- How do the carotid bodies sense arterial blood gases?
    - The carotid bodies weigh 25mg, yet they have their own artery. This means that they have the highest blood flow of all organs, which makes them sensitive to changes.
- **Ventilation at high altitudes:**
    - As we ascend the atmospheric pressure decreases. If we go up Mount Everest, for example, the blood pressure will drop to about 230mmHg. (The mountain is 9500 meters high).
    - At this height the concentration of oxygen can be calculated as follows:
        - 21% * 230 = 50mmHg.
    - If your arterial PO_2 is above 60, you are in a good condition. However, if it drops below 60, they body starts hyperventilating.
- To control our breathing, we have:
    - Central control centers
    - Peripheral control centers: Aortic and carotid bodies.
- Carotid bodies are more important than arterial bodies as they sense changes in blood pressure at lower threshold. Aortic sense the change at 80mmHg, while carotid bodies sense it at 95mmHg.
- What are carotid bodies mainly sensitive to? **Oxygen**
    - When carotid bodies are stimulated, they are going to carry a signal to efferent neurons through the glossopharyngeal nerve. This nerve in turn will carry the signal to nucleus solitarius (the respiratory center) to stimulate ventilation.
    - The central control center is sensitive to CO_2 and H^+ concentrations; however, the peripheral centers is sensitive to O_2 concentrations. In fact, the peripheral centers are mainly sensitive to hypoxia. The center starts sending signals when PO_2 drops below 60; its advantage lies in the deoxyhemoglobin curve's shape.
    - When your blood pressure drops, there are three main control mechanism that help restore the body's balance:
        - Neural: does not replace potassium, but it is the fastest.
        - Hormonal: through rennin-angiotensin-aldosterone system which absorbs sodium along with water. It restores the blood volume.
        - Renal system: restores the bodily balance
    - When you suffer from hypercapnia (increased CO_2), the carotid bodies are the first to sense this increase. They drive ventilation, but at $1/7^{th}$ the strength of the central system. It is very fast, but it is not efficient. Its goal is to make you survive until other mechanisms start working. The same thing applies to hydrogen; so the carotid bodies sense CO_2, H^+, and O_2 changes but they are mainly sensitive to changes in oxygen

- Control mechanisms:
  - Double-tail (CO_2):
    - when it increases → hyperventilation.
    - When it decreases → hypoventilation.
  - Half-tail (O_2):
    - When it increases → nothing happens.
    - When it decreases → nothing happens, unless it is a significant decrease.
- Why do divers hyperventilate? Short answer, to decrease CO_2
  - Hyperventilation tries to bring the alveolar concentration of air as close as possible to the atmospheric air (High O_2 and low CO_2). What divers do is wash out Carbon dioxide. When you hold your breath, CO_2 starts accumulating. When you hyperventilate, accumulation starts from a lower pressure and gives you more time. However, you should not overdo it, or you will end up with low oxygen.
- There are four types of hypoxia:
  - Hypoxic hypoxia
  - Anemic hypoxia
  - Histotoxic hypoxia
  - Stagnant hypoxia
- When you ascend upwards, oxygen levels decrease. This drives ventilation.
- What is the drawback?
  - When you ventilate, you wash out CO_2 which might cause alkalosis. Low oxygen will cause ventilation, but the alkalosis will suppress it. Peripherally, hypoxia will stimulate ventilation. Centrally, hypocapnia will suppress ventilation. This will cause a slight increase in the ventilation opposed to the expected 4 times increase. Moreover, the hydrogen ion concentration exerts controls over this process.
  - We go back to Handerson's equation:
    - $pH = 6.1 + \log (HCO_3^- / CO_2)$
    - Usually, the kidney reabsorbs 100% of bicarbonate. However, under these conditions, it excretes some of it. Thus, the urine will be full of bicarbonate (past papers question). This decrease in the bodily amounts of bicarbonate will bring pH to normal. This will remove the suppression and you're left with normal peripheral stimulation. This will allow ventilation to increase to its maximal capacity (4-5 times normal)
  - When you descend, you will suffer from shortness of breath for a couple of days. This is due to acidosis. Acidosis happens because CO_2 accumulates while bicarbonate levels are still low (the kidney is not back to normal, yet)
  - Normally, the kidney does not excrete bicarbonate at all. When you descend from a high place, not only the kidney will not excrete bicarbonate, it will produce its own bicarbonate until bicarbonate levels become normal again.

- **During exercise:**
  - Before you run, you start hyperventilating. Because you're hyperventilating, you are washing out CO_2 decreasing its levels in the bloodstream. Once you start exercising, your ventilation rate increases until the rate of production of CO_2 equates its rate of excretion. The main driving force of ventilation during exercises is not the arterial blood gases level (they only drive the exercise towards its final anaerobic stages causing slight acidosis). What drives ventilation during exercise are the impulses from the cortex that go to both skeletal muscles and respiratory muscles. Arterial blood should remain constant. Once oxygen consumption increases, the ventilation increases

- What limits VO2 max? (possible exam question, and the Dr. did not answer it. He just gave us hints)
  - Lungs?
  - Cardiovascular system?
  - Mitochondria?
- Mitochondria will consume oxygen, while the cardiovascular system will deliver it through diffusion. Is it the lung which cannot make more than 4L of oxygen? Is it the cardiovascular which cannot pump more blood? Is it the mitochondria that cannot increase in number even if there is a lot of oxygen present?
- Pulmonary diseases are divided into three categories:
  - Obstructive (70%)
  - Restrictive (20-25%)
  - Vascular (5-10%) like pulmonary hypertension

- **COPD (obstructive disease)**
  - patients have low arterial oxygen pressure with high arterial carbon dioxide pressure. To be more specific a patient is classified as a COPD patient when PO_2 is less than 50 and PCO_2 is more than 50.
- What do you do with a COPD patient?
  - PCO_2 is high but pH is normal, so what drives the ventilation in this case is the low oxygen. If you give 100% oxygen, and you increase the oxygen, you remove the driving stimulus of ventilation and you kill the patient. You should give oxygen at low concentrations and intermittently.

Past paper questions:

(The ones I managed to understand, the others are not clear). I will attach the pictures at the end of this document:

- Which of the following will return toward normal few weeks following ascending to high altitude (and stay at the top of the mountain)?:
  - **Arterial hydrogen ion concentration**
  - Arterial carbon dioxide tension
  - Arterial bicarbonate ion concentration
  - Arterial hemoglobin concentration
  - Alveolar ventilation
- Which of the following is most likely cause of a high arterial PCO2?
  - Increased metabolic activity during exercise
  - Increased alveolar dead space volume
  - **Depressed medullary respiratory centers**
  - Alveolar capillary block
  - Increased alveolar ventilation

- Which of the following statements characterize pulmonary compliance?
  - **Increases during emphysema**
- Which of the following shifts the oxyhemoglobin curve to the left?
  - Increased temperature
  - Exercise
  - **Hyperventilation**
  - Metabolic acidosis
- Which of the following has to be less in the fetus than in the mother?
  - PaCO2
  - Pulmonary vascular resistance
  - Affinity to hemoglobin
  - **PaO2**
  - Arterial hydrogen ion concentration
- Lack of oxygen equilibration due to diffusion limitation (in alveolar capillary block) can be evaluated by measuring
  - **Diffusion capacity of CO**
  - Diffusion capacity of CO2
  - Diffusion capacity of N2

- [illegible] residual volume
- normal FEV_1/FVC
- d- increased lung compliance
- e- decreased peak expiratory flow corrected for lung volume

37- In diving, divers first hyperventilate before they go into water. This hyperventilation allows one to hold one's breath for a longer period of time because hyperventilation:

a- increases the oxygen reserve of systemic arterial blood

b- decreases the PCO_2 of systemic arterial blood

c- increases the pH of systemic arterial blood

d- increases brain blood flow

e- make alveolar air full of O_2 which divers can use while diving

38- In an [illegible] person at high altitudes, oxygen delivery to the tissues may be adequate at rest because of:

a- An increase in hemoglobin concentration

b- The presence of an acidosis

c- A decrease in the number of tissue capillaries

d- The presence of a normal arterial P_{O_2}

e- The presence of a lower-than-normal arterial P_{CO_2}

39- The arterio-venous PO_2 difference of the carotid bodies is small because:

a- carotid bodies are metabolically inactive.

b- P_{O_2} of the blood supplying the carotid bodies is extremely high

c- carotid bodies blood flow is equal to 20 ml/g tissue weight.

d- carotid bodies receive venous blood and not arterial blood.

e- O_2 extraction ratio is the highest when compared to other tissues

40- The elastic strength of the lungs is less than the elastic strength of the chest wall at all volumes

a- within the vital capacity range

b- less than the total lung capacity

c- at the vital capacity range

d- greater than the residual volume

e- less than the functional residual capacity.

Use the respiratory data below to answer the following question.

In a person breathing room air at sea level, the following data were obtained.

Tidal volume	= 400 ml
Dead space volume	= 100 ml
Breathing frequency	= 10 breaths/min
PaCO2 (arterial)	= 50 mmHg

41- If the patient doubles his tidal volume without changing his CO2 production, his PaCO2 will be about:

a- [illegible] mmHg

b- [illegible] mmHg

c- 25 mmHg 54

d- [illegible] mmHg

e- [illegible] mmHg 20

42- A person ascends to the top of a mountain where the atmospheric pressure is below normal. Which one of the following arterial blood gases was drawn from the person at the top of the mountain?

	PO_2	PCO_2
a-	50	30
b-	[illegible]	[illegible]
c-	[illegible]	[illegible]
d-	[illegible]	[illegible]
e-	[illegible]	[illegible]

43- Choose the correct statement [illegible] breathing 100% [illegible]

a- [illegible]

b- [illegible]

c- [illegible]

d- the PO_2 [illegible]

e- dissolved O_2 remains less than bound O_2 in this indi[illegible]

44- In normal individual, the conducting zone of the lung:

a- accounts for more than [illegible] of the total lung capacity

b- contains [illegible] only at bronchi[illegible]

c- provides [illegible] when compared to [illegible]

d- receives its blood supply from [illegible] arteries.

e- [illegible]