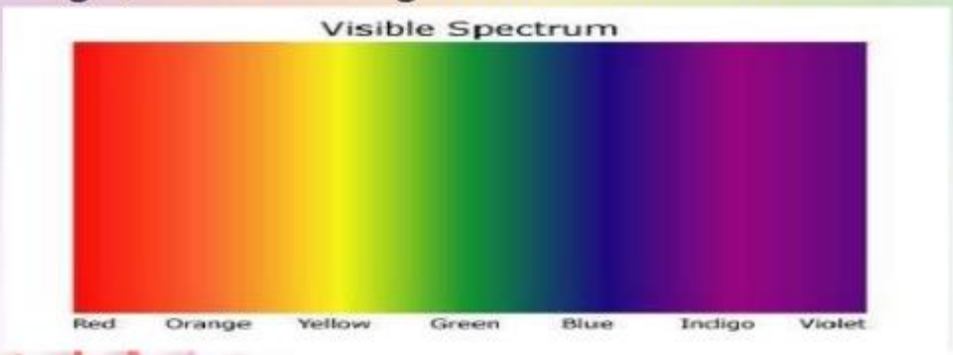
- A special property of the cone system is **color vision**. Perceiving **color** allows humans (and many other animals) to discriminate objects on the basis of the distribution of the wavelengths of light that they reflect to the eye

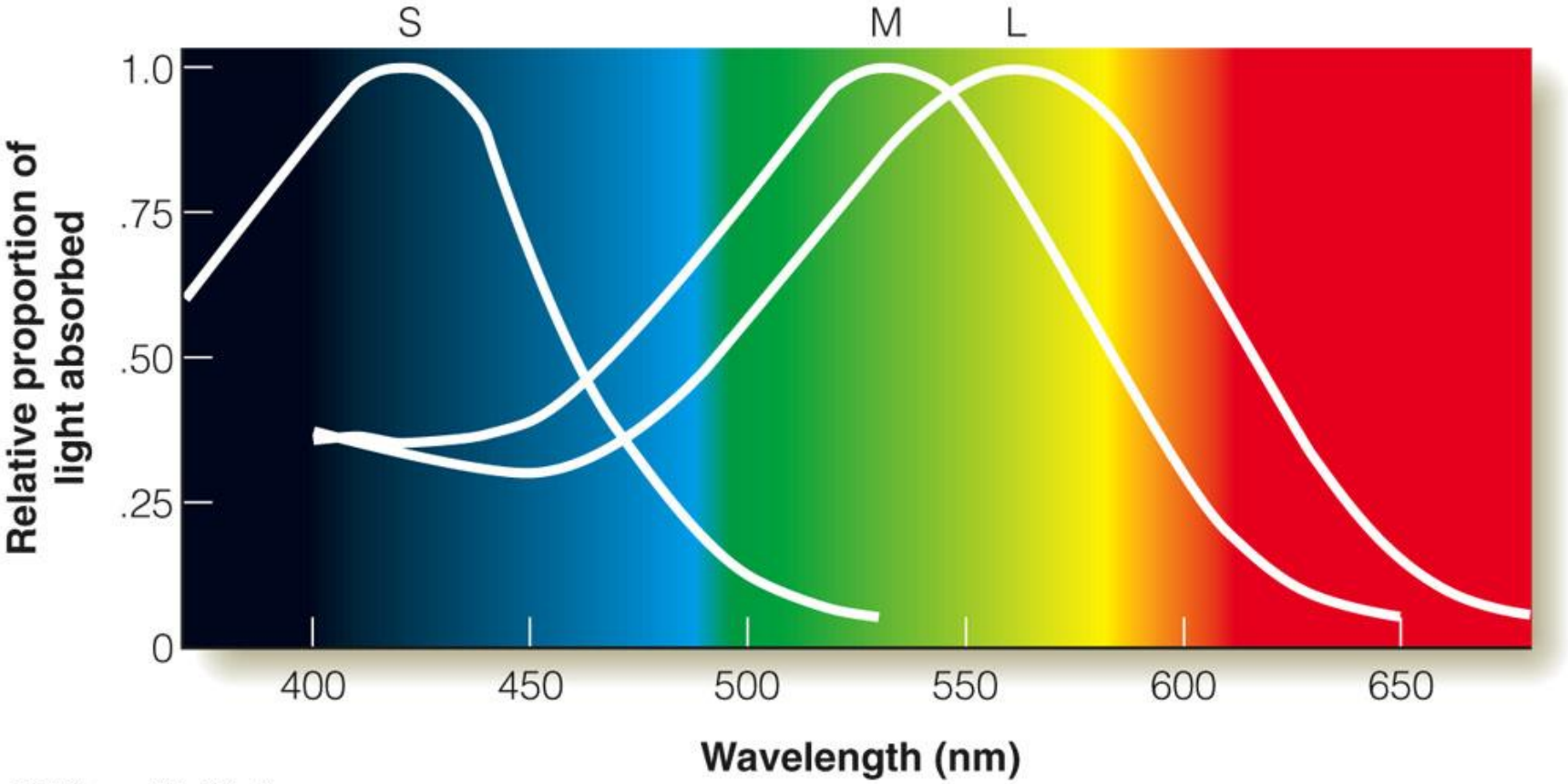
- Isaac Newton discovered that white light, after being split into its component colours when passed through a dispersive prism could be recombined to make white light by passing them through a different prism.
- The characteristic colours are, from long to short wavelengths (and, correspondingly, from low to high frequency), red, orange, yellow, green, blue, and violet.
- the just-noticeable difference in wavelength varies from about 1 nm in the blue-green and yellow wavelengths, to 10 nm and more in the longer red


White Light
Glass Prism
Red
Orange
Yellow
Green
Blue
Indigo
Violet

Contd…

- For humans, the shortest light waves are seen as violet and light waves that get longer and longer are seen as blue, then green, then yellow, then orange, and the longest are seen as red.

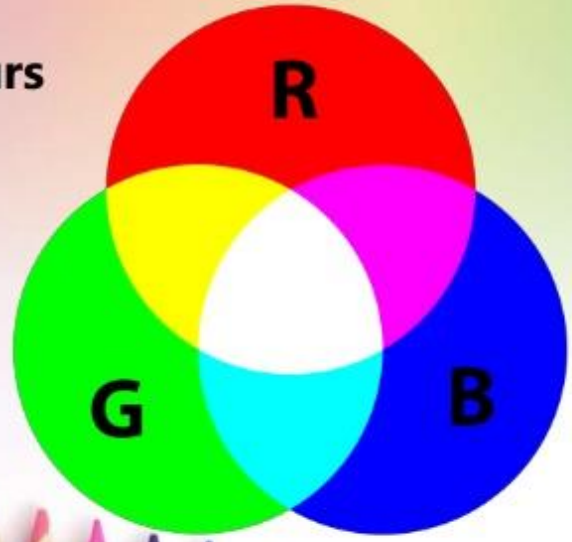




- In very low light levels, vision is scotopic: light is detected by rod cells of the retina. Rods are maximally sensitive to wavelengths near 500 nm, and play little, if any, role in colour vision.
- In brighter light, such as daylight, vision is photopic: light is detected by cone cells which are responsible for colour vision. Cones are sensitive to a range of wavelengths, but are most sensitive to wavelengths near 555 nm.
- Between these regions, mesopic vision comes into play and both rods and cones provide signals to the retinal ganglion cells. The shift in colour perception from dim light to daylight gives rise to differences known as the Purkinje effect.
- The perception of "white" is formed by the entire spectrum of visible light, or by mixing colours of just a few wavelengths in animals with few types of colour receptors.
- In humans, white light can be perceived by combining wavelengths such as red, green, and blue, or just a pair of complementary colours such as blue and yellow

Types of Colours

Primary colours



Types of Vision

- Sensation of white vision with no colour vision

Achromatic

- Spectral colour vision & Extra spectral colour vision - i.e., Mixing of two spectrum

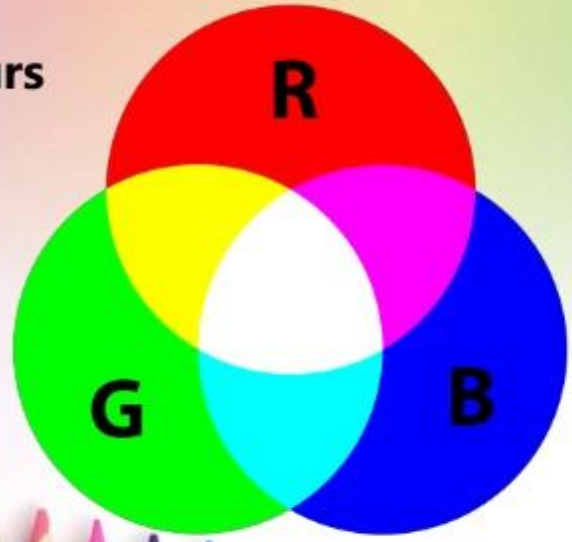
Chromatic

Theories of Colour Vision

- There are two major theories that explain and guide research on colour vision: the *trichromatic* theory also known as the Young-Helmholtz theory, and the *opponent-process* theory. These two theories are complementary and explain processes that operate at different levels of the visual system.
-
- Trichromatic Theory
- Evidence for the trichromatic theory comes from colour matching and colour mixing studies.
- Young and Helmholtz carried out experiments in which individuals adjusted the relative intensity of 1,2, or 3 light sources of different wavelengths so that the resulting mixture field matched an adjacent test field composed of a single wavelength. Individuals with normal colour vision needed three different wavelengths (i.e., primaries) to match any other wavelength in the visible spectrum.
- This finding led to the hypothesis that normal colour vision is based on the activity of three types of receptors, each with a different peak sensitivity. Consistent with the trichromatic theory, we now know that the overall balance of activity in S (short wavelength), M (medium wavelength), and L (long wavelength) cones determines our perception of colour as shown in the figure below.

Types of Colours

Primary colours



Types of Vision

- Sensation of white vision with no colour vision

Achromatic

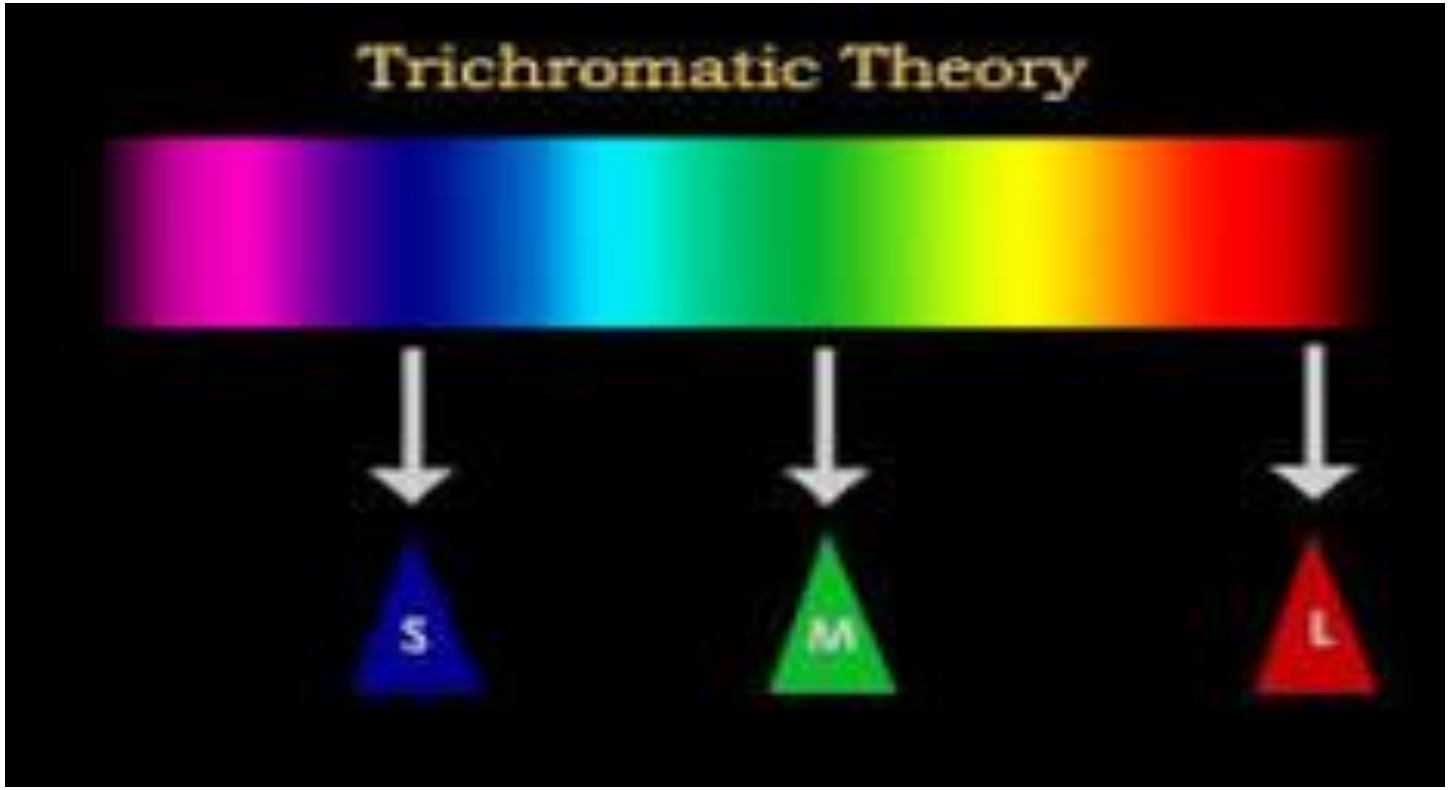
- Spectral colour vision & Extra spectral colour vision - i.e., Mixing of two spectrum

Chromatic

Drawbacks

Though it accounts well for laws of color mixing, has difficulty with other basic phenomena

- Dichromats who confuse red with green can see yellow
- Difficulty in explaining complementary color after-images


Trichromatic Theory
S
M
L

- A range of wavelengths of light stimulates each of these receptor types to varying degrees.
- **Yellowish-green** light, for example, stimulates both L and M cones equally strongly, but only stimulates S-cones weakly.
- **Red light**, on the other hand, stimulates L cones much more than M cones, and S cones hardly at all
- **blue-green** light stimulates M cones more than L cones, and S cones a bit more strongly, and is also the peak stimulant for rod cells
- **blue** light stimulates S cones more strongly than red or green light, but L and M cones more weakly.
- The brain combines the information from each type of receptor to give rise to different perceptions of different wavelengths of light.

CONCLUSION

- **Every object seems to bear one or more colors, making our world look brightly colored. Blue waters, green grass, and colourful clothes – these do not have color at all.**
- Psychologists say that color is an experience of the mind. All objects only reflect or produce light in different intensities, amplitudes and wavelengths.
- The process by which light information is processed through the sensory organs and the brain can be explained by the above discussed theories.

Color blindness, also known as **color vision deficiency**,

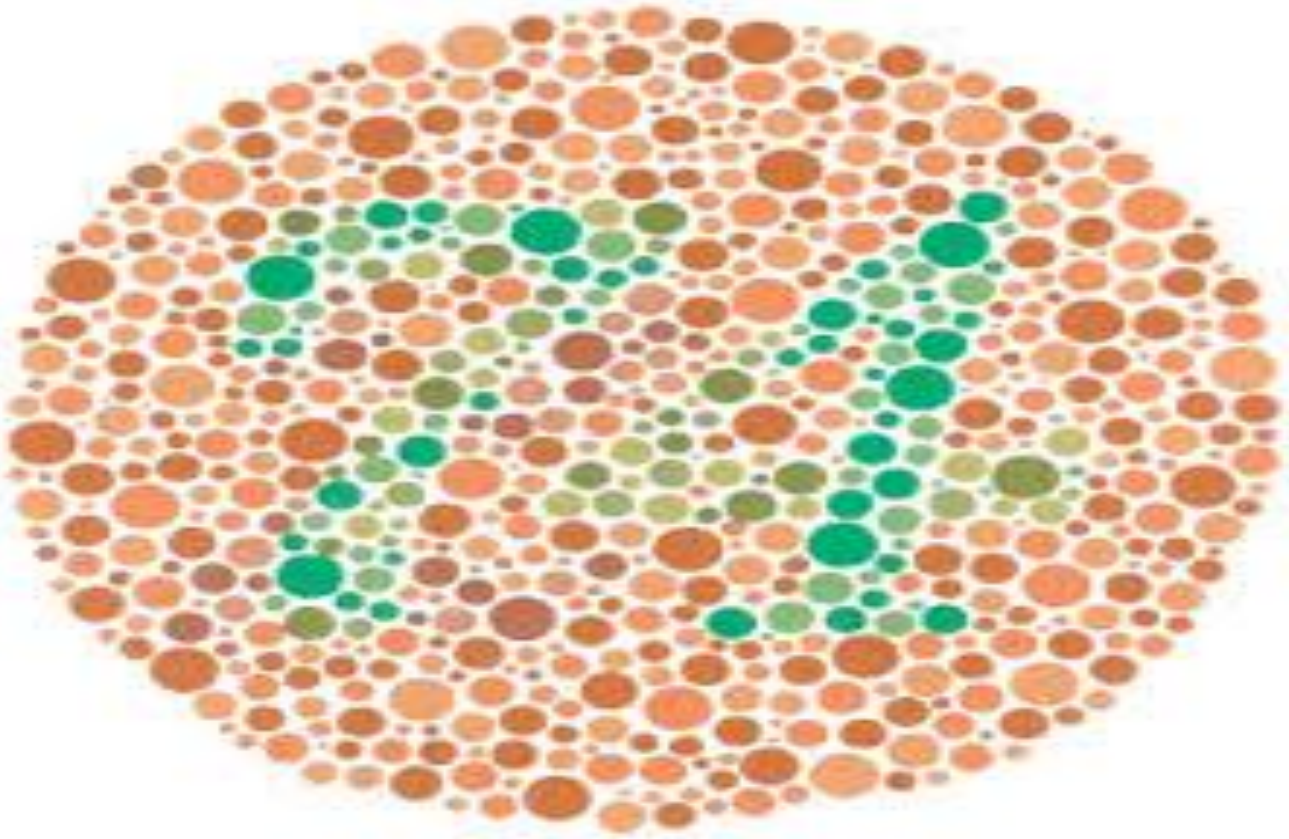
- is the decreased ability to see color or differences in color.
- Color blindness may also make some educational activities more difficult.
- People with total color blindness (achromatopsia) may also have decreased visual acuity and be uncomfortable in bright environments.
- The most common cause of color blindness is an inherited problem in the development of one or more of the three sets of color-sensing cones in the eye.
- Males are more likely to be color blind than females, as the genes responsible for the most common forms of color blindness are on the X chromosome
- As females have two X chromosomes, a defect in one is typically compensated for by the other, while males only have one X chromosome.
- Color blindness can also result from physical or chemical damage to the eye, optic nerve or parts of the brain.
- Diagnosis is typically with the Ishihara color test; however, a number of other testing methods, including genetic testing, also exist.

- Although some people become colour blind as a result of other diseases such as diabetes and multiple sclerosis or they acquire the condition over time due to the aging process, medication etc.
- The different anomalous conditions are
- **protanomaly**, which is a reduced sensitivity to **red** light
- **deuteranomaly** which is a reduced sensitivity to green light and is the most common form of **colour blindness**
- **tritanomaly** which is a reduced sensitivity to blue light and is extremely rare.
- EnChroma **glasses** are an optical assistive device for enhancement **of color** discrimination in persons **with color blindness**; they are not a **cure for color blindness**.

Tritanopia

Deuteranopia

Ishihara plates



- There are three main kinds of **color blindness**, based on photopigment defects in the three different kinds of cones that respond to blue, green, and red light. Red-green **color blindness** is the most common, followed by blue-yellow **color blindness**. A complete absence of **color vision** —total **color blindness** – is rare

1

The tissue surrounding an entire muscle is known as

- A)epimysium.
- B)perimysium
- C)endomysium
- D)superficial mysium

2

The tissue that surrounds a muscle cell (myofiber) is known as

A)epimysium.

B)perimysium

C)Endomysium

D)superficial mysium

3

Muscle fibers are bundled into groups known as

- A)myotendrils
- B)endomysium
- C)myosin
- D)fascicles.

4

Bundles of muscle fibers (fascicles) are wrapped by a tissue known as

- A)epimysium
- B)perimysium.
- C)endomysium
- D)superficial mysium

5

A connective tissue on the surface of muscles (that extends onto the tendon and bone) is known as

- A)fascia.
- B)perimysium
- C)endomysium
- D)connective to muscle tissue

6

One of the characteristics of muscle tissue is that is has conductivity. Which of the following best describes this characteristic?

- A)Muscles contract when stimulated
- B)Muscles have local electrical charges that are capable of moving along the muscle fiber.
- C)Muscles only pull; they cannot push
- D)Muscles can stretch when needed

7

One of the characteristics of muscle tissue is that is has extensibility. Which of the following best describes this characteristic?

- A)Muscles contract when stimulated
- B)Muscles have local electrical charges that move along the muscle fiber
- C)Muscles only pull; they cannot push
- D)Muscles can stretch when needed.

- The cytoplasm within the muscle fiber contains a molecule to distribute oxygen within the cell. This molecule is known as
- **A)**myoglobin.
- **B)**sarcolemma
- **C)**hemoglobin
- **D)**sarcoplasmic reticulum

Action potential frequency is best described as:

- **A)**The strength of the muscle contractions.
- **B)**The distance the action potential travels in a second.
- **C)**The duration of an action potential.
- **D)**The number of action potentials produced per unit of time.
- **Feedback: Frequency describes the number of action potentials that occur within a specific time.**

8

One of the characteristics of muscle tissue is that is has excitability. Which of the following best describes this characteristic?

- A)Muscles respond when stimulated.
- B)Muscles have membrane potentials
- C)Muscles only pull; they cannot push
- D)Muscles can stretch when needed

9

Invaginations of the sarcolemma are called _____.

- A)actin myofilaments
- B)end plates
- C)thick filaments
- D)transverse tubules.

10

Cross-bridges are formed by _____.

- A)F-actin
- B)troponin
- C)myosin heads.
- D)synapses

11

A muscle fiber is a _____.

- A)actin molecule
- B)myosin molecule
- C)muscle cell.
- D)bundle of actin and myosin inside of a muscle cell

12

The plasma membrane of the muscle fiber is known as the

- A)cell surface membrane
- B)sarcolemma.
- C)sarcoplasm
- D)sarcoplasmic reticulum

13

The cytoplasm within the muscle fiber is known as the

- A)myoglobin component
- B)sarcolemma
- C)sarcoplasm.
- D)sarcoplasmic reticulum

14

The cytoplasm within the muscle fiber contains a molecule to distribute oxygen within the cell. This molecule is known as

- A)myoglobin.
- B)sarcolemma
- C)hemoglobin
- D)sarcoplasmic reticulum

15

The molecule within the cytoplasm of a muscle fiber that stores glucose for quick energy is

- A)fructose
- B)glycogen.
- C)sucrose
- D)hemoglobin

16

The myofilaments within the muscle fiber are

- A)myosin, actin, and elastic (titin) filaments.
- B)thick, thin, and straight filaments
- C)A, H, and B filaments
- D)sarcoplasm and sarcolemma components

17

Thick filaments within the myofibril are composed of

- A)actin
- B)myosin.
- C)titin
- D)sarconin

18

Thin filaments within the myofibril are composed primarily of

- A)actin.
- B)myosin
- C)titin
- D)sarconin

19

The elastic filaments within a myofibril are composed of molecules known as

- A)tropomyosin
- B)titin.
- C)troponin
- D)ADP

20

The elastic filaments within a myofibril are attached to Z disks and to the molecule _____.

- A)myosin.
- B)troponin
- C)actin
- D)sarcolemma

21

In the myofibril, ATP is used for which of the following?

- A)muscle tone
- B)muscle contraction
- C)muscle relaxation
- D)All of the above.

22

Which of the following muscle cells has the smallest diameter?

- A)skeletal
- B)cardiac
- C)smooth.
- D)all the same

23

Of the following muscles types, which one has long, cylindrical-shaped cells?

- A)skeletal muscle.
- B)cardiac muscle
- C)smooth muscle
- D)all are about the same

25

Of the following muscle types, which one does NOT have striations?

- A)skeletal muscle
- B)cardiac muscle
- c)smooth muscle.
- D)None of the above

- _____ muscle is found in the walls of the small intestine.
- **A)**Skeletal
- **B)**Smooth
- **C)**Cardiac
- **D)**All of the above

- Of the following muscle types, which one is found in the middle layer of the aorta?
- **A)**skeletal muscle
- **B)**cardiac muscle
- **C)**smooth muscle.
- **D)**None of the above

26

Of the following muscle types, which one is usually under voluntary control?

- **A)**skeletal muscle.
- **B)**cardiac muscle
- **C)**smooth muscle
- **D)**None of the above.

An action potential

- **A)**lasts for 1-2 minutes
- **B)**propagates along the actin myofilaments
- **C)**is all or none.
- **D)**is always below threshold

- Which of the following best describes the use of skeletal muscle tone in the body?
- **A)**It keeps the heart beating.
- **B)**It keeps food moving through the intestines.
- **C)**It prevents indigestion.
- **D)**It keeps our backs straight and our heads up.
- **Feedback: Muscle tone helps us maintain posture, such as keeping our backs straight and our heads up.**

32

Triads in skeletal muscle consist of which of the following?

- **A)**sarcoplasm, sarcoplasmic reticulum, calcium ions
- **B)**sarcoplasmic reticulum, terminal cisterna, sarcoplasm
- **C)**two terminal cisternae and a T-tubule.
- **D)**two T-tubules and one terminal cisterna

33

When acetylcholine is broken down by acetylcholinesterase in the synaptic cleft, what happens to the choline?

- **A)**It is destroyed
- **B)**It is made into new acetylcholinesterase
- **C)**It is reabsorbed at the presynaptic terminal and combined with more acetic acid to make acetylcholine.
- **D)**It is taken up at the postsynaptic terminal

34

The recovery stroke os myosin involves which of the following?

- **A)**movement of the myosin molecule while the cross-bridge is attached
- **B)**return of the myosin head to its original position after the cross bridge releases.
- **C)**actin slides on myosin
- **D)**myosin slides on actin

35

Which of the following is one of the primary functions of muscle tissue?

- **A)**regeneration of mass
- **B)**heat production.
- **C)**growth
- **D)**the ability to last forever

36

The ability of a muscle to be stimulated is called

- **A)**contractility
- **B)**elasticity
- **C)**extensibility
- **D)**excitability.

38

Which of the following types of muscles contain intercalated discs and branching fibers?

- **A)**skeletal
- **B)**smooth
- **C)**cardiac.
- **D)**all of the above

- Which of the following would represent incomplete tetanus?
- **A)**multiple contractions with no relaxation
- **B)**multiple contractions with slight relaxation between each peak
- **C)**multiple contractions followed by a long rest period
- **D)**a long rest period before contractions start
- **Feedback: Incomplete tetanus has a slight rest period between each contraction.**

39

Which of the following muscle types contains peripherally located, multiple nuclei in its cells?

- **A)**skeletal.
- **B)**cardiac
- **C)**smooth
- **D)**all of the above

40

The striations in striated muscle correspond with actual molecular structures. Which of the following is the Z disk?

- **A)**a band where only actin myofilaments are found
- **B)**a band where only myosin myofilaments are found
- **C)**an attachment point for actin myofilaments.
- **D)**an attachment point for myosin myofilaments

41

The striations in striated muscle correspond with actual molecular structures. Which of the following is the I band?

- **A)**a band where only actin myofilaments are found.
- **B)**a band where only myosin myofilaments are found
- **C)**an attachment point for actin myofilaments
- **D)**an attachment point for myosin myofilaments
- **Feedback: The I bands are a regions of sarcomeres where only actin myofilaments are found.**

42

The striations in striated muscle correspond with actual molecular structures. Which of the following is the H band?

- **A)**a band where only actin myofilaments are found
- **B)**a band where only myosin myofilaments are found.
- **C)**an attachment point for actin myofilaments
- **D)**an attachment point for myosin myofilaments

43

Which of the following is the A band within a myofibril?

- **A)**the length of the actin myofilaments
- **B)**the length of the myosin myofilaments.
- **C)**the width of the Z disks
- **D)**gaps between the actin and myosin myofilaments

44

Which of the following is the unit in a myofibril from Z disk to Z disk?

- **A)**sarcomere.
- **B)**sarcolemma
- **C)**somatic motor fibers
- **D)**thick and thin filaments uniting

45

Which of the following best describes a motor unit?

- **A)**a section of a myofibril from Z disk to Z disk
- **B)**one motor neuron and all the muscle fibers innervated by that neuron.
- **C)**all of the neurons that unite to make a whole muscle contract
- **D)**all of the fascicles innervated by several neurons

46

On the surface of the sarcolemma, the membrane potential may depolarize and repolarize rapidly. This change in electrical potential caused by membrane permeability changes for ions is known as

- **A)**action potential.
- **B)**myosin potential
- **C)**energy of dissipation
- **D)**resting membrane potential

47

During a muscle action potential, calcium is released into the sarcoplasm, near the actin and myosin molecules. Which of the following is the best explanation of what the calcium does.

- **A)**The calcium binds to the actin and myosin and makes them work together
- **B)**The calcium breaks apart ATP to ADP and P
- **C)**The calcium removes the tropomyosin block.
- **D)**The calcium causes the release of acetylcholine

48

When the myosin head (of the thick filament) flexes into a bend, while releasing ADP and inorganic phosphate, pulling the thin filament along with it, this is called the

- **A)**action reaction
- **B)**power stroke.
- **C)**recovery stroke
- **D)**muscle tone

49

When the thick and thin filaments slide past each other, which of the following is TRUE?

- **A)**The Z disk to Z disk unit moves apart
- **B)**The myofibril doubles in size
- **C)**The muscle loses tone
- **D)**The sarcomere gets shorter.

50

The tissues of cardiac muscle have unique structures known as

- **A)**circular muscle fibers
- **B)**abundant elastic fibers
- **C)**intercalated disks.
- **D)**pacemaker cells

51

Intercalated disks are capable of doing which of the following?

- **A)**allow for re-growth of damaged muscle cells
- **B)**pass the resting potential to other cardiac cells
- **C)**pass electrical stimulation to other cardiac cells.
- **D)**allow for cardiac tissue to expand and contract properly

55

The functional connection between a nerve axon terminal and a muscle fiber is called a(an)

- **A)**T tubule
- **B)**I band
- **C)**synapse.
- **D)**troponin-myosin component

56

When the neuron stimulates a muscle fiber, what molecule diffuses across the synaptic cleft?

- **A)**calcium
- **B)**acetylcholine.
- **C)**sodium
- **D)**sodium and potassium

57

Once a signal molecule has left the neuron and binds to a receptor molecule on the surface of the muscle fiber, a sodium channel opens, allowing more sodium entry into the muscle fiber and the creation of an action potential. Which substance is then released from the sarcoplasmic reticulum?

- **A)**calcium.
- **B)**acetylcholine
- **C)**sodium
- **D)**sodium and potassium

- Slow twitch oxidative fibers contain myoglobin and many _____.
- **A)**mitochondria
- **B)**motor end plates
- **C)**intercalated disks
- **D)**lysosomes
- **Feedback: Correct Answer**

58

Muscle fibers and neurons are called electrically excitable cells because

- **A)**their membranes change shape in response to electricity
- **B)**they generate action potentials.
- **C)**their surfaces respond to the release of acetylcholine
- **D)**they have junctional folds in the membranes that can trap electrical charges

59

Movement of which protein directly causes exposure of the active sites on the actin molecule?

- **A)**troponin
- **B)**tropomyosin.
- **C)**myosin
- **D)**acetylcholine
-

60

What type of molecule is acetylcholine?

- **A)**It is a protein
- **B)**It is a neurotransmitter.
- **C)**It is an activator ion
- **D)**It is a calcium binding molecule

61

Binding of acetylcholine with its receptor on muscle cells causes

- **A)**opening of a ligand-gated sodium channel.
- **B)**a gap in the cell membrane for calcium diffusion
- **C)**vesicular release of sodium ions
- **D)**opening of a voltage-gated calcium channel

62

What kind of molecule is an acetylcholine receptor?

- **A)**nucleic acid
- **B)**protein.
- **C)**carbohydrate
- **D)**lipid

63

What is the function of acetylcholinesterase?

- **A)**It closes the neuromuscular junction to stop a muscle contraction
- **B)**It acts as a receptor for acetylcholine
- **C)**It deactivates acetylcholine.
- **D)**It stimulates the synaptic knob into functioning
-

64

What is a typical value of the resting potential of the sarcolemma?

- **A)**70 to 80 mv
- **B)**-70 to -90 mv.
- **C)**-45 to -50mv
- **D)**-15to -20 mv

65

Which of the following is a molecule that binds to a receptor?

A) Acetylcholine.

B) Tropomyosin

C) Acetylcholinesterase

D) all of the above

66

Which of the following assures quick removal of neurotransmitter at the junction between a nerve and a muscle?

A) Acetylcholine

B) Dopamine

C) Acetylcholinesterase.

D) PABA

67

A buildup of acetylcholine in the synaptic cleft without breakdown may cause which of the following?

A) spastic paralysis.

B) Treppe

C) myasthenia gravis

D) flaccid paralysis

68

In a muscle twitch, which of the following represents the time between application of a stimulus and the beginning of contraction?

A) Treppe

B) Tetany

C) lag or latent phase.

D) relaxation phase

69

Which of the following determines the height of the peaks in multiple motor unit summation?

A) the speed of stimuli

B) the amount of tension produced by the number of motor units responding.

C) the strength of each stimulus

D) none of the above

72

Which of the following is true of an isometric muscle contraction?

- **A)**The length of the muscle increases during the contraction
- **B)**It is responsible for rapid movements of the extremities
- **C)**The contraction is divided into concentric and eccentric
- **D)**The amount of tension increases during the contraction.

73

Eccentric muscle contractions occur when

- **A)**a person slowly lowers a heavy weight.
- **B)**no tension is developed in the muscle
- **C)**a person rapidly raises a lighter weight
- **D)**the length of the muscle decreases

One of the characteristics of muscle tissue is that is has conductivity. Which of the following best describes this characteristic?

- **A)**Muscles contract when stimulated.
- **B)**Muscles have local electrical charges that are capable of moving along the muscle fiber.
- **C)**Muscles only pull; they cannot push.
- **D)**Muscles can stretch when needed.
- **Feedback: Conductivity means that muscles have local electrical charges that are capable of moving along the muscle fiber.**

77

The sum of active and passive tension is called

- **A)**concentric tension
- **B)**total tension.
- **C)**sarcomere tension
- **D)**treppe

78

Which of the following types of muscle fatigue are due to calcium imbalances?

- **A)**psychological
- **B)**synaptic
- **C)**muscular.
- **D)**axonic

79

Which of the following types of fatigue is caused by the release of more acetylcholine than can be produced to replace it?

- **A)**muscular
- **B)**psychological
- **C)**synaptic.
- **D)**physiological

80

Muscle soreness can be produced by which of the following?

- **A)**damage to muscle fibers
- **B)**enzymes in the extracellular fluid commonly found within muscle
- **C)**collagen fragments in the extracellular fluid
- **D)**all of the above.

81

Which of the following represents extreme muscular fatigue when the muscle is incapable of either contracting or relaxing?

- **A)**physiological contracture.
- **B)**physiological contraction
- **C)**psychological fatigue
- **D)**synaptic fatigue

82

Which of the following energy storages source is most commonly used during the first 10 seconds of exercise?

- **A)**ATP
- **B)**creatine phosphate.
- **C)**lactic acid
- **D)**none of the above
-

83

During anaerobic respiration, what is the net amount of ATP produced?

- **A)**4 ATP.
- **B)**6 ATP
- **C)**20 ATP
- **D)**2 ATP

84

Which of the following represents the amount of oxygen that is necessary for the body to recover from anaerobic respiration?

- **A)**creatine phosphate utilization period
- **B)**oxygen overload
- **C)**oxygen debt.
- **D)**aerobic respiration

85

All of the following are characteristics of slow-twitch fibers except

- **A)**slow contraction
- **B)**large diameter.
- **C)**good blood supply
- **D)**many mitochondria

86

All of the following are true about fast-twitch fibers except

- **A)**high amount of myoglobin.
- **B)**rapid contraction
- **C)**break down ATP rapidly
- **D)**fewer mitochondria than slow-twitch fibers

87

Which of the following is true about distribution of fast and slow-twitch fibers in the body?

- **A)**Fast-twitch fibers are primarily found in long distance runners
- **B)**Slow-twitch fibers are usually more resistant to fatigue.
- **C)**There is a clear separation of slow- and fast-twitch fibers in individual muscles
- **D)**Training does not influence the balance of fast- and slow-twitch fibers

88

A person with an arm immobilized in a cast for 6 weeks will

- **A)**develop muscular hypertrophy
- **B)**decrease the number of muscle fibers
- **C)**develop muscular atrophy.
- **D)**Both B and C

89

Which of the following effects of exercise elevate the body temperature?

- **A)**elevated metabolism from the oxygen debt
- **B)**an increased rate of chemical reactions
- **C)**skeletal muscle contractions
- **D)**all of the above.

90

Unitary smooth muscle is found in which of the following locations in the body?

- **A)**digestive tract
- **B)**reproductive tract
- **C)**urinary tract
- **D)**all of the above.

91

Which of the following is true about smooth muscle?

- **A)**The resting membrane potential is usually less negative than in skeletal muscle
- **B)**It responds in an "all or none" fashion
- **C)**It does not respond to hormones
- **D)**It has a faster speed of contraction than skeletal muscle.

92

Which of the following are the most common neurotransmitters in smooth muscle?

- **A)**dopamine and epinephrine
- **B)**acetylcholine and epinephrine
- **C)**acetylcholine and norepinephrine.
- **D)**acetylcholine and dopamine

93

All of the following are properties of cardiac muscle cells except

- **A)**intercalated discs
- **B)**involuntary
- **C)**branching fibers
- **D)**shorter in duration of contraction than skeletal. muscles.

94

Which of the following is not an effect of aging on skeletal muscle?

- **A)**increased time for muscle to respond to stimuli
- **B)**increased myoglobin.
- **C)**increased recovery time
- **D)**loss of muscle fibers

95

Dystrophin is a(an)

- **A)**ion channel
- **B)**lipid that binds myosin myofilaments to the Z disk
- **C)**protein in the sarcoplasmic reticulum
- **D)**protein.

Which of the following toxins inhibits the release of acetylcholine from alpha-motor neurons?

- A.Botulinum toxin.
- B.Cholera toxin
- C.Saxitoxin
- D.Tetanus

A stronger than normal stimulus can cause

- excitation of nerve or muscle during the:
- A.absolute refractory period
- B.relative refractory period.
- C.spike potential
- D.overshoot

Excitability, in neurophysiology, is defined as

- A. presence of a resting membrane potential
- B.use of more than 30% of ATP synthesized for powering the Na-K ATPase
- C.response to a threshold stimulus with a propagated action potential.
- D.presence of voltage gated ion channels in a

White blood cell,

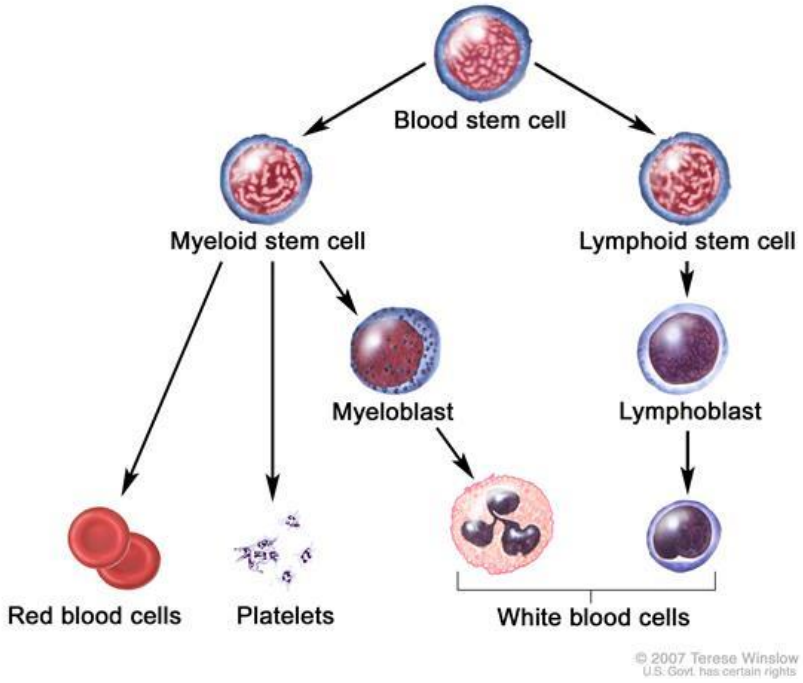
- also called **leukocyte** or **white corpuscle**, a cellular component of the blood.
- lacks hemoglobin,
- has a nucleus,
- is capable of motility,
- and defends the body against infection and disease by ingesting foreign materials and cellular debris, by destroying infectious agents , or by producing antibodies.

Definition

The tissues and organs that produce, store, and carry white blood cells that fight infections and other diseases.

This system includes the

- Bone Marrow
- Spleen
- Thymus



- The granulocytes and monocytes are formed only in the bone marrow.
- Lymphocytes and plasma cells are produced mainly in the various lymphogenous tissues- especially the lymph glands
- spleen
- Thymus
- Tonsils
- various pockets of lymphoid tissue such as bone marrow
- and in payer patches underneath the epithelium in the gut wall.

Leucopoiesis

Definition

The process of development and maturation of white blood cells(leucocytes), is called leucopoiesis.

Definition

- ***White blood cells*** *or* ***leukocytes*** are cells of the immune system which defend the body against both infectous disease and foreign materials.

➢ ***Characters of WBCs:***

1. Whenever a germ or infection enters the body the white blood cells have a variety of ways by which they can attack. Some will produce protective antibodies that will overpower the germ. Others will surround and devour the bacteria.

- A healthy adult human has between 4,500 and 11,000 white blood cells per cubic millimetre of blood.

Leukocytosis

- Fluctuations in white cell number occur during the day; lower values are obtained during rest and higher values during exercise. An abnormal increase in white cell number is known as leukocytosis
- White cell count may increase in response to intense physical exertion, convulsions acute emotional reactions, pain, pregnancy, labour (physiological leukocytosis)and certain disease states, such as infections and intoxications.(pathological leukocytosis).

- Although white cells are found in the circulation, most occur outside the circulation, within tissues, where they fight infections; the few in the bloodstream are in transit from one site to another.
- White cells, containing a nucleus and able to produce ribonucleic acid (RNA) can synthesize protein
- White cells are highly differentiated for their specialized functions
-

White blood cells

- On the basis of their appearance under a light microscope, white cells are grouped into three major classes—lymphocytes, granulocytes, and monocytes—each of which carries out somewhat different functions.

lymphocytes

- mostly stored in the various lymphoid tissues except for a small number that are temporarily being transported in the blood.
- Lymphocytes which are further divided into B cells and T cells, are responsible for the specific recognition of foreign agents and their subsequent removal from the host.
- B lymphocytes secrete antibodies, which are proteins that bind to foreign microorganisms in body tissues and mediate their destruction.

  Typically, T cells recognize virally infected or cancerous cells and destroy them, or they serve as helper cells to assist the production of antibody by B cells.
- Also included in this group are natural killer (NK) cells, so named for their inherent ability to kill a variety of target cells. In a healthy person, about 25 to 33 percent of white blood cells are lymphocytes

Their common functions are

1. **NK Cells:**

   Usually have cytotoxic activity against a wide range of tumor cells and also against some cells infected with viruses.

2. **T-Lymphocytes**

   They identify and bind to antigenswhich are bound to MHC complex,a self antigen on the surface of T-cells.

3. **B-Lymphocytes**

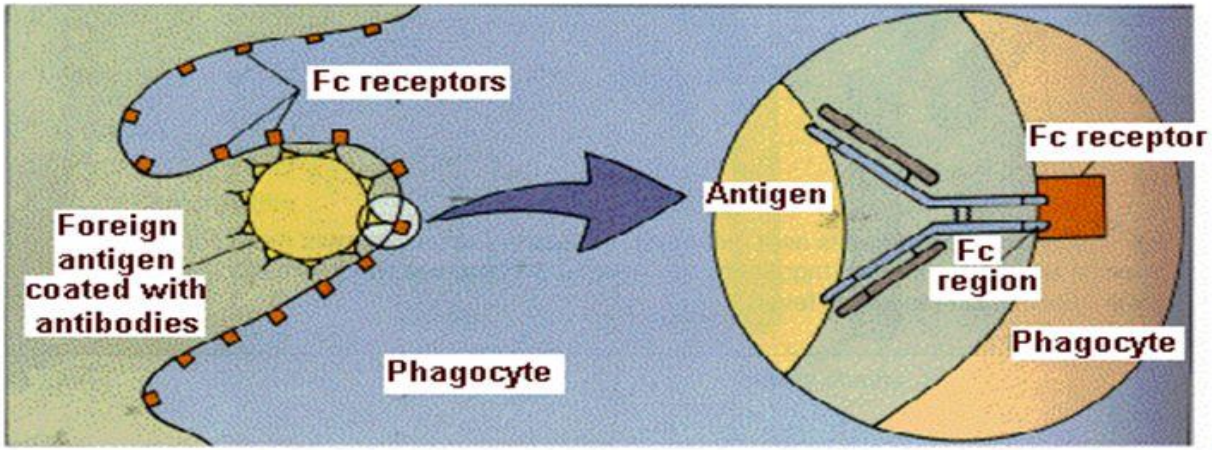
   Produce antibodies against a given antigen.The Abs act as receptors.

T cells

T cells or **T lymphocytes** are a type of lymphocytes (itself a type of white blood cells) that play a central role in cell-mediated immunity. They can be distinguished from other lymphocytes, such as B cells and natural killer cells (NK cells), by the presence of a *T-cell receptor* (TCR) on the cell surface. They do not have antigen-presenting They are called *T* cells because they mature in the thymus.

Opsonization and Inactivating an Antigen

Opsonization: Certain bacterial cells have so many AG determinants that the antibodies coat the bacteria cell. The constant regions stick out (called the FC region). The phagocytes have FC receptors. This interaction allows the phagocyte to roll over the pathogen and phagocytosis occurs.

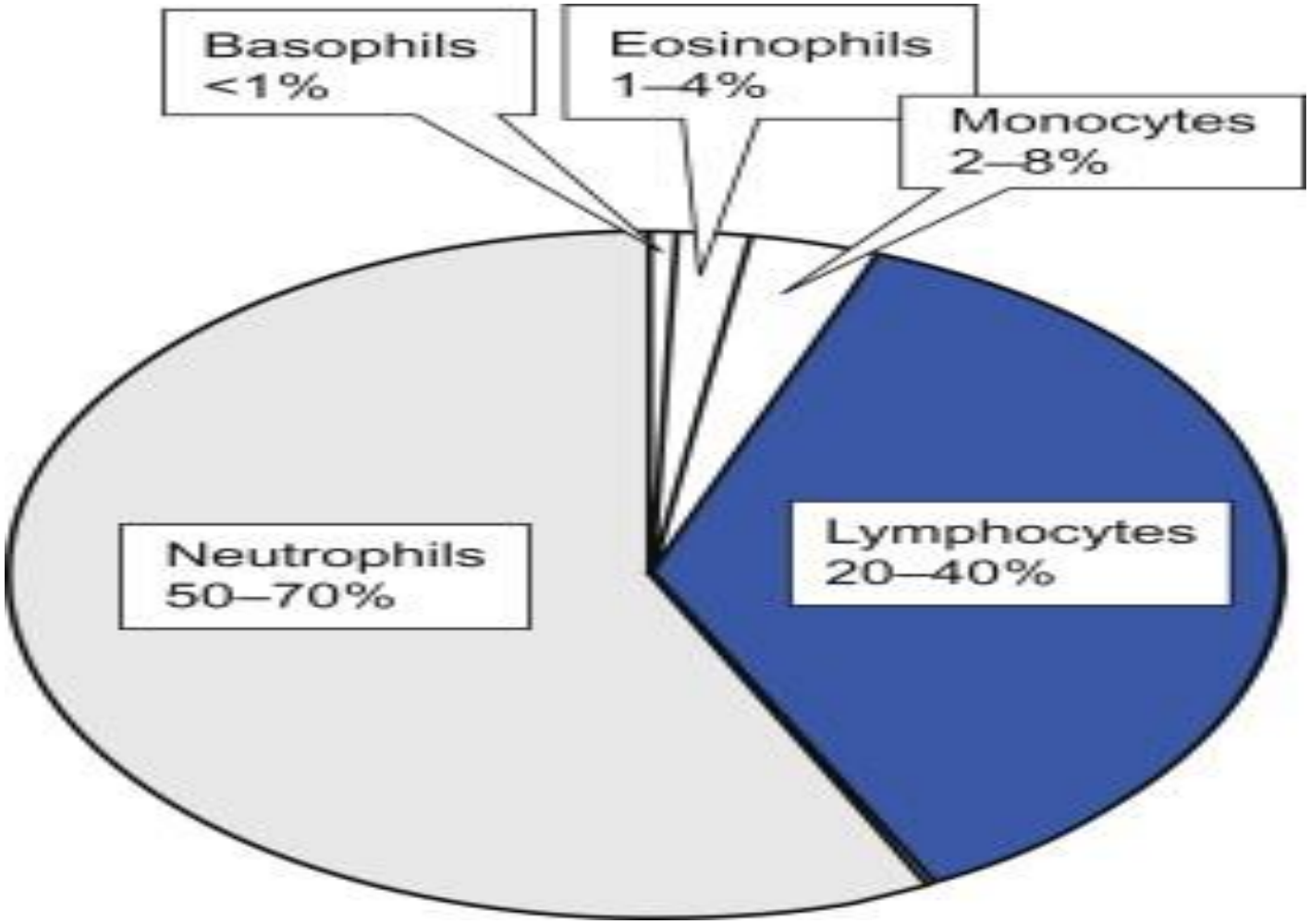


Granulocytes

- most numerous of the white cells, rid the body of large pathogenic organisms such as protozoans or helminths and are also key mediators of allergy and other forms of inflammation
- These cells contain many cytoplasmic granules, or secretory vesicles, that harbour potent chemicals important in immune responses.
- They also have multilobed nuclei, and because of this they are often called polymorphonuclear cells.

Granulocytes--- subdivided into three categories

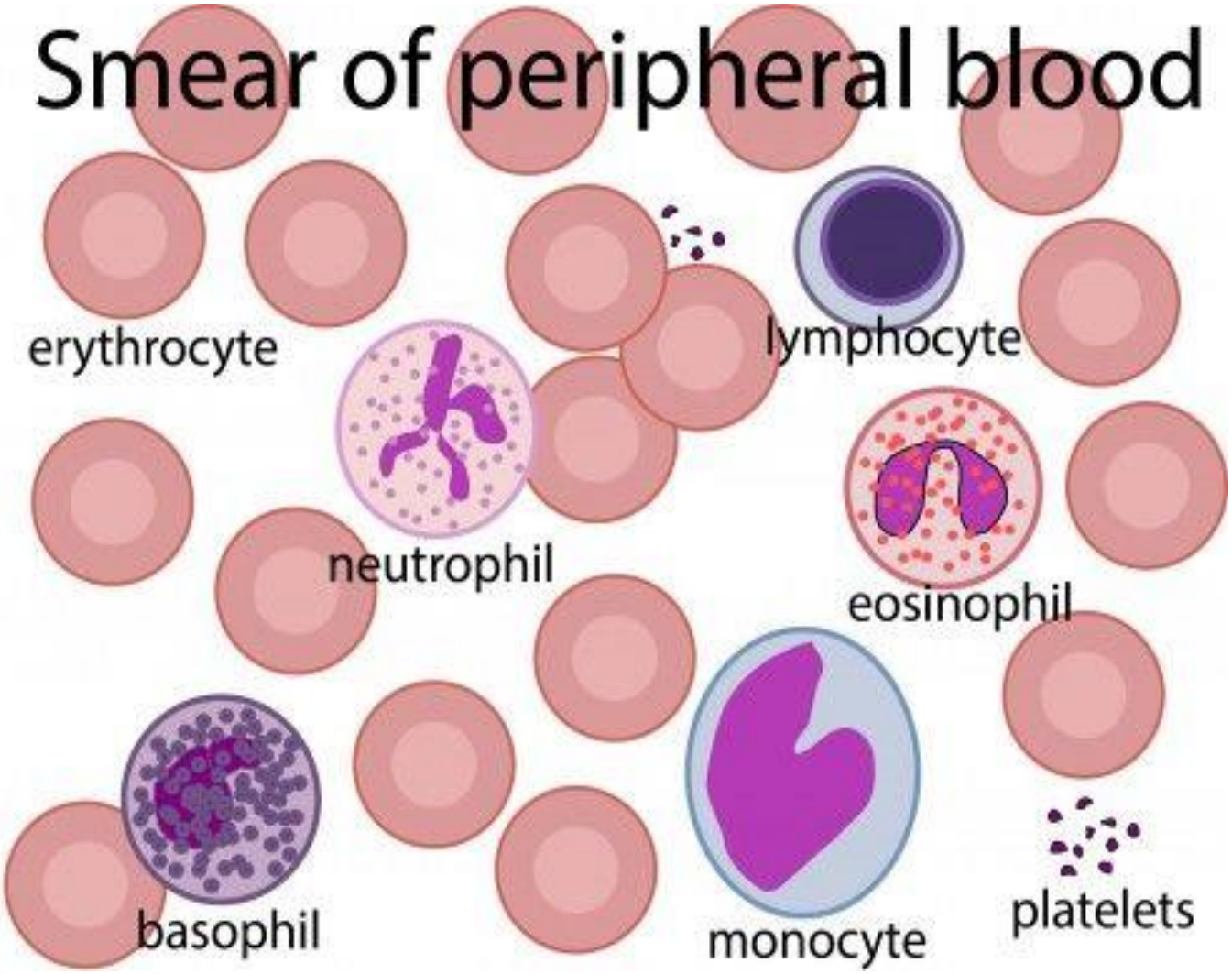
- : **NEUTROPHILS, EOSINOPHILS** and **BASOPHILS.**
- The most numerous of the granulocytes—making up 50 to 80 percent of all white cells—are neutrophils.
-


Basophils
<1%
Eosinophils
1–4%
Monocytes
2–8%
Lymphocytes
20–40%
Neutrophils
50–70%

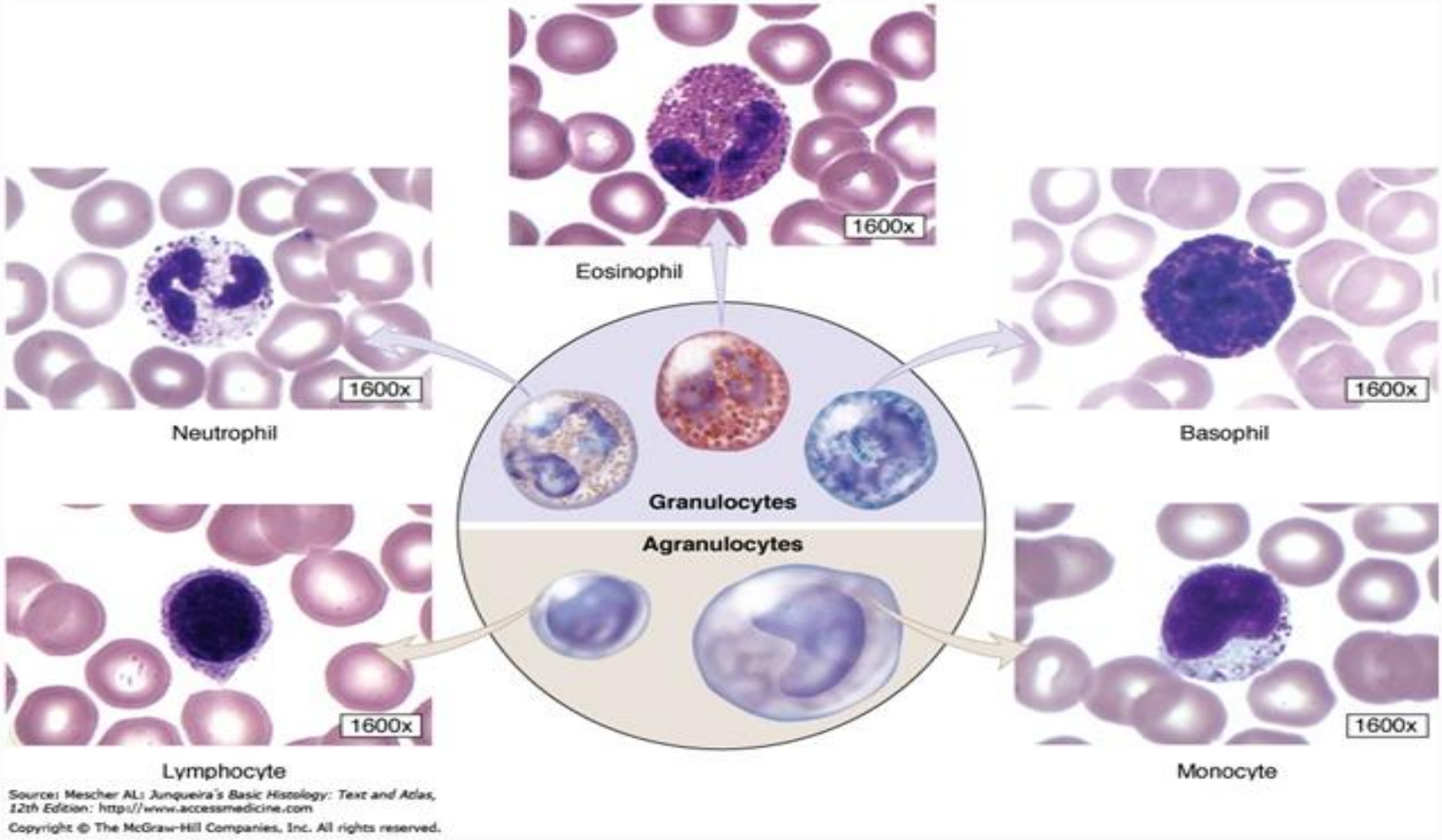
- Eosinophils and basophils, as well as the tissue cells called mast cells, typically arrive later.
- The granules of basophils and of the closely related mast cells contain a number of chemicals, including **histamine** and **leukotrienes**, that are important in inducing allergic inflammatory responses.
- Eosinophils destroy parasites and also help to modulate inflammatory responses.

- **MONOCYTES** which constitute between 4 and 8 percent of the total number of white blood cells in the blood, move from the blood to sites of infection, where they differentiate further into **MACROPHAGES.**
- These cells are scavengers that phagocytose whole or killed microorganisms and are therefore effective at direct destruction of pathogens and cleanup of cellular debris from sites of infection.
- macrophage are more powerful phagocytes than neutrophils.

Smear of peripheral blood



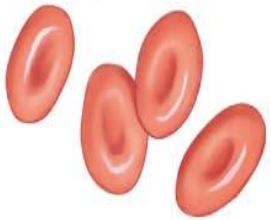
Wbcs serve as Sanitary engineers cleaning up dead cells and tissue debris that otherwise accumulate to and lead to problems.



The formed elements in blood, a fluid connective tissue with a watery matrix called plamsa

Red Blood Cells

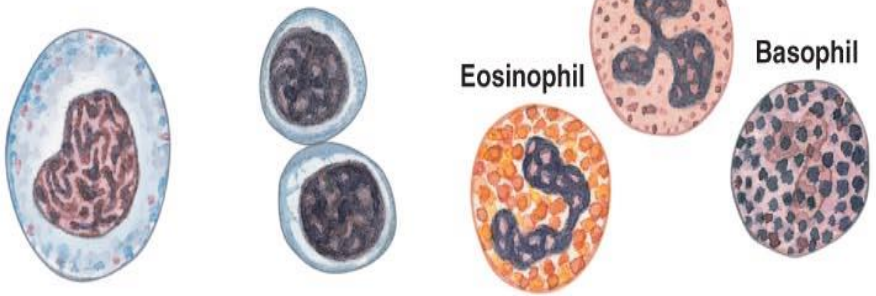
Red blood cells are formed elements responsible for the transport of oxygen (and, to a lesser degree, of carbon dioxide) in the blood.



Red blood cells account for roughly half the volume of whole blood and give blood its color.

White Blood Cells

White blood cells are formed elements that help defend the body from infection and disease.



Monocytes are phagocytes similar to the free macrophages in other tissues.

Lymphocytes are uncommon in the blood but they are the dominant cell type in lymph, the second type of fluid connective tissue.

Eosinophils and **neutrophils** are phagocytes. **Basophils** promote inflammation much like mast cells in other connective tissues.

Platelets

Platelets are formed elements consisting of membrane-enclosed packets of cytoplasm.

These cell fragments are involved in the clotting response that seals leaks in damaged or broken blood vessels.

Life Span Of WBC

- Not constant.
- ❑ Neutrophils -> 2-5 days
- ❑ Eosinophils -> 7-12 days
- ❑ Basophils -> 12-15 days
- ❑ Monocytes -> 2-5 days
- ❑ Lymphocytes -> ½-1 day

Life span of white blood cells

- Granulocytes after being released from the bone marrow is normally 4 to 8 hours circulating in the blood and another 4 to 5 days in tissues where they are needed.
- In case of serious tissue infection it is shortened to only few hours because the granulocytes proceed even more rapidly to the infected area perform their functions and in the process are themselves destroyed.

- Monocytes life span is 10 to 20 hours in the blood before wandering through the capillary membranes into the tissues.
- Once in the tissues they swell to much larger sizes(60 -80 micron the size that can barely be seen by the naked eye) to become tissue macrophage system which provides continuing defense against infection.

Lymphocytes

- Lymphocytes enter the circulatory system continually along with drainage of lymph from the lymph nodes and other lymphoid tissues.
- After few hours they pass back into the tissues by diapedesis..
- then they re enter the lymph and return to the blood again and again thus there is continual circulation of lymphocytes through the body.
- Lymphocytes have life span of weeks or months depending on the body need for these cells.

- **Neutrophils and macrophages are the main phagocytic cells of the body,**
- but macrophages are much larger and longer-lived than neutrophils.
- Some macrophages are important as antigen-presenting cells, cells that phagocytose and degrade microbes and present portions of these organisms to T lymphocytes, thereby activating the specific acquired immune response.

- Specific types of cells are associated with different illnesses and reflect the special function of that cell type in body defense.
- In general, newborns have a high white blood cell count that gradually falls to the adult level during childhood.
- An exception is the **lymphocyte count**, which is low at birth, reaches its highest levels in the first four years of life, and thereafter falls gradually to a stable adult level.

Leukopenia

- whereas an abnormal decrease in number is known as Leukopenia.
- The count may decrease in response to certain types of **infections** or **drugs** or in **association with certain conditions, such as chronic anemia**, **malnutrition**, or anaphylaxis

Table 4. Selected Conditions Associated with Elevations in Certain White Blood Cell Types

White blood cell line	*Conditions that typically cause elevations*
Basophils	Allergic conditions, leukemias
Eosinophils	Allergic conditions, dermatologic conditions, eosinophilic esophagitis, idiopathic hypereosinophilic syndrome, malignancies, medication reactions, parasitic infections
Lymphocytes	Acute or chronic leukemia, hypersensitivity reaction, infections (viral, pertussis)
Monocytes	Autoimmune disease, infections (Epstein-Barr virus, fungal, protozoan, rickettsial, tuberculosis), splenectomy
Neutrophils	Bone marrow stimulation, chronic inflammation, congenital, infection, medication induced, reactive, splenectomy

Neutrophil recruitment

- Neutrophils make up the first wave of cells that cross blood vessel wall to enter inflammatory site
- Four steps:

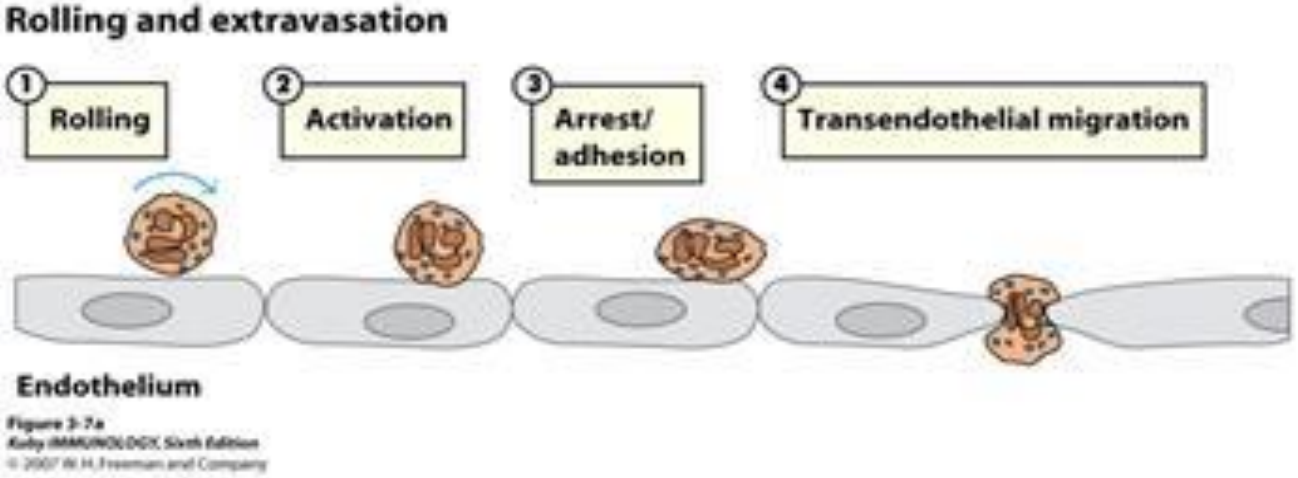


Figure 3-7a
Kuby IMMUNOLOGY, Sixth Edition
© 2007 W. H. Freeman and Company

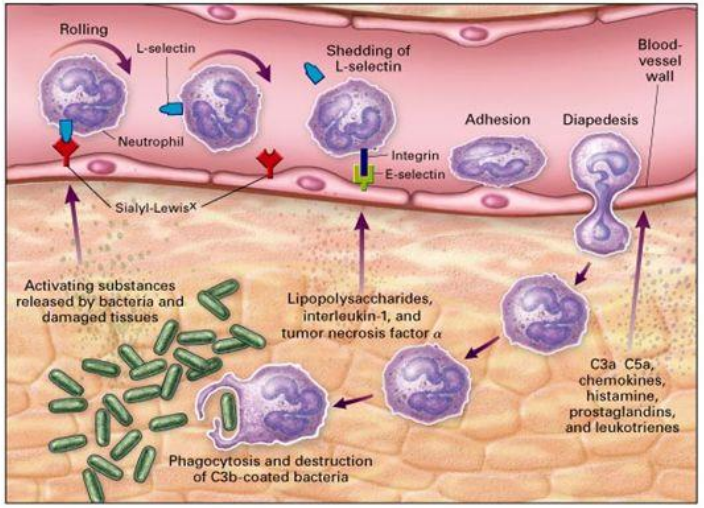
http://www.youtube.com/watch?v=xKoncIMFPtg

Neutrophil function

The main function of neutrophils – internalization of microorganisms

Phagocytosis - three phases:

1. Migration and diapedesis (outward passage of cells through intact vessel walls)
2. Opsonization and recognition
3. Ingestion, killing and digestion (phagocytosis)

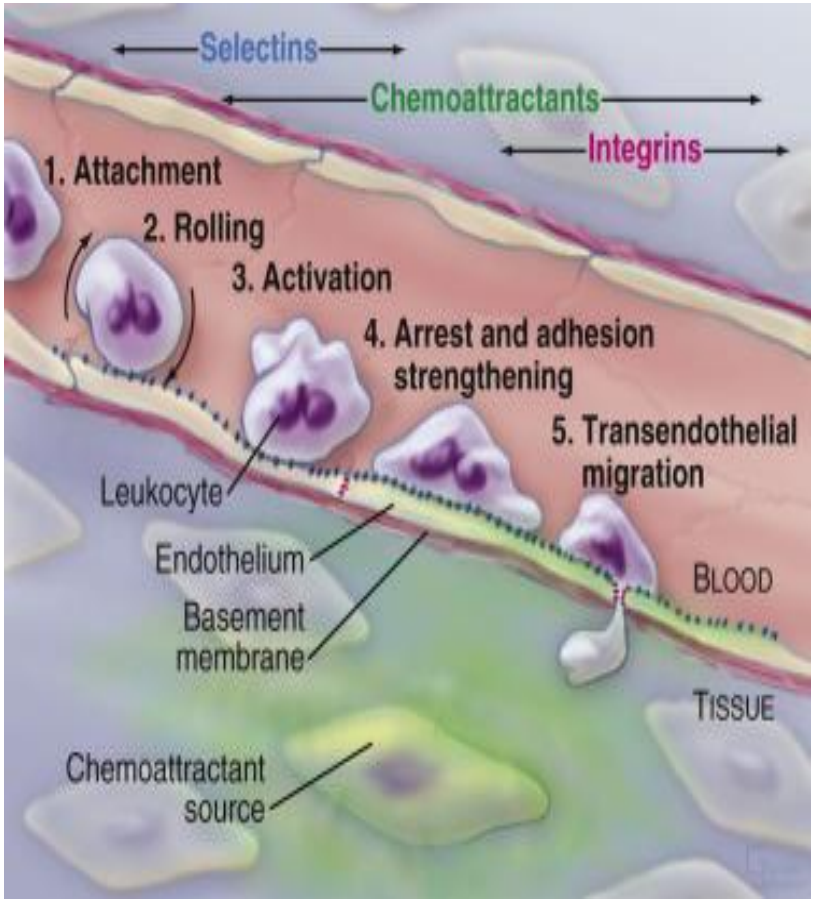


- Neutrophils and monocytes can squeez through the pores of the blood capillaries by **Diapedesis.**
- That is even through the pores is much smaller then the cell a small portion of the cell slide through the pore at a time, the portion sliding through is momentarily constricted to the size of pore.

- White blood cells move through tissues spaces by **ameboid motion.**
- Both neutrophils and macrophages can move through the tissues by ameboid motion.
- Some cells move at velocities of 40 micro meter/min a distance great as their own length each minute

margination

- When the inside of the capillary wall is altered the neutrophils stick to the capillary walls.This is called as margination.



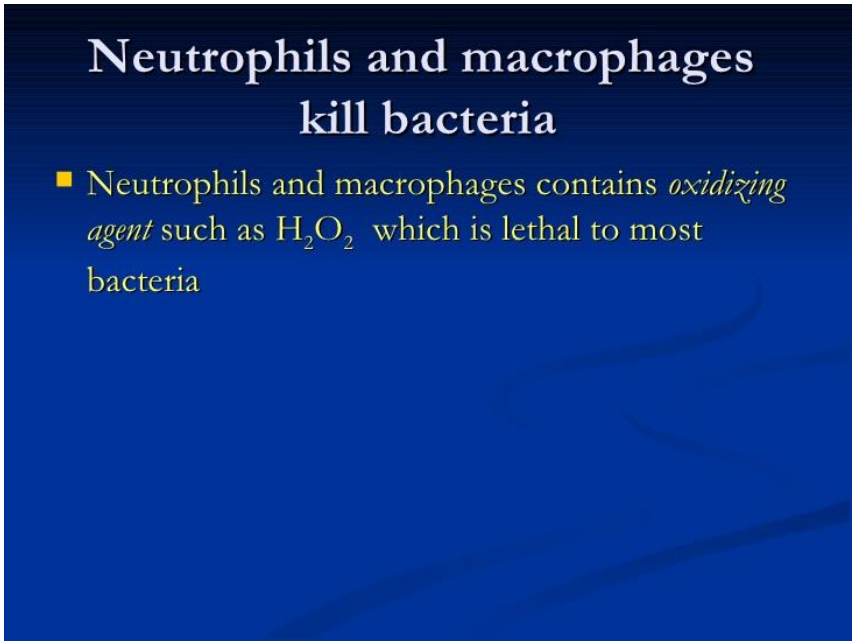
Chemotaxis

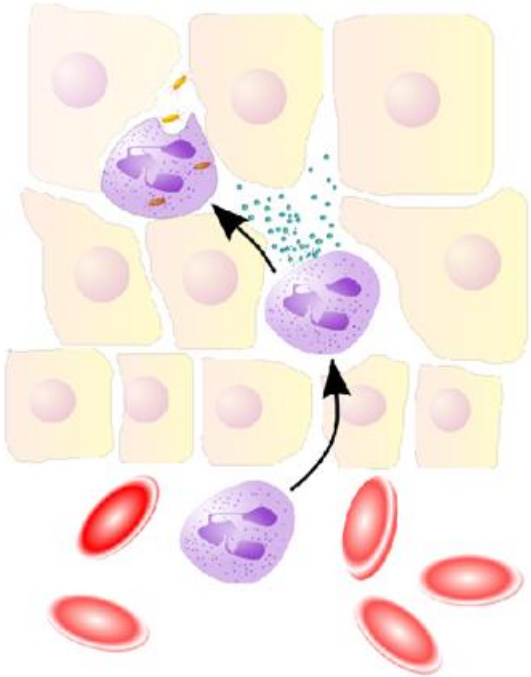
- Many different chemical substances in the tissues cause both neutophils and macrophages to move towards the source of the chemical .this phenomenon is called as Chemotaxis.They include
- some of the bacterial or viral toxins
- Degenerative products of the inflammed tissues.
- Several reaction products of the plasma clotting in the inflamed area.
- Chemotaxis depends upon the concentration gradient of chemotaxic substances.

PHAGOCYTOSIS or cellular ingestion of the offending agent

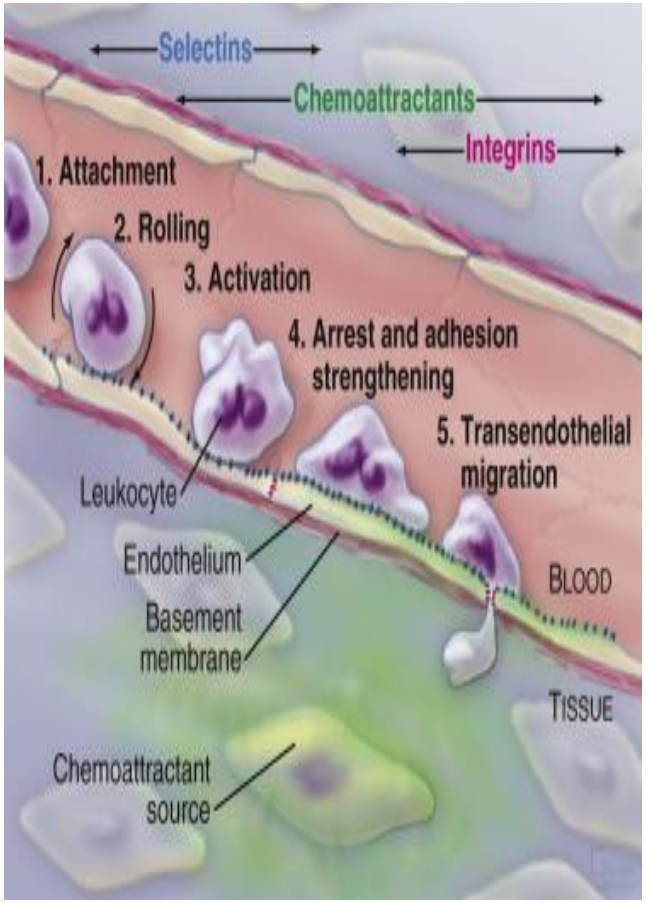
- Neutrophils are first cell types to arrive at a site of infection, where they engulf and destroy the infectious microorganisms through a process called **PHAGOCYTOSIS**,
- phago meaning eating cyte meaning vessel and osis meaning process.
- The likelihood of phagocytosis is increased
- if the surface is rough
- the particles is dead
- foreign particles
- as the natural substances in the tissues have smooth protein coats which repel phagocytosis.

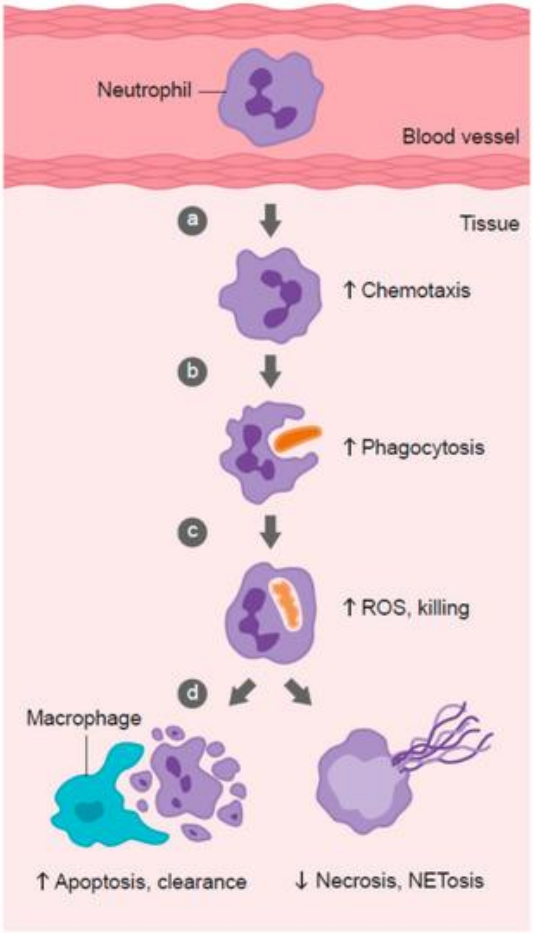
- Lysosome in the neutrophils and macrophages come in contact with the phagocytic vesicles and digestion of phagocytized particles begin.
- Both neutrophils and macrophages contain proteolytic enzymes
- The lysosome in the macrophages contain lipases





Neutrophils migrate from blood vessels to the inflamed tissue via chemotaxis, where they remove pathogens through phagocytosis and degranulation


Selectins
Chemoattractants
Integrins
1. Attachment
2. Rolling
3. Activation
4. Arrest and adhesion strengthening
5. Transendothelial migration
Leukocyte
Endothelium
Basement membrane
BLOOD
TISSUE
Chemoattractant source


Neutrophil
Blood vessel
Tissue
a
↑ Chemotaxis
b
↑ Phagocytosis
c
↑ ROS, killing
d
Macrophage
↑ Apoptosis, clearance
↓ Necrosis, NETosis

Monocyte-Macrophage Cell System

- The combination of monocytes, mobile macrophages, fixed tissue macrophages and specialized endothelial cells in the bone marrow, spleen and lymph nodes is called Monocyte-Macrophage cell system or *reticuloendothelial* system

- Tissue macrophage provide a **first line of defence**.
- Neutrophil invasion of the inflamed area is a **second line of defence**.
- Second macrophage invasion into the inflamed tissue is a **third line of defence.**
- Increased production of granulocytes and monocytes by the bone marrow is a **fourth line of defence**.