

- A. Upper - mouth to 5th tracheal cartilage; Lower - everything beyond the 5th tracheal cartilage
- * B. Upper - mouth to trachea carina; Lower - beyond carina through to the alveoli
- C. Upper - mouth to larynx; Lower - beyond larynx through to the alveoli
- D. Upper - mouth to primary bronchi; Lower - beyond bronchi through to the alveoli

The conducting zone starts with the nares (nostrils) of the nose, which open into the nasopharynx (nasal cavity). The primary functions of the nasal passages are to: filter warm moisten provide resonance in speech The nasopharynx opens into the oropharynx (behind the oral cavity) The oropharynx leads to the laryngopharynx, and empties into the larynx (voicebox), which contains the vocal cords, passing through the glottis, connecting to the trachea (wind pipe). The trachea leads down to the thoracic cavity (chest) where it divides into the right and left "main stem" bronchi The subdivision of the bronchus are: primary, secondary, and tertiary divisions (first, second and third levels). In all, they divide 16 more times into even smaller bronchioles. The bronchioles lead to the respiratory zone of the lungs which consists of respiratory bronchioles, alveolar ducts and the alveoli, the multi-lobulated sacs in w

2) The muscles involved with inspiration include

- A. External intercostals, internal intercostals, internal and external obliques
- * B. Diaphragm, external intercostals and internal intercostals
- C. Diaphragm, internal and external obliques
- D. Diaphragm, external intercostals and rectus abdominus

Inspiration is always active. It begins with the onset of contraction of the diaphragm, which results in expansion of the intrapleural space and an increase in negative pressure according to Boyle's Law. This negative pressure generates airflow because of the pressure difference between the atmosphere and alveolus. Air enters, inflating the lung through either the nose or the mouth into the pharynx (throat) and trachea before entering the alveoli. The external intercostal muscles and the ventral part of the internal intercostal muscles also play a role in expansion of the thorax.

3) The volume of air that enters the lungs during a single breath of normal or unforced inspiration is defined as

- A. functional residual capacity
- B. the minute volume
- C. vital capacity
- * D. the tidal volume
- E. functional capacity

Tidal volume is the amount of air breathed in or out during respiration - that is, the volume of air an individual is breathing in and out. Tidal volume increases during exercise. As a general guideline, tidal volume of a resting animal is about 12 ml/kg. <p>Minute volume is the volume of air which can be inhaled (inhaled minute volume) or exhaled (exhaled minute volume) from an animal's lungs in one minute. Or, tidal volume x breaths per minute.<p>Vital capacity the maximum amount of air that can be exhaled after a maximum inhalation (usually tested with a spirometer) <p>Functional residual capacity is the volume of air left in the lungs after normal expiration when pulmonary and thoracic elastic recoil forces are in equilibrium.<p>

4) Expiration at rest is always passive

- * A. False
- B. True

Horses and dogs have an active component during normal expiration.

5) Expiration is mostly passive due to the elastic recoil of the chest and lungs. Most of the lung recoil is generated by

- A. Diaphragm
- B. External and internal intercostal muscles
- * C. Alveoli
- D. Elastic tissue of lungs

Two-thirds of lung recoil force is created by the surface tension of alveoli. A third is derived from elastic tissue of the lungs. The surface tension is kept in check by a lipid, surfactant. The surfactant lining of the alveolus plays an important part in proper lung function including minimizing the work of breathing, ensuring uniform lung inflation, and reducing chemical and particulate damage to the deep lungs. In addition, recoil forces of the thorax help expel air during expiration. A Neonate's thorax has compliance (lack of rigidity) making lung collapse more probable. Premature foals, in addition, have insufficient surfactant, increasing the surface tension of alveoli, further increasing the possibility of respiratory failure.

6) The pleural cavity is the space between the parietal pleura (attached to the chest wall) and the visceral plura (attached to the lung). It is normally filled with

- * A. Only pleural fluid
- B. Pleural fluid and lymph
- C. Only air
- D. A small amount of plural fluid and air

The lungs are surrounded by two membranes, the pleurae. The outer pleura is attached to the chest wall and is known as the Parietal pleura; the inner one is attached to the lung and other visceral tissues and is known as the Visceral pleura. In between the two is a thin space known as the pleural cavity or pleural space. It is filled with pleural fluid, a serous fluid produced by the pleura. Pleural fluid is generated by visceral and parietal pleura and absorbed by the parietal pleura. In humans, there is normally a small quantity (about 3 to 4 teaspoons) of fluid that is spread thinly over the visceral and parietal pleurae and acts as a lubricant between the two membranes. Any significant increase in the quantity of pleural fluid is a pleural effusion.

7) Pleural pressure is normally lower (by about 5cm of water) than atmospheric pressure. During inspiration, pleural pressure

- * A. becomes more negative
- B. may become more negative or less negative, depending on the individual
- C. stays the same
- D. becomes less negative

Pleural pressure (Ppl) becomes more negative during inspiration (up to 10 cm of H₂O). In dogs and horses, because they normally employ forced expiration, pleural pressure may actually go above atmospheric pressure momentarily during expiration. Just to add perspective to this : While pleural pressure differs from atmospheric pressure by -10 to +1 cms of H₂O, the absolute atmospheric pressure (at sea level) is over 1000 cms of H₂O.

8) Alveolar pressure drops during inspiration, going down by how many cm of H₂O?

- * A. 1
- B. 5
- C. 15
- D. 10

Alveolar pressure drops by about 1 cm of water during inspiration while it rises by about 0.25 cms of water during expiration. To put that into perspective, note that atmospheric pressure at sea level is a little over 1000 cms of water (760mm Hg).

9) When lungs are affected by fibrosis, their compliance

- A. Could increase or decrease depending on the degree of infection
- B. Increases
- * C. Decreases
- D. Remains the same

Compliance is synonymous with elasticity. Fibrosis is the formation or development of excess fibrous connective tissue in an organ or tissue as a reparative or reactive process, for example, in reaction to repeated infection. The most current thinking is that the fibrotic process is a reaction to microscopic injury to the lung. While the exact cause remains unknown, associations have been made with smoking (including passive), inhaled pollution, some diseases (lupus, rheumatoid arthritis), medications and therapeutic radiation.

10) Pleural pressure (Ppl) becomes more negative during inspiration (up to 10 cm of H₂O). How negative it becomes is dependent

- A. directly on exercise and lung compliance; inversely on airway resistance
- B. directly on exercise; inversely on lung compliance, airway resistance
- * C. directly on exercise and airway resistance; inversely on lung compliance
- D. directly on exercise, airway resistance and lung compliance

Pleural pressure determines lung volume (as it provides the suction force that pulls in air). When lungs are affected by fibrosis, their non-compliance requires greater suction force to fill (or a lower pleural pressure). This can only be generated using a higher consumption of energy (by the diaphragm and thorax muscles).

11) At rest, the effort of breathing is to overcome the recoil forces of the lungs and thorax as well as to overcome the resistance to air flow in airways. Which portion of the airway offers the greatest resistance?

- A. Alveolar ducts and alveoli
- B. Bronchi and bronchioles
- * C. Nasal cavity, pharynx and larynx
- D. Trachea

During inspiration, 60% of resistance to air flow in the airways occurs in the nasal cavity, pharynx and larynx. While the various ducts (trachea, bronchi, bronchioles, etc) gradually reduce in diameter the closer they are to alveoli, the combined cross-section is actually increasing. Bronchioles only account for about 20% of resistance. <p>During expiration, the higher pressure increases the size of the upper airway while the bronchi and other lower airways reduce in diameter. Total resistance is approximately equally distributed between the nose, remaining upper airways and the lower airways (bronchi to alveoli).<p>

12) Changes in diameter during inspiration and expiration occur as follows

- A. Trachea : identical during inspiration and expiration; Bronchi larger during inspiration than expiration.
- B. Trachea : larger during inspiration than expiration; Bronchi smaller during inspiration than expiration.
- C. Trachea : larger during inspiration than expiration; Bronchi larger during inspiration than expiration.
- * D. Trachea : smaller during inspiration than expiration; Bronchi larger during inspiration than expiration.

Pleural pressure, varying between about 0 to -10 cm of water (differential from atmospheric pressure), defines inspiration and expiration. When the pleural pressure is less negative, expiration of the lungs occur; when pleural pressure is more negative, inspiration occurs.<p>How a respiratory structure is affected by pleural pressure is dependent on where it is. If outside the thorax, the structure tends to collapse during inspiration (think of the trachea as a weak straw). Structures within the thorax tend to expand. During expiration, the reverse happens with the trachea expanding while bronchi contract.<p>This is why an upper respiratory obstruction tends to cause dyspnea during inspiration while lower airway obstructions cause dyspnea during expiration.

13) The response of lungs with an obstructed airway differs from ones affected by fibrosis as follows:

- A. There is no difference; in both cases, the lungs cannot expand to full capacity
- * B. Lungs with an obstructed airway are capable of expanding to full capacity - they just take longer to do so; fibrosis reduces the capacity of lungs
- C. There is no difference; in both cases, the lungs can expand to full capacity, but slower
- D. Lungs with fibrosis are capable of expanding to full capacity - they just take longer to do so; obstructed airways reduce the capacity of lungs

Fibrosis affects the elasticity of lungs, reducing its ability to expand fully, thus lowering its capacity. An obstructed airway, on the other hand, does not affect the lungs' elasticity. If the obstruction is high up in the respiratory tract, a tracheotomy or tracheostomy may be performed on the neck to open a direct airway through an incision in the trachea (the windpipe), thus restoring 'normal' lung function.

14) Dyspnea (difficulty breathing) tends to worsen as follows :

- * A. Upper respiratory obstruction - during inspiration; lower respiratory obstruction - during expiration.
- B. Upper respiratory obstruction - during expiration; lower respiratory obstruction - during expiration.
- C. Upper respiratory obstruction - during expiration; lower respiratory obstruction - during inspiration.
- D. Upper respiratory obstruction - during inspiration; lower respiratory obstruction - during inspiration.

Pleural pressure, varying between about 0 to -10 cm of water (differential from atmospheric pressure), defines inspiration and expiration. When the pleural pressure is less negative, expiration of the lungs occur; when pleural pressure is more negative, inspiration occurs. How a respiratory structure is affected by pleural pressure is dependent on where it is. If outside the thorax, the structure tends to collapse during inspiration (think of the trachea as a weak straw). Structures within the thorax tend to expand. During expiration, the reverse happens with the trachea expanding while bronchi contract. This is why an upper respiratory obstruction tends to cause dyspnea during inspiration while lower airway obstructions cause dyspnea during expiration. Typical upper airway obstructions include

- physical narrowing of airways (e.g. stenotic nares)
- functional narrowing (e.g. dorsal displacement of soft palate in horses)

 Typical lower airway obstructions include

- phys

15) Typical causes of small (or lower) airway obstruction include :

- A. Constriction of smooth muscle
- B. Obstruction of airway
- C. Thickened mucosa
- D. Dynamic collapse of airways
- E. A, B and C only
- F. A, B and D only
- * G. All of A, B, C and D

Airway smooth muscle may be constricted by

- Ach (PNS stimulation of muscarinic receptors)
- tachykinins like substance P
- inflammatory mediators like histamine, bradykinin and leukotrienes

 Airway smooth muscle relaxes under the influence of

- SNS stimulation (beta2 adrenergic receptors like Salbutamol)
- nitric oxide (not to be confused with nitrous oxide, the anesthetic)
- vasoactive intestinal peptide (VIP)

16) Which of the following airways is least likely to suffer from dynamic narrowing?

- A. Trachea
- B. Nares
- * C. Nasal cavity
- D. Pharynx
- E. Larynx

Airway walls are not rigid and are therefore subject to expansion or contraction by a pressure gradient across their walls. The upper airways are subject to dynamic compression or narrowing during inspiration because the pressure within the airway is lower than the pressure outside (atmospheric pressure). Because the nasal cavity has bony support, it is least prone to compression. Contraction of the abductor muscles of the nares, pharynx and larynx during inhalation is necessary to prevent their collapse. <p>Horses suffering from laryngeal hemiplegia (roaring) are a result of failure of the abductor muscles of the larynx to contract, thus allowing vocal folds to be sucked into the lumen of the airway.

17) Dynamic collapse of airways is always undesirable.

- A. True
- * B. False

Cough is a forced exhalation during which dynamic collapse narrows the lower airways. The high air velocity through the narrowed portion of the airway facilitates removal of foreign material. This is a good thing. <p> Toy breeds of dogs have a high prevalence of collapsing trachea. In this disease, the weakened intrathoracic trachea is dynamically collapsed during the forceful ventilation of exercise. Affected dogs make a 'honking' noise as air is forced past the collapsed region of the trachea.

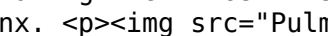
18) The effect of a minor upper airway obstruction on inspiration and expiration is:

- A. Plural pressure become less negative during inspiration; during expiration it also becomes less negative.
- B. Plural pressure become less negative during inspiration while remaining about the same during expiration
- * C. Plural pressure become more negative during inspiration while remaining about the same during expiration
- D. Plural pressure become more negative during inspiration while becoming more positive during expiration

Upper airways tend to contract during inspiration and expand during expiration. A minor upper airway obstruction's impact would, therefore, be enhanced during inspiration leading to a more negative pleural pressure while its impact would be reduced during expiration leaving the pressure gradient relatively unchanged. The speed of airflow at the obstruction will tend to be higher in both cases. Tidal volume could be lower (depends on how bad the obstruction is) with the animal compensating with an increased rate of respiration.

19) The effect of exercise on pulmonary resistance is as follows:

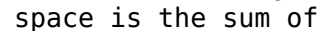
- A. During inspiration, the proportion of resistance of upper airways to total resistance reduces
- * B. During inspiration, the proportion of resistance of lower airways to total resistance reduces
- C. During expiration, the proportion of resistance of lower airways to total resistance reduces
- D. The comparative resistance of the nose, other upper airways and lower airways stays relatively constant during inspiration and expiration.

Upper airways tend to contract during inspiration and expand during expiration. The lower airways, on the other hand, tend to expand during inspiration but contract during expiration. Consequently, during inspiration, the upper airways offer most of the resistance; during exhalation, the lower airways offer most of the resistance. Mouth breathing decreases upper airway resistance. Horse, which don't mouth breathe, decrease resistance by flaring their nostrils, constricting vessels and maximally dilating the pharynx and larynx. 

20) Dead space

- * A. is any part of the respiratory system in which gas exchange does not occur
- B. cannot be manipulated by the individual
- C. is never found within alveoli
- D. is usually greater in small animals than in larger animals

Factors affecting dead space are

- Species differences : large animals tend to have more dead space than small animals The higher the rate of respiration, the higher the dead space The higher the tidal volume, the lower the dead space Anesthetic equipment will increase dead spaceAlveolar dead space occurs when ventilated alveoli are not adequately perfused Anatomical dead space includes areas where gas exchange is not possible - upper airways and bronchioles Physiologi dead space is the sum of alveolar and anatomical dead space. 

- * A. Large airways
- B. Small airways
- C. Large and small airways
- D. Large airways during expiration, small airways during inspiration

Most pulmonary sounds are due to the high velocity and turbulence of air in large airways. Bronchioles (due to their large overall cross-section) and alveoli do not contribute to breath sounds directly. Normal breath sounds include the following :

- Tracheal breath sounds are heard over the trachea. These sounds are harsh and sound like air is being blown through a pipe. Bronchial sounds are present over the large airways in the anterior chest near the second and third intercostal spaces; these sounds are more tubular and hollow-sounding than vesicular sounds, but not as harsh as tracheal breath sounds. Bronchial sounds are loud and high in pitch with a short pause between inspiration and expiration; expiratory sounds last longer than inspiratory sounds. Bron sounds are heard in the posterior chest between the scapulae and in the center part of the anterior chest. Bronchovesicular sounds are softer than bronchial sounds, but have a tubular quality. Bronchovesicular sounds

22) The partial pressure of a particular gas in a sample of air reflects

- A. The number of molecules of the gas present within the sample relative to the total number of molecules
- * B. The number of molecules of the gas present within the sample
- C. The weight of the gas within the sample relative to the total weight of the sample
- D. The molecular weight of the gas within the sample

The partial pressure of a gas is independent of other gases. It is equal to the pressure it would exert if it occupied the same volume alone at the same temperature. This pressure is directly proportional to the number of molecules of the gas within the sample.

23) Which of the following is true?

- * A. Carbon dioxide is much more soluble in water than oxygen
- B. Both carbon dioxide and oxygen do not dissolve in water
- C. Carbon dioxide and oxygen have about equal solubility in water
- D. Carbon dioxide is much less soluble in water than oxygen

CO₂ is about 20 times more soluble in water than oxygen. Thus, even though the driving pressure for diffusion across capillaries in the lung is only 6 mm Hg compared to about 60 mmHg for oxygen, the amount of CO₂ diffusing into the lungs equals the amount of O₂ diffusing into blood. For the same reason, CO₂ diffusion between the blood and alveoli is rarely affected by lung disease.

Lipids : All gases are very soluble; diffusion is instantaneous.

24) In a normal animal, diffusion of oxygen across the alveolar and endothelial walls is approximately the same as that of carbon dioxide (in the opposite direction). This is because

- A. The diffusion coefficients of CO₂ and O₂ are the same
- B. The surface area available to CO₂ and O₂ is identical
- C. The diffusion coefficients and driving pressures of CO₂ and O₂ are the same
- * D. Even though the relative diffusion coefficient of CO₂ is 20 times that of O₂, the much higher driving pressure of O₂ makes up for it.

The driving pressure (or pressure differential across the alveolar and endothelial wall) of oxygen is about 60mm Hg while that of CO₂ is just 6 mm Hg. However, CO₂ has a high affinity for water as indicated in its relative diffusion coefficient that is 20 times that of oxygen.

Gas exchange is directly proportional to

- relative diffusion coefficient
- driving pressure
- surface area available for exchange
- inverse proportional to the thickness of the alveolar and endothelial walls

25) The exchange rate (of O₂ and CO₂) in muscle tissue goes up during exercise because

- A. The driving pressure gradients and the surface area available for exchange reduces
- * B. The driving pressure gradients and the surface area available for exchange increases
- C. The driving pressure gradients increase but the surface area available for exchange reduces
- D. The driving pressure gradients reduce but the surface area available for exchange increases

When muscles are active, they use up more O₂ and create more CO₂. This raises both exchange driving pressures (difference between capillary and tissue partial pressures). In addition, there is increased perfusion of blood as more capillaries open to cater to the increased blood flow to the muscles. While the time for diffusion does decrease (due to increased blood flow), it is not, normally, enough to impact diffusion substantially. Blood flow to the lung increases (lung blood flow approximately equals systemic blood flow). This causes recruitment of additional blood vessels thus reducing alveolar dead space. In addition, the lung driving pressures increases due to reduced O₂ and increased CO₂ in venous blood.

26) Normally, the approximate partial pressures of O₂ and CO₂ in venous blood are :

- A. PvO₂ = 100 mm Hg, PvCO₂ = 40 mm Hg
- * B. PvO₂ = 40 mm Hg, PvCO₂ = 46 mm Hg
- C. PvO₂ = 100 mm Hg, PvCO₂ = 40 mm Hg
- D. PvO₂ = 40 mm Hg, PvCO₂ = 46 mm Hg

Alveolar partial pressures are PAO₂=100 mm Hg and PACO₂=40 mm Hg. Thus, the driving pressure (or pressure differential across the alveolar and endothelial wall) of oxygen is about 60 mm Hg while that of CO₂ is just 6 mm Hg. However, CO₂ has a high affinity for water as indicated in its relative diffusion coefficient that is 20 times that of oxygen. Gas exchange is directly proportional to

- relative diffusion coefficient
- driving pressure
- surface area available for exchange
- inversely proportional to the thickness of the alveolar and endothelial walls

27) As ventilation of the lungs increase, the tendency is for

- A. PAO₂ to decrease and PACO₂ to increase
- B. PAO₂ to increase and PACO₂ to increase
- C. PAO₂ to decrease and PACO₂ to decrease
- * D. PAO₂ to increase and PACO₂ to decrease

The capital "A" in PAO₂ and PACO₂ indicates "alveolar" (small "a" indicates arterial). The air in the alveoli is constantly losing O₂ and gaining CO₂ from blood (due to exchange). An increase in ventilation (breathing harder) will increase alveoli air turnover thus making it closer in composition to atmospheric air, increasing PAO₂ while decreasing PACO₂. The reverse happens when ventilation reduces, keeps all else constant. Similarly, if metabolic activity reduces, venous blood returning to lungs will show higher PvO₂ and lower PvCO₂ values; consequently, PAO₂ will tend to rise while PACO₂ will fall as driving pressures reduce.

28) Swanks, a hound, is hot in pursuit of a squirrel. Blood in his veins has changed from its "resting state" as follows

- * A. PvO₂ down, PvCO₂ up
- B. PvO₂ up, PvCO₂ up
- C. PvO₂ down, PvCO₂ down
- D. PvO₂ unchanged, PvCO₂ unchanged

During exercise, muscle creation of CO₂ increases. In addition, blood supply to the muscle increases as

- more capillaries open thus increasing the area available for diffusion of O₂ (into muscle) and CO₂ (out of muscle)
- the distance for diffusion decreases as capillaries expand, thus increasing the rate of diffusion

 Consequently, more O₂ is taken up by muscle while simultaneously the higher than normal CO₂ being produced diffuses quickly into blood. Such venous blood also results in increased pressure gradients in the lungs, allowing for quicker diffusion of O₂ (into blood) and CO₂ (into alveolar air).

29) Ventilation (V) relates to circulation of air; perfusion (Q) relates to blood flow. In the lungs, they should, ideally, relate to each other as follows

- A. They relate to different entities (ventilation to air, perfusion to blood); consequently, they have no connection with each other.
- B. Perfusion is inversely related to ventilation - as ventilation reduces, the body compensates by increasing perfusion so that maximal O₂/CO₂ exchange can occur
- * C. Perfusion should match ventilation. If ventilation increases, so should perfusion ... and vice-versa
- D. They are inversely related to each other - as perfusion rises, the increased blood pressure reduces ventilation ... and vice-versa

Ideally, ventilation and perfusion must be exactly matched

- ventilation must be distributed to perfused areas
- perfusion must be distributed to ventilated areas

 The ratio of ventilation to perfusion (V/Q) is the critical factor governing gas exchange

- regions of high ventilation should have high blood flows (base of lung)
- regions of low ventilation should have low blood flows (apex of lung)

30) Lung overall V/Q (ventilation to perfusion) ratio is affected as follows

- A. Reduces when there is an airway blockage or when a pulmonary artery thrombosis exists
- B. Increases when there is an airway blockage or when a pulmonary artery thrombosis exists
- * C. Reduces when there is an airway blockage; increases when a pulmonary artery thrombosis exists
- D. Increases when there is an airway blockage; reduces when a pulmonary artery thrombosis exists

An airway obstruction reduces airflow into alveoli, thus reducing ventilation and lowering the V/Q ratio. Similarly, a pulmonary artery thrombosis (or right-sided heart failure) reduces blood flow to the lungs, thus lowering Q, increasing V/Q ratio. In both cases, gas exchange is non-optimal. Ideally, ventilation and perfusion must be exactly matched

- ventilation must be distributed to perfused areas
- perfusion must be distributed to ventilated areas

 The ratio of ventilation to perfusion (V/Q) is the critical factor governing gas exchange

- regions of high ventilation should have high blood flows (base of lung)
- regions of low ventilation should have low blood flows (apex of lung)

31) Respiratory Quotient is

- A. inverse of the V/Q ratio
- B. The ratio of the tidal volume to the vital capacity of lungs
- C. the V/Q ratio
- * D. The ratio of the volume of CO₂ released to the volume of O₂ consumed by a body tissue

The oxidation of carbohydrate results in a respiratory quotient of 1.0, whereas the oxidation of fat results in a quotient of 0.7. So, an increase in the respiratory quotient is sometimes related to increased use of carbohydrate and reduced use of fat to meet specific energy requirements.

32) A cyanotic cat is determined to have a large alveolar-arterial oxygen difference (A-a gradient). Its problem is probably related to

- A. Perforation of the pleural cavity
- B. Right-sided heart failure
- C. Obstruction in the upper airways
- * D. Diffusion of O₂ from alveoli into blood

The normal A-a gradient is between 0 and 10mm of Hg. This means that it is OK for the arterial partial pressure of O₂ to be upto 10 mm of Hg less than that in the air of alveoli. Anything higher than that signifies that diffusion across the alveolar-capillary wall is impaired. <p>An upper airway obstruction or perforation of the pleural cavity will reduce airflow to alveoli; this will not affect the A-a gradient (although the animal will be in distress as oxygen supply is reduced). <p>Right-sided heart failure will reduce perfusion of blood to the lungs, thus reducing overall uptake of oxygen; again, the A-a gradient will remain unaffected.

33) Oxygen in alveoli diffuses through the wall, dissolves into plasma, then diffuses across the wall of red blood cells before finally binding to hemoglobin. The percentage of oxygen transported by hemoglobin is about

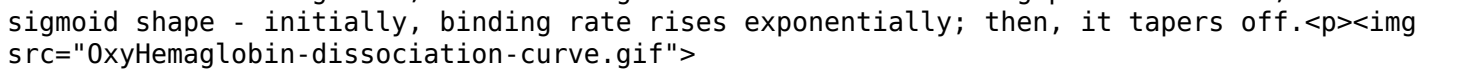
- A. 75
- B. 80
- * C. 97
- D. 50

Oxyhemoglobin is formed during respiration when oxygen binds to the heme component of the protein hemoglobin in red blood cells. This process occurs in the pulmonary capillaries adjacent to the alveoli of the lungs. Deoxyhemoglobin is the form of hemoglobin without the bound oxygen. The absorption spectrums of oxyhemoglobin and deoxyhemoglobin differ. Oxyhemoglobin has significantly lower absorption of the 660 nm wavelength than deoxyhemoglobin. This difference is used for measurement of the amount of oxygen in patient's blood by an instrument called pulse oximeter.

34) The oxyhemoglobin dissociation curve reflects the changing affinity of hemoglobin for O₂. Its shape is

- * A. Sigmoid, positive (curved like the letter S, the higher the O₂, the higher the binding)
- B. Exponential, positive (as O₂ increases, ever more of it binds to hemoglobin)
- C. Linear, flat (All O₂ binding occurs at a specific threshold)
- D. Linear, positive (the higher the O₂, the higher the binding)

O₂ binding to hemoglobin is a 4 step process. With every O₂ bound, the conformation of the complex changes to make the next O₂ easier to bind. This suggests that oxyhemoglobin curve should be exponential. However, in the larger picture, a fully bound oxyhemoglobin molecule cannot participate in further binding; instead, it obstructs contact between O₂ and unbound hemoglobin, thus slowing down the overall binding process. Hence, the sigmoid shape - initially, binding rate rises exponentially; then, it tapers off.



- A. Blood CO₂, then derives hemoglobin saturation
- * B. Hemoglobin O₂ saturation directly
- C. Blood oxygen, then derives hemoglobin saturation
- D. Carboxyhemoglobin, then derives O₂ saturation

Oximetry is not a complete measure of respiratory sufficiency. A patient suffering from hypoventilation (poor gas exchange in the lungs) given 100% oxygen can have excellent blood oxygen levels while still suffering from respiratory acidosis due to excessive carbon dioxide. Nor is it a complete measure of circulatory sufficiency. If there is insufficient bloodflow or insufficient hemoglobin in the blood (anemia), tissues can suffer hypoxia despite high oxygen saturation in the blood that does arrive. It also should be noted that two-wavelength saturation level measurement devices can not distinguish carboxyhemoglobin (due to carbon monoxide inhalation) from oxyhemoglobin, which must be taken into account when diagnosing a patient in emergency rescue from e.g. a fire in an apartment. A CO-oximeter measures absorption at additional wavelengths to distinguish CO from O₂ and determine the blood oxygen saturation more reliably. In 2005 Masimo Corporation introduced the first FDA-approved pulse oximeter to

36) The normal results from an arterial blood gas analysis are approximately

- * A. pH : 7.35-7.45, P_{O2} : 85-100 mmHG, P_{CO2} : 40 mmHg, O₂ saturation : 95-100%
- B. pH : 7.15-7.25, P_{O2} : 60-80 mmHG, P_{CO2} : 46 mmHg, O₂ saturation : 85-90%
- C. pH : 6.95-7.05, P_{O2} : 85-100 mmHG, P_{CO2} : 46 mmHg, O₂ saturation : 95-100%
- D. pH : 7.35-7.45, P_{O2} : 46 mmHG, P_{CO2} : 46 mmHg, O₂ saturation : 68-77%

Arterial blood gas measurement is a blood test that is performed to determine the concentration of oxygen, carbon dioxide and bicarbonate, as well as the pH, in the blood. Its main use is in pulmonology, as many lung diseases feature poor gas exchange, but it is also used in nephrology (kidney diseases) and electrolyte disturbances.

- The pH indicates if a patient is acidotic (pH <7.35) or alkalotic (pH > 7.45).
- The carbon dioxide partial pressure (P_{CO2}) indicates a respiratory problem: for a constant metabolic rate, the P_{CO2} is determined entirely by ventilation. A high P_{CO2} (respiratory acidosis) indicates underventilation, a low P_{CO2} (respiratory alkalosis) hyper- or overventilation.
- The HCO₃⁻ ion or base excess indicates whether a metabolic problem is present (such as ketoacidosis). A low HCO₃⁻ or negative base excess indicates metabolic acidosis, a high HCO₃⁻ or high positive base excess, metabolic alkalosis

37) The volume of oxygen held in 100 ml of blood is primarily dependent on

- A. Percent oxygen saturation of hemoglobin
- B. Volume of Oxygen dissolved in plasma
- C. Hematocrit
- * D. Percent oxygen saturation of hemoglobin and the percent hematocrit

97% of oxygen in arterial blood is held within RBC in Oxyhemoglobin (the complex between hemoglobin and oxygen). Hematocrit is the percentage of red blood cells in the blood - the higher the hematocrit, the greater the amount of hemoglobin available for binding to oxygen. Typical hematocrit values are 37-55% for dogs and 30-45% for cats. Surely, **MCHC** (Mean Corpuscular Hemoglobin Concentration) also plays a role (Hematology segway!).

38) The oxyhemoglobin dissociation curve depicts the percentage saturation of hemoglobin as a function of P_{O2}. When pH lowers or temperature rises, it shifts to the right. This will result in

- A. Changes in pH do not affect the oxyhemoglobin dissociation curve
- B. Easier binding of oxygen to hemoglobin
- * C. Easier dissociation of oxygen from hemoglobin
- D. The dissociation curve is only affected when pH rises

A change in pH alters oxygen binding by changing the structure of hemoglobin. A higher, more alkaline, pH shifts the dissociation curve to the left while a lower, more acidic, pH shifts the curve to the right. The Bohr effect is an adaptation in animals to reduce the affinity of hemoglobin for oxygen as a response to an increase in blood carbon dioxide levels and a decrease in pH. This makes sense as blood normally encounters a low pH in tissue. The position of the oxyhemoglobin dissociation curve shifts to the right (and vice-versa) with increased blood temperature, lowered pH, increased PCO₂ (as it lowers pH) and the intracellular concentration of certain organic phosphates.

39) Carbon monoxide (CO) poisoning occurs because

- A. It depletes oxygen in air by spontaneously reacting with oxygen to form CO₂
- B. It binds to the same sites that oxygen uses
- * C. It has a much higher affinity for hemoglobin than oxygen and because it binds to the same sites that oxygen uses
- D. It has a much higher affinity for hemoglobin than oxygen

Carbon monoxide has **200 times** the affinity to hemoglobin than oxygen, saturating hemoglobin at a partial pressure of just 0.4 mmHg (Oxygen saturates Hb at around 100 mmHg). Equally bad, it binds to the same sites that oxygen uses. Finally, it also increases oxygen binding (shift dissociation curve to right), thus reducing release in tissue. Blood gas analysis will not detect CO poisoning because it measures O₂ dissolved in plasma, which remains unaffected in the presence of CO. It also should be noted that two-wavelength saturation level measurement pulseoximeters cannot distinguish carboxyhemoglobin (due to carbon monoxide inhalation) from oxyhemoglobin. Enough! This is getting really scary. A CO-oximeter measures absorption at additional wavelengths to distinguish CO from O₂ and determine the blood oxygen saturation more reliably. In 2005 Masimo Corporation introduced the first FDA-approved pulse oximeter to monitor carbon monoxide levels noninvasively. Whew!

40) Methemoglobinemia occurs when

- * A. there are large amounts of methemoglobin (an altered hemoglobin which does not carry oxygen) in the blood
- B. Hematocrit is low
- C. Methane is inhaled
- D. Oxygen partial pressure is reduced, as at Mt. Everest

Methemoglobinemia is a condition that reduces the ability of the blood to transport oxygen throughout the body for essential metabolism. It is due to the replacement of hemoglobin with methemoglobin in the blood. A small amount of methemoglobin is present in the blood normally, but injury or toxic agents – such as nitrites – convert a larger proportion of hemoglobin into methemoglobin.

41) The primary mode of CO₂ transport in blood is

- A. as carbamino compounds
- * B. as HCO₃ (bicarbonate)
- C. in solution (dissolved in plasma)
- D. dissolved within RBCs, but not bound to hemoglobin
- E. bound to hemoglobin

- About 70% of CO₂ is transported as bicarbonate (HCO₃)
- 25% as carbamino compounds (i.e. bound to NH of proteins, esp. Hb)
- 5% dissolved in plasma.

 Blood gas analysis measures dissolved CO₂, then calculates total CO₂ in blood. CO₂ produced in tissue diffuses into plasma, then into the RBC where the presence of the enzyme carbonic anhydrase accelerates the hydration of CO₂ in H⁺ and HCO₃⁻. H⁺ is buffered by hemoglobin, so the reaction continues. Most of the HCO₃⁻ diffuses back into plasma in exchange for Cl⁻. Carbamino compounds are formed by coupling of CO₂ to the -NH groups of proteins, particularly hemoglobin.

42) Within the brain, the respiratory centers are contained within the

- A. Cerebellum
- B. Cerebrum
- * C. Medulla and Pons
- D. Hippocampus

The mechanism of generation of the ventilatory pattern is not completely understood, but involves the integration of neural signals by respiratory control centres in the medulla and pons. Ventilatory rate (minute volume) is tightly controlled and determined primarily by blood levels of carbon dioxide as determined by metabolic rate although blood levels of oxygen become important in hypoxia. These levels are sensed by chemoreceptors in the medulla oblongata for carbon dioxide (H⁺ is the direct stimulant), and the carotid (mainly) and aortic bodies for oxygen. Afferent neurons from the carotid bodies and aortic bodies travel via the glossopharyngeal nerve (CN IX) and the vagus nerve (CN X), respectively.

43) Peripheral chemoreceptors are those outside the CNS. They are found in the carotid bodies at the bifurcation of the common carotid and in the aortic bodies in the aortic arch. They are most sensitive to changes in

- A. PCO₂
- * B. PO₂
- C. Both PO₂ and PCO₂
- D. HCO₃⁻

While peripheral chemoreceptors are most sensitive to changes in PO₂, they also respond to pH and PCO₂. The mechanism of generation of the ventilatory pattern is not completely understood, but involves the integration of neural signals by respiratory control centres in the medulla and pons. Ventilatory rate (minute volume) is tightly controlled and determined primarily by blood levels of carbon dioxide as determined by metabolic rate although blood levels of oxygen become important in hypoxia. These levels are sensed by chemoreceptors in the medulla oblongata for carbon dioxide (H⁺ is the direct stimulant), and the carotid (mainly) and aortic bodies for oxygen, CO₂ and pH. Afferent neurons from the carotid bodies and aortic bodies travel via the glossopharyngeal nerve (CN IX) and the vagus nerve (CN X), respectively.

44) Central chemoreceptors exist in the medulla oblongata. They are directly stimulated by

- A. O₂
- B. CO₂
- C. HCO₃⁻
- * D. H⁺

Central chemoreceptors are most sensitive to changes in PCO₂. When PCO₂ is high, CO₂ crosses the blood-brain barrier (which is relative impermeable to H⁺ and HCO₃⁻) into the CSF and interstitial fluid. There, CO₂ reacts with H₂O to create HCO₃⁻ and H⁺. It is the rise in H⁺ that stimulates chemoreceptors to increase ventilation rate.

45) Normal systolic pressure in the pulmonary artery is about

- A. 10mm Hg
- * B. 25 mmHg
- C. 80mm Hg
- D. 120 mmHg

Pulmonary arterial systolic, diastolic and mean pressures average 25, 10 and 15 mmHg respectively in mammals at sea level. Diastolic pressure is as low as 5 mmHg. Pulmonary vascular resistance to blood flow is low as indicated by the small difference in pressure between the pulmonary artery and the left atrium. Arterial pressure increases to only about 35 mmHg during exercise, through the recruitment of previous unperfused vessels and through distention of all vessels. In horses, though, severe exercise can increase pulmonary vascular pressures to as much as 90 mmHg, often resulting in pulmonary hemorrhage. Most resistance to pulmonary blood flow is in, or just before, capillaries.

46) Under hypoxic conditions, pulmonary arterioles

- * A. constrict
- B. may constrict or dilate depending on pH
- C. remain unaffected
- D. dilate

While systemic capillaries and arterioles dilate under hypoxic (lack of oxygen) conditions, small pulmonary arteries constrict. The hypoxic vasoconstriction reduces blood flow to poorly ventilated alveoli, thus redistributing pulmonary blood flow to better ventilated regions of the lung so that optimal oxygen/CO₂ transfer can occur.

47) Pulmonary vascular pressure is actively affected by :

- * A. P_{O2} levels
- B. P_{CO2} levels
- C. Pulmonary inflation
- * D. Neural and hormonal factors
- E. Cardiac pressure

Pulmonary vascular pressure is actively affected by

- Neural and hormonal factors
- Vasoconstriction - activation of alpha-adrenergic receptors, inflammatory mediators (histamine, serotonin, bradykinin) or some F-type prostaglandins.
- Vasodilation - activation of Beta-adrenergic receptors, NO or D/E/I-type prostacyclins.

- Hypoxia (reduced P_{AO2}) : causes vasoconstriction.

Pulmonary vascular pressure is passively affected by

- Cardiac pressure
- Pulmonary inflation : At low lung volume, extra-alveolar arteries and veins are compressed, while alveolar capillaries are distended. At high lung volume, the reverse happens

48) In most species pulmonary arterial pressure during exercise is about 35 mmHg. In the horse, during severe exercise, it can be

- A. 45 mmHg
- B. 20 mmHg
- * C. 90 mmHg
- D. 35 mmHg

This is probably attributable in large part to a very high left atrial pressure (50 mmHg) which is probably necessary to ensure rapid ventricular filling when the heart rate exceeds 200 beats per minute. These high exercise-associated intravascular pressures can cause leakage of RBCs from pulmonary capillaries, a phenomenon known as exercise-induced pulmonary hemorrhage.

49) Pulmonary edema can result from

- A. Increased pulmonary capillary pressure
- B. Decreased plasma oncotic pressure
- C. Damaged pulmonary capillaries
- * D. All of the above

According to Starling's equation, the movement of fluid depends primarily on the following variables:

- Capillary hydrostatic pressure (P_c)
- Interstitial hydrostatic pressure (P_i)
- Capillary oncotic pressure (p_c)
- Interstitial oncotic pressure (p_i)
- Filtration coefficient (K_f)

Under normal circumstances, there is a gradient of about 7 mmHg pulling fluid into pulmonary interstitial spaces. The uptake of interstitial fluid by lymphatics is, therefore, critical to keep alveoli free of excess fluid. Pleural fluid pressure is kept low by the same mechanism.

50) During exercise, cardiac output can increase five-fold, but pulmonary arterial pressure may not even double. This occurs because

- A. pulmonary vascular resistance decreases during exercise
- B. unperfused capillaries are recruited during exercise
- C. previously perfused vessels are distended during exercise
- D. factors that dilate the pulmonary arteries are released by the endothelium during exercise
- * E. all of the above

Cunningham 3rd edition, pg 485

- * A. Exposure of a cow to the hypoxia of high altitude
- B. A twofold increase in pulmonary blood flow
- C. Stimulation of the vagus nerve (PNS) in a sheep
- D. Inhalation of a tidal volume in a horse
- E. None of the above

Pulmonary vascular pressure is **actively** affected by

- Neural and hormonal effects : These affect vascular smooth muscle in small pulmonary arteries. Their impact depends on how much such muscle the specie has. Cattle, pigs >> horses > dogs, sheep
- Vasoconstriction (which results in an increase in pulmonary vascular pressure) occurs by
 - activation of alpha-adrenergic receptors
 - inflammatory mediators like histamine, serotonin and bradykinin
 - Prostaglandin F
- Vasodilation happens through
 - activation of Beta-adrenergic receptors
 - Nitric oxide
 - Prostaglandins D, E and I

: Low alveolar oxygen levels cause vasoconstriction, diverting blood to better ventilated alveoli

Pulmonary vascular pressure is **passively** affected by

- Cardiac pressure, which is pulsatile
- Pulmonary inflation : Low lung volume allows distension of alveolar capillaries but compression of extra-alveolar arter

52) Bronchial circulation

- * A. drains into the pulmonary circulation and azygous vein
- B. has a bronchial arterial pressure of the same magnitude as pulmonary arterial pressure
- C. receives the total output of the right ventricle
- D. vasoconstricts in response to hypoxia
- E. supplies nutrient blood flow only to bronchi and no other structures

Bronchial circulation is systemic circulation to the airways and vessels of the lung. It receives about 2% of the output of the left ventricle, originating from 2 sources :

- The bronchoesophageal artery, which supplies the airways and the interlobular septa
- The right apical bronchial artery, a branch of the bicarotid trunk, that supplies the airways of the right apical lobe.

There are extensive anastomoses between bronchial and pulmonary vessels. Bronchial blood flow to the large extrapulmonary airways drains into the azygous vein while venous drainage of the intrapulmonary bronchial circulation enters the pulmonary circulation. Like other systemic arteries, bronchial circulation dilate in response to hypoxia.

53) In quadrupeds, pulmonary blood flow

- * A. is distributed so that the dorsal regions of the lung receive the most blood flow
- B. is distributed uniformly among the alveoli
- C. is distributed uniformly when the animal is anesthetized
- D. is distributed within the lung as would be predicted by the action of gravity
- E. is distributed primarily to the ventral part of the lung during exercise

This dorsal distribution applies even during (1) exercise and (2) dorsal recumbency (e.g. during an operation).

54) The lungs trap particles in air that's breathed. One of the mechanisms involved is sedimentation. This occurs mainly in

- A. Upper airways
- B. Alveoli
- C. Nasal epithelium
- * D. Lower airways

Large particles (greater than 5 μm in diameter) are usually trapped through inertial impaction, because they have so much momentum that they fail to negotiate bends in the upper airways. Such sites of inertial impaction are provided with lymphoid tissue, such as tonsils or bronchus-associated lymphoid tissue. Sedimentation occurs in airways where the speed of airflow is low, affecting particles that are 1 to 5 μm in diameter. Essentially, these particles settle onto the walls. The smallest particles reach the alveoli where they either contact the epithelium or are exhaled again. Deposited particles are trapped by mucus generated by

- Clara cells in respiratory bronchioles
- Goblet cells and submucosal bronchial glands

55) The mucociliary system of the lungs

- * A. has a more rapid transport rate in the trachea than in the bronchioles
- B. consists of a gel layer in which cilia beat, overlain by a sol layer that entraps particles
- C. lacks ciliated cells in the bronchioles, so mucus must be pulled into the larger airways by viscous drag
- D. is restricted to the nasal cavity and trachea

The sol layer of mucus is relatively less viscous, covering the epithelial cells. The gel layer is much more viscous and floats on the sol layer : it traps particles. Composition and secretion is under autonomic control. <p>Cilia in airways are immersed in the sol layer. The forward stroke catches the gel layer and moves it towards the nasopharynx, where it is swallowed. Impairments of this movement have serious consequences

56) Fetal tissue functions in a hypoxic condition relative to adult tissue. It uses the following mechanisms to cater to this :

- A. Vasoconstriction of coronary arteries
- * B. Higher cardiac output
- C. Lower cardiac output
- D. Its erythrocytes have a lower affinity for oxygen
- * E. Its erythrocytes have a higher affinity for oxygen
- * F. Its erythrocytes have a higher hemoglobin concentration
- * G. Rerouting of blood to high-importance tissue (e.g. brain, heart)

Fetal arterial blood has a low P_{O2} because the placenta is not a highly efficient gas exchanger and because oxygenated and venous blood mix at several points in the fetal circulation. Fetal erythrocytes have a higher affinity for oxygen than maternal erythrocytes (left-shift in the dissociation curve), allowing improved transfer of oxygen. In ruminants, this is accomplished by fetal hemoglobin. Dogs, horses and pigs do not have fetal hemoglobin but they contain reduced 2,3 diphosphoglycerate that provides a similar left-shift in the dissociation curve.<p>

57) The lung is an outgrowth of the foregut. It develops in three stages

- * A. First, the major airways; then pulmonary blood vessels; finally, alveoli
- B. First, the minor airways and alveoli; then the major airways which connect with the trachea; finally, blood circulation
- C. First, blood circulation; then, the minor airways and alveoli; finally, the major airways which connect with the trachea
- D. First, the major airways; then minor airways and alveoli; finally, blood circulation

The lung develops in 3 stages of equivalent duration.Beginning as an outgrowth of the foregut, the lung bud invades the mesenchyme of the thorax and divides into all the major airways branches during the first third of gestation. In the second phase, the lung is invaded by blood vessels. Finally, alveolar sacs and, in some species, alveoli, develop. <p>Pulmonary surfactant is essential if the lung is to remain inflated after birth (else the surface tension is strong enough to collapse the lungs). Beginning about mid-gestation, there is an increase in the synthesis of surfactant components (like lecithin) within the lung. Around the same time, Type II alveolar cells (the source of surfactant) begin to appear.

58) Immediately after birth, there is a strong stimulus to inhale because

- * A. fetal PaCO₂ rises
- B. air fills the mouth of the fetus
- * C. fetal PaO₂ drops
- D. of the trauma of travelling through the birth canal

In addition, Cunningham (3rd edition) suggests that stimulation to breathe is also a result of

- Cooling of the fetus as fetal fluid evaporate from the skin and
- a generalized increase in sensory input to the fetus as it is licked and nuzzled by its dam.

 Moving the first breath of air into the lungs requires a considerable effort as viscous fluids must be inhaled down the airways before air can enter the alveoli. The critical opening pressures of the fluid-filled small airways and alveoli must also be exceeded. Not all alveoli open in the first few breaths but surfactant begins to be distributed, stabilizing alveoli, thus establishing a stable end-expiratory lung volume, know as functional residual capacity.

- * A. Reduction in the pressure of the right atrium and ventricle
- * B. Complete closure of the foramen ovale
- * C. Pulmonary vasodilation
- D. Complete closure of the ductus arteriosus
- E. Decrease in the pressure of the left atrium and ventricle

The following sequence of events occur after the first neonatal breaths

- Inflation and oxygenation of the lungs reduce the pulmonary vascular resistance, which leads to decreased pressure in the pulmonary artery, right ventricle and right atrium.
- At about the same time, umbilical vessels rupture. Umbilical blood flow is arrested by local vasoconstriction. The removal of the low-resistance placental circulation increases systemic vascular resistance, which results in increased pressure in the aorta, left ventricle and left atrium.
- This causes blood flow in the foramen ovale (foramen between the left and right atrium) and ductus arteriosus (a shunt connecting the pulmonary artery to the aortic arch) **to reverse**, resulting in
 - The foramen ovale flap closes to occlude the foramen, ultimately adhering to the wall of the atrium
 - The ductus arteriosus, under the influence of well-oxygenated blood, constricts. If the neonate remains hypoxic, it may fail to close. This is

60) Mouth breathing decreases upper airway resistance. By how much does mouth breathing reduce resistance in horses?

- A. 10%
- B. 15%
- C. 30%
- D. 45%
- * E. Horses don't mouth breathe

Horses don't mouth breathe. During exertion, upper airway resistance is reduced by

- Flaring of nostrils
- Constricting vessels
- Maximally dilating pharynx and larynx

61) The partial pressure of water vapour in exhaled air is approximately

- A. 3.7 mmHg
- B. 13.7 mmHg
- * C. 47.0 mmHg
- D. 159 mmHg
- E. 760 mmHg

The partial pressure of water vapour in inhaled air varies with humidity and temperature. Once in the lungs of a normal animal, air reaches body temperature and is fully saturated with water vapour. This corresponds to a partial pressure of water vapour of about 47 mmHg at sea level.

- A. stimulation of alpha adrenergic receptors
- B. vasoactive intestinal peptide (VIP)
- * C. histamine
- * D. stimulation of muscarinic receptors
- E. stimulation of beta-adrenergic receptors

Airway smooth muscle may be constricted by

- Ach (PNS stimulation of muscarinic receptors)
- tachykinins like substance P
- inflammatory mediators like histamine, bradykinin and leukotrienes

 Airway smooth muscle relaxes under the influence of

- SNS stimulation (beta2 adrenergic receptors like Salbutamol)
- nitric oxide (not to be confused with nitrous oxide, the anesthetic)
- vasoactive intestinal peptide (VIP)

Muscarinic receptors are those membrane-bound acetylcholine receptors that are more sensitive to muscarine than to nicotine. Those for which the contrary is true are known as nicotinic acetylcholine receptors.

Don't confuse airway smooth muscle with pulmonary arteriole smooth muscle... which is controlled as follows :

- Vasoconstriction - activation of alpha-adrenergic receptors, inflammatory mediators (histamine, serotonin, bradykinin) or some F-type prostaglandins.
- Vasodilation - activation of Beta-adrenergic receptors

63) Peripheral chemoreceptors detect which of the following:

- A. carbon monoxide
- * B. hydrogen ions
- C. nitrogen
- * D. oxygen
- * E. carbon dioxide

64) Fetal hemoglobin

- A. has a lesser affinity for oxygen than adult hemoglobin
- * B. has an oxyhemoglobin dissociation curve that is shifted to the left relative to the adult
- * C. has a greater affinity for oxygen than adult hemoglobin
- D. has an oxyhemoglobin dissociation curve that is shifted to the right relative to the adult
- * E. is able to unload oxygen in fetal tissues due to their very low P_{O2}

65) Fetal adaptations to low oxygen partial pressures include:

- A. hemoglobin with lower affinity for oxygen
- * B. higher cardiac output
- * C. hemoglobin with higher affinity for oxygen
- * D. more oxygenated blood shunted to the head and brain
- E. lower cardiac output
- * F. higher hemoglobin concentration

66) Marked ventilation/perfusion mismatches (inequalities) can be due to which of the following factors?

- * A. collapsed (=atelectatic) alveoli that are still perfused
- * B. blocked airways leading to still perfused lung
- * C. blocked pulmonary arteries leading to ventilated lung
- D. blocked airways leading to un-perfused lung
- E. blocked pulmonary veins leading to the heart

67) In healthy animals, the partial pressures in pulmonary blood returning to the heart

- A. are lower for CO₂ compared to the alveolar partial pressure for CO₂
- B. are lower for oxygen compared to the alveolar partial pressure for O₂
- C. are higher for CO₂ compared to the alveolar partial pressure for CO₂
- * D. reflect the alveolar partial pressures

68) Even in healthy animals, minute ventilation does not match minute perfusion perfectly, leading to a V/Q ratio close to 0.8. Which of the following factors contribute to this ratio?

- * A. direct emptying of some coronary veins into the left ventricle
- * B. shunting of some deoxygenated blood from bronchial vessels into pulmonary veins
- C. shunting of oxygenated blood from pulmonary vessels into bronchial veins
- D. patent ductus arteriosus in neonates

69) Pulmonary vessels constrict in response to which of the following stimuli?

- A. prostaglandins D and E
- * B. activation of alpha-adrenergic receptors
- C. nitric oxide
- * D. hypoxia

70) Cattle are the domestic species most often affected by altitude sickness, which can occur when animals are moved from a low to a high altitude environment. This is due to which of the following factors?

- A. ruminal distension at high altitude
- * B. pulmonary vasoconstriction in response to hypoxia
- * C. more muscular pulmonary arteries than most other domestic species
- D. lower oncotic pressure in the blood
- E. lower hemoglobin concentrations

71) Which of the following statement(s) correctly describe the pulmonary circulatory system?

- A. mean arterial pressures of the pulmonary and systemic circulations are similar
- * B. flow is pulsatile in all pulmonary vessels
- * C. pulmonary vessels constrict in response to hypoxia
- D. flow is only pulsatile in larger pulmonary arteries
- E. it receives half the output of the right side of the heart

72) Which of the following statements is correct?

- * A. one third of the elastic recoil of the lungs is due to the elastic tissues of the pulmonary parenchyma
- * B. two thirds of the elastic recoil of the lungs is due to the surface tension in alveoli
- * C. at the end of normal expiration, the elastic recoil of the lungs is equal and opposite to the forces exerted by the thoracic wall.
- * D. surface tension is due to the physical properties of water lining the alveoli
- * E. without surfactant coating the fluid layer, surface tension would be much greater

That right, all the above statements are true!

73) Which of the following forces return the lungs and chest wall to their resting dimensions at the end of expiration?

- * A. elastic recoil of the thorax
- * B. elastic recoil of the lungs
- C. relaxation of abdominal muscles (diaphragm is not an abdominal muscle)
- * D. surface tension within the alveoli
- E. contraction of the diaphragm
- F. atmospheric pressure

74) The compliance of the thorax is

- * A. greater in carnivores than in large herbivores
- * B. a reflection of the physical properties of the musculoskeletal components of the thorax
- * C. greater in neonates than in adults
- D. greater in adults than in neonates
- E. greater in large herbivores than in carnivores

75) How do horses decrease the resistance to airflow during exercise?

- * A. distend (flare) nostrils
- * B. dilate the pharynx and larynx
- * C. constrict bloodvessels in upper airways
- D. mouth breathe

Mouth breathing decreases upper airway resistance and most animals resort to it during exercise. Horses, however, don't mouth breathe; instead, they decrease resistance by flaring their nostrils, constricting vessels and maximally dilating the pharynx and larynx.

<p>

76) Alveolar air

- * A. contains proportionally more CO₂ than inspired air
- * B. contains proportionally less N₂ than inspired air
- * C. contains proportionally less O₂ than inspired air
- D. contains proportionally less CO₂ than inspired air
- * E. has the same barometric pressure as inspired air
- F. contains proportionally more O₂ than inspired air
- * G. generally contains more water vapour than inspired air

77) The affinity of hemoglobin for oxygen is increased by which of the following factors

- A. hyperthermia
- * B. hypothermia
- * C. the presence of fetal hemoglobin in some species
- * D. alkalosis
- * E. carbon monoxide poisoning
- F. acidosis

78) Angiotensin-converting enzyme

- A. is present on the luminal surface of alveolar cells
- B. is inactivated in the lung
- C. is present on the luminal surface of renal glomerular arteries
- * D. is present on the luminal surface of pulmonary endothelial cells
- * E. inactivates bradykinin
- * F. converts angiotensin I to angiotensin II

79) When cardiac output increases, one or more of the following happens :

- * A. previously unused capillaries in the lungs are recruited
- * B. increases in pulmonary arterial pressures passively distend the pulmonary vessels
- C. acetylcholine causes vasodilation of pulmonary vessels
- D. reflex constriction of pulmonary arteries
- * E. the first effect is an increase in pulmonary arterial pressures
- * F. distension of pulmonary vessels leads to release of nitric oxide, which causes pulmonary vasodilation

80) Where would you take an arterial blood sample in dogs?

- A. saphenous
- * B. lingual
- C. jugular
- * D. femoral
- * E. brachial

The dorsal pedal artery is also used. The cephalic and carotid arteries can also be sources of arterial blood. <p>With respect to horses : All ages: facial, greater metatarsal a., carotid a., digital a. (difficult!). Foals: brachial, femoral.

81) The normal difference between O₂ partial pressure of Alveoli and arteries is between

- A. 0 and 10 cm H₂O
- * B. 0 and 10 mmHg
- C. 10 and 20 cm H₂O
- D. 10 and 20 mmHg
- E. -5 to +5 mmHg

PaO₂ (arterial) is returned by blood gas analysis. PAO₂ (alveolar) is calculated using the following formula :<p> $PAO_2 = [(PB - PAH_2O) \times FI_{O_2}] - PaCO_2/0.8$ where PB is the barometric pressure of inspired air PAH₂O is the partial pressure of water (normally 47 mmHg) FI_O₂ is the fraction of oxygen in the air breathed PaCO₂ is the partial of CO₂ returned by blood gas analysis PAO₂ (alveolar) is normally greater than PaO₂ (arterial) by 0 to 10 mmHg (should not exceed 15 mmHg).

82) Where could you take an arterial blood sample in an adult horse?

- A. Saphenous, Carotid
- B. Facial, femoral, brachial
- C. Brachial, femoral, lingual
- * D. Facial, greater metatarsal, carotid

All ages: facial, greater metatarsal a., carotid a., digital a. (difficult!). Foals: brachial, femoral.

83) Partial pressure of inhaled gases almost always reduces by the time it reaches small airways because

- A. Pressure within smaller airways increases
- * B. It gets humidified
- C. Pressure within smaller airways reduces
- D. Some exchange occurs
- E. Nitrogen tends to build up

Inhaled air is maximally humidified in its passage into the lungs. Since the pressure of the air is relatively constant, the increased partial pressure of water vapour causes a reduction in partial pressure of all other gases. For example, the partial pressure of nitrogen reduces from 597 to 563, oxygen from 159 to 149 while water vapor increases from as low as 3.7 to 47 mmHg.

- A. Left, allowing oxygen to dissociate less easily
- * B. Right, allowing oxygen to dissociate more easily
- C. Left, allowing oxygen to dissociate more easily
- D. Right, allowing oxygen to dissociate less easily

The Hemoglobin-Oxygen dissociation curve is affected by a number of factors. Variation of the hydrogen ion concentration. This changes the blood's pH. A decrease in pH shifts the standard curve to the right, while an increase shifts it to the left. This is known as the Bohr effect.Effects of carbon dioxide : Lowers pH and carbamino effect.of 2,3-DPG : High levels of 2,3-DPG shift the curve to the rightTemperature. Temperature does not have so dramatic effect as the previous factors, but hyperthermia causes a rightward shift, while hypothermia causes a leftward shift.Carbon Monoxide : Block oxygen binding, but also shifts curve to the leftEffects of Methemoglobinemia (a form of abnormal hemoglobin). Methemoglobinemia causes a leftward shift in the curve.Hemoglobin : structurally different, causes left shift.<p>- SM stimulation of Beta2 adrenergic receptorsNitric OxideVasoactive intestinal peptide (VIP)