Cardiac Action Potential

1. What two cell types are involved in producing a coordinated heart contraction?

Cardiac autorhythmic cells and cardiac contractile cells.

2. How do the cardiac autorhythmic cells and cardiac contractile cells work together to produce a coordinated heart contraction?

Action potentials generated by autorhythmic cells, create waves of depolarization that spread to contractile cells via gap junctions.

3. Before cardiac autorhythmic and contractile cells depolarize, what is the charge inside and outside the cell?

Positive out, negative in.

4. When cardiac autorhythmic and contractile cells depolarize, what happens to the charge inside and outside the cell?

Charge becomes negative outside, positive inside.

5. When cardiac autorhythmic and contractile cells repolarize, what happens to the charge inside and outside the cell?

Charge becomes positive outside, negative inside

6. When do cardiac contractile cells contract and relax with respect to depolarization and repolarization of the cell?

The cells depolarize first, then the muscle contracts, repolarization occurs, and the cells relax.

7. Embedded in the plasma membrane of an autorhythmic cell are protein channels that allow sodium, calcium, and potassium to move into or out of the cell. In which direction do the ions move through these channels?

Sodium and calcium move into the cell, potassium moves out of the cell.

8. What is the function of gap junctions?

Gap Junction connects adjacent cardiac cells, allowing ions to pass between cells. When ions pass from one cell to another, they cause depolarization in the other cell.

9. What are the three steps in the initiation of action potential in an autorhythmic cell?
1. Pacemaker Potential 2. Depolarization and Reversal of the Membrane Potential 3. Repolarization

10. What is responsible for the pacemaker potential?

 Autorhythmic cells slowly but spontaneously depolarize due to a slow continuous influx of sodium through the sodium channels.

11. What is the order of steps in an action potential within an autorhythmic cell? (write letters in the correct order)

   a. Fast calcium channels open and positively-charged calcium ions rush in.

   b. Depolarization peaks at about +10 mV.

   c. Autorhythmic cell starts out at resting membrane potential (~-60 mV), positive out, negative in.

   d. When the membrane potential gets to -40 millivolts, it has reached threshold for initiating an action potential.

   e. Potassium channels open, resulting in potassium rapidly leaving the cell.

   f. Cell begins depolarizing due to a slow continuous influx of sodium.

   g. Calcium influx produces the rapidly rising phase of the action potential (depolarization), which results in the reversal of membrane potential from negative to positive inside the cell.

   h. Membrane potential goes from +10 mV to resting membrane potential (-60 mV).

   c,f,d,a,g,b,e,h

12. What is responsible for reestablishing ion levels in autorhythmic cells?

 Ionic pumps actively transport calcium back to the extracellular space during repolarization. Na+/K+ pumps also pump sodium out and potassium in.

13-15. Match the following events in autorhythmic cells:

A. Repolarization       y       x. due to influx of sodium

B. Pacemaker Potential   x       y. due to efflux of potassium

C. Depolarization and reversal of the membrane   z. due to influx of calcium
16. What allows depolarization to move from autorhythmic cells to the contractile cells?

Gap junctions

17. What allows depolarization to move from one contractile cell to another contractile cell?

Gap junctions

18. Where is calcium stored within contractile cells?

In the sarcoplasmic reticulum.

19-21. What are the three steps in the action potential in a contractile cell?

1. Depolarization 2. Plateau 3. Repolarization

Anatomy Review: The Heart

22. What's the difference between the blood in the right side of the heart and the left side of the heart?

In the right side of the heart, the blood is oxygen-poor, CO₂-rich. In the left side of the heart, the blood is oxygen-rich, CO₂-poor.

23-25. a. Where does the blood go that is pumped out of the right heart?

To the lungs

b. What happens to the blood in the lungs?

It receives oxygen

c. Where does the blood go that is pumped out of the left heart?

To the organs and the tissues of the rest of the body (besides the lungs)

26. What are the pulmonary circuit and the systemic circuit?

Pulmonary Circuit: Oxygen-poor blood is pumped from the right side of the heart to the lungs. Here it receives oxygen and travels back to the left heart.

Systemic Circuit: The left side of the heart pumps oxygen-rich blood out to the body's tissues and organs. After the blood's oxygen is depleted, it returns to the right side of the heart.
27. What three structural features are found on histological images of cardiac muscle?

**Nuclei, Intercalated Disks, and Cardiac Myofibrils**

28. What are the names of the two types of cell junctions in cardiac muscle cells?

**Desmosomes and gap junctions**

29. What is the function of desmosomes?

**The desmosomes are anchoring junctions that hold adjacent cells together.**

30. What is the function of gap junctions?

**The gap junctions allow the stimulating impulse to move across the heart, from cell-to-cell, so the heart beats as an entire unit.**

**Autoregulation and Capillary Dynamics**

31. What is autoregulation?

**The process by which the various organs and tissues of the body self-regulate blood delivery.**

32. Where does blood flow regulation occur?

**At the capillary beds.**

33. Where does exchanges of materials take place between tissue cells and the blood?

**Only in the true capillaries.**

34. What regulates the flow of blood into the true capillaries?

**Precapillary sphincters.**

35. The build-up of certain chemical signals in an area of the body can act as a metabolic control, bringing more blood to the capillaries of the area. What two types of blood vessels do these chemical signals affect and how do they work?

**(1) The chemicals cause the feeder arterioles to dilate, bringing more blood into the local area. (2) The chemicals also cause the precapillary sphincters to relax allowing blood to enter the capillaries.**

36. Will the precapillary sphincters open or close in a capillary bed that is high in oxygen? Explain.
Close, because if the oxygen levels in the tissue cells are high, no more blood flow is needed in that area until the oxygen levels are lower again.

37. Will the precapillary sphincters open or close in a capillary bed that is high in carbon dioxide? Explain.

Open. Carbon dioxide is a waste product. If it builds up in a capillary bed, then the precapillary sphincters will open to allow it to be removed from the area.

38. Will the precapillary sphincters open or close in a capillary bed that has a high pH? Explain.

Close. Typically acids that accumulate must be removed from tissues. So when there is a low pH a lot of acid is present and the precapillary sphincters open. When there is a high pH the precapillary sphincters close.

39. Will the precapillary sphincters open or close in a capillary bed that is high in nutrients? Explain.

Close. If nutrients are already present in a capillary bed, precapillary sphincters will close. They open when nutrients are needed.

40. Why would a decreased blood pressure cause precapillary sphincters to open?

It allows more blood to reach the capillary bed, even though the pressure is low.

41. List three ways materials move from the lumen of the capillary into the interstitial spaces.

(1). Through fenestrations  (2) Through clefts  (3) Via cytoplasmic vesicles

42. What are fenestrations?

Pores between capillary endothelial cells that may be opened or covered by a very delicate membrane.

43. How do clefts differ from fenestrations?

Fenestrations tend to be larger than clefts. Clefts are not covered by a membrane.

44. Explain how materials are moved across an endothelial cell via bulk transport.

The materials would be brought into the endothelial cell via endocytosis at the side of the cell facing the lumen of the capillary. The cytoplasmic vesicle moves to the side of the endothelial cell facing the interstitial fluid. Exocytosis occurs, which releases the materials into the interstitial fluid.

45. Most solutes move across the capillary wall by diffusion. Define diffusion.
The movement of solutes from an area of higher concentration to lower concentration.

46. What happens if more fluid leaves the capillaries than is returned to the capillaries?

The fluid enters the lymph capillaries and are carried back to the bloodstream.

47. Why is the osmotic pressure of the interstitial fluid typically very low?

Because proteins which leak out of the blood are quickly gathered up by the lymph capillaries, keeping the protein concentration low.

Blood Pressure Regulation

48. What are baroreceptors?

Sensory receptors that detect increased pressure, by increased stretch in arterial walls.

49. Where are the baroreceptors that sense blood pressure located?

In the carotid sinus, aortic arch, and other large arteries of the neck and thorax.

50. What happens to baroreceptors when blood pressure is high?

Increased blood pressure stretches arterial walls, stimulating the baroreceptors. The result is an increase in sensory signals to the brain.

51. What happens to both parasympathetic activity and sympathetic activity when blood pressure is high?

Get increased parasympathetic activity and decreased sympathetic activity.

52. What is angiotensinogen?

An inactive plasma protein.

53. How is angiotensinogen activated?

It binds to renin which activates it into angiotensin I.

54. What happens when aldosterone binds to the cells of the distal convoluted tubule?

Sodium ions are reabsorbed from the filtrate within the distal convoluted tubule into the peritubular capillaries.

55. How does aldosterone increase the blood volume and blood pressure?
Aldosterone causes sodium to move into the bloodstream. The water that follows the sodium increases the blood volume and therefore the blood pressure.

56. What effect does dehydration due to sweating, diarrhea, or excessive urine flow have on osmolarity of the blood, blood volume, and blood pressure?

It increases the osmolarity of the blood, decreases the blood volume, and decreases the blood pressure.

57. An increased osmolarity of the blood causes the release of what hormone? What is its effect? What is its mechanism to accomplish this?

Antidiuretic hormone (ADH) increases water reabsorption in the kidney by stimulating an increase in the number of water channels.

**Measuring Blood Pressure**

58. What is the term used to express the force that blood exerts against the walls of blood vessels?

Blood pressure.

59. How is blood pressure generated?

The heart pumps the blood, and that blood flow is met by resistance from blood vessel walls.

60. In what units is blood pressure expressed?

In millimeters of mercury (mm Hg).

61. Does blood flow at the same rate in the exact center of a vessel compared to at the sides of the vessel?

No. Blood flows faster in the center of the vessel compared to near the walls of the vessel.

62. What is laminar flow and what causes it?

Laminar flow is the tendency for blood to flow faster in the center of a vessel than near the sides. It is due to the friction (resistance) between the blood and the vessel walls.

63. What is a pulse?

A pressure wave which travels from your heart throughout the arteries.

64. What is systolic pressure and what causes it?
Systolic pressure is the maximum pressure exerted by the blood against the artery walls when the ventricles pump the blood out of the heart.

65. What is ventricular systole?

Contraction of the ventricles.

66. What is a typical normal value for systolic pressure?

About 120 mm Hg

67. What does the dicrotic notch represent?

The interruption of smooth flow due to the brief backflow of blood that closes the aortic semilunar valve when the ventricles relax.

68. What is diastolic pressure and what causes it?

Diastolic pressure is the lowest pressure in the artery. It's a result of the relaxation of the ventricle.

69. What is ventricular diastole?

Relaxation of the ventricles.

70. What is pulse pressure?

The difference between systolic and diastolic pressure.

71. Why is mean arterial pressure closer to diastolic pressure than systolic pressure?

Because the heart stays longer in diastole.

72. Calculate the mean arterial pressure when systolic pressure is 120 mm Hg and the diastolic pressure is 80 mm Hg.

\[
\text{Mean Arterial Pressure (MAP)} = \text{Diastolic Pressure} + \frac{1}{3} \text{Pulse Pressure}
\]

\[
\sim 93 \text{ mm Hg} = \sim 80 \text{ mm Hg} + \sim 40 \text{ mm Hg}/3
\]

73. What do the sounds correspond to when a blood pressure is taken?

The first sounds that are heard indicate systolic pressure. When the sounds stop, diastolic pressure has been reached.

Match these terms to their characteristics:
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>74</td>
<td>Systolic Pressure</td>
<td>e</td>
</tr>
<tr>
<td>75</td>
<td>Dicrotic Notch</td>
<td>b</td>
</tr>
<tr>
<td>76</td>
<td>Diastolic Pressure</td>
<td>c</td>
</tr>
<tr>
<td>77</td>
<td>Pulse Pressure</td>
<td>a</td>
</tr>
<tr>
<td>78</td>
<td>Mean Arterial Pressure</td>
<td>d</td>
</tr>
</tbody>
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- **a.** the throb you feel when you take your pulse
- **b.** interruption of smooth flow due to the brief backflow of blood
- **c.** result of ventricular diastole
- **d.** the force that propels the blood through the arteries
- **e.** the result of ventricular systole