Pranayama

Teachers Training
Level 1 2023

Anatomy & Physiology
Class 6
Biochemistry of breathing

Yoga Education Collective

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श्री गुरुभ्यो नमः हरिः ॐ

Om Om Om

Sri Gurubhyo Namah Harih Om

Salutations to the Gurus!

ॐ सह नाववतु ।
सह नौ भुनक्तु ।
सह वीर्यं करवावहै ।
तेजस्वि नावधीतमस्तु मा विद्विषावहै ।
ॐ शान्तिः शान्तिः शान्तिः ॥

oṃ saha nāvavatu saha nau bhunaktu
saha vīryaṃ karavāvahai
tejasvi nāvadhītamastu mā vidviṣāvahai
oṃ śāntiḥ śāntiḥ śāntiḥ

May that Brahman protect us together. May it nourish us together. May we both gain great vitality. May our learning be brilliant. May we never argue. Om peace, peace, peace.

Biochemistry of breathing - The Bohr Effect

- **Oxygen is essential for life on earth.**
  Amount our bodies can use is not entirely dependent on amount of O2 in the blood
- If out of breath or very stressed you need more O2 in the tissues required to act.
- Red blood cells are usually saturated with 95-99% O2
- Its use by the body is determined by the amount of CO2 in the blood
- The CO2 in the blood is the main variable allowing release of O2 to the cells
- This called the **Bohr Effect** - First described by Danish physiologist Christian Bohr in 1904.

Since CO2 reacts with water to form carbonic acid, an increase in CO2 results in a decrease in blood pH, resulting in hemoglobin proteins releasing their load of O2. Conversely, a decrease in CO2 provokes an increase in pH, which results in hemoglobin picking up more O2. *Wikipedia*

- Increased levels of CO2 leads to increased release of O2 when needed.

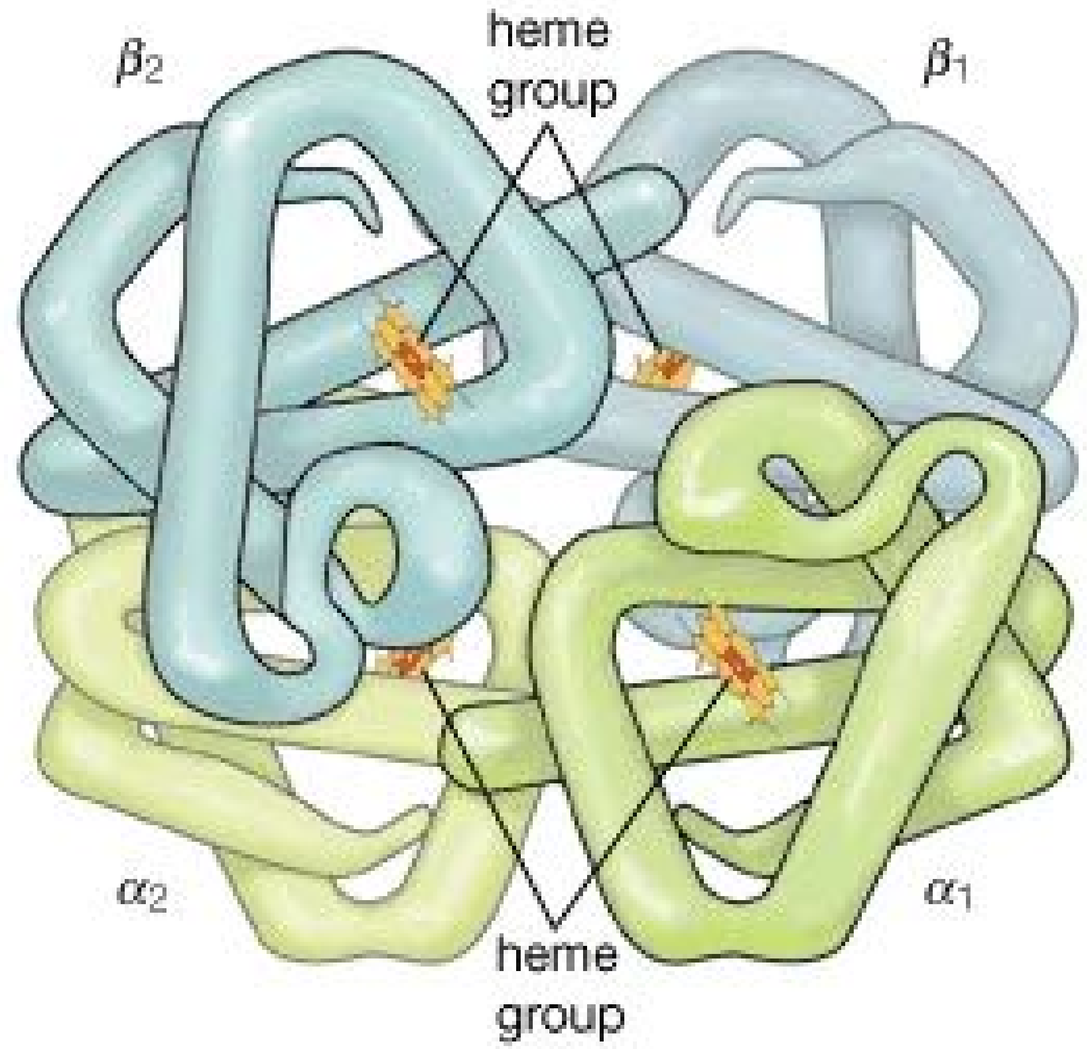
Biochemistry of breathing - The Bohr Effect & Haldane Effect

- The **Bohr effect** explains red blood cells' ability to adjust to changes in their biochemical climate, maximizing haemoglobin-oxygen binding potential in the lungs while enhancing O2 delivery to the most demanding tissues.
- It allows for better O2 unloading in metabolically active peripheral tissues like skeletal muscle during exercise.
- Increased skeletal muscle activity causes localized increases in CO2 partial pressure, which lowers the local blood pH.
- The **Haldane effect** is a haemoglobin property in which oxygenation of blood in the lungs displaces CO2 from haemoglobin, raising CO2 removal.
- The Haldane Effect (along with the Bohr Effect) makes it easier for O2 to be released from tissues and absorbed into the lungs.

byjus.com

Hemoglobin

- **Hemoglobin**, also spelled **haemoglobin**, iron-containing protein that makes blood red.
- In the red blood cells (erythrocytes) of vertebrates
- Transports oxygen to the tissues.
- Hemoglobin forms an unstable reversible bond with O2. In the oxygenated state, it is called oxyhemoglobin and is bright red; in the reduced state, it is purplish blue.
- Hemoglobin develops in cells in the bone marrow that become red blood cells. When red cells die, hemoglobin is broken up: iron is salvaged, transported to the bone marrow by proteins called transferrins, and used again in the production of new red blood cells



https://www.britannica.com/science/hemoglobin

Biochemistry of breathing - The Bohr Effect

- The Bohr effect is a result of the effect CO2 has on hemoglobins affinity for O2
- As CO2 increases, it combines with water to form Carbonic Acid
- Then blood pH lessens (becomes more acidic)
- The lowered pH then decreases hemoglobins* affinity for O2, meaning hemoglobin lets go of O2 more easily.
- **Hemoglobin releases O2 in the presence of CO2**
- As a result, more O2 is released to the muscles and tissues that need it most.
- Thus the amount of CO2 in the blood determines how much O2 we can use.

**Hemoglobin is a protein in your blood that picks up O2 from your lungs and transports it around the body*

The Bohr Effect - What it means for breathing

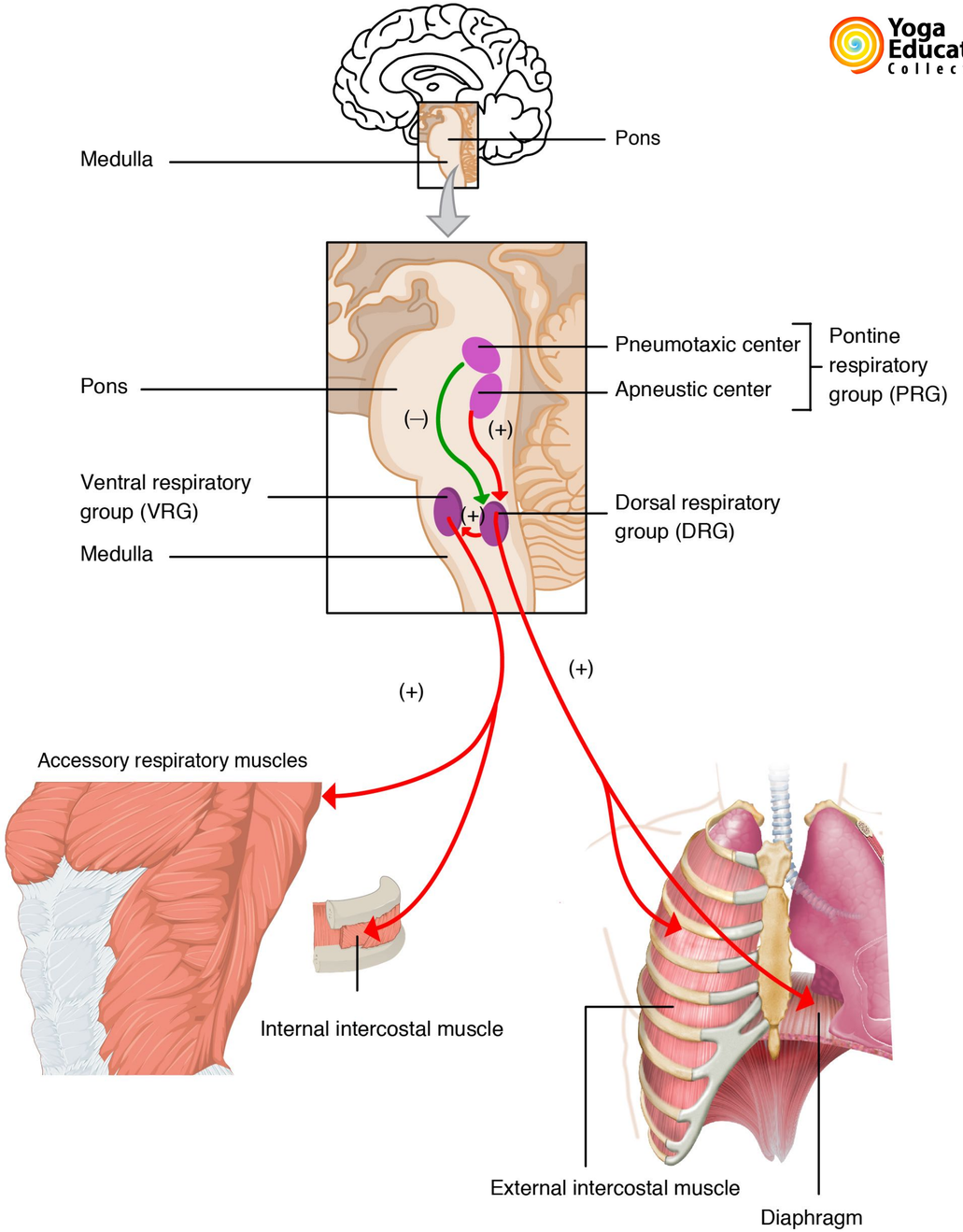
- Our breathing determines the levels of CO2 in the blood.
- Erratic short breaths offload too much CO2 leaving us depleted of O2.
- Balanced, quieter, rhythmic and focussed breathing enables an increase and tolerance to C02 allowing our bodies to properly utilize O2.
- This is especially true for our brains and hearts to function optimally.
- All muscular activity and all around homeostasis will benefit as well.

Cellular “Respiration”

- “Respiration” is used to describe breathing
- Biochemists use “respiration” in terms of the processes that take place in your cells to use the O2 you get when you breath to make energy.
- Cellular respiration means that you breathe in O2, combine it with digested products like glucose (blood sugar) to make the energy storage molecule ATP, and generate CO2 that you breathe out as a waste product.
- That occurs in cells throughout your body. O2 has to be able to get to all of those cells. CO2 is being produced in all of those cells.
- You only have O2 entering your body in one place – the lungs

Respiratory centers

1. When CO2 levels are high in the blood Ph will go down (too acidic) and respiratory rate will increase.
2. Too high can lead to Hypercapnia. Anxiety, shortness of breath, headache, daytime sleepiness/ sluggish > paranoia, delirium etc.



Proper Breath Regulation

1. There are 2 main aspects to breathing.
    1. The rate or number of breaths taken in 1 minute. Average 10-12 bpm.
    2. The volume of air drawn in with each breath. Average 500 Ml.

2. CO2 not O2 is the primary influence on efficient breathing.

3. Rate & volume are determined by receptors in the brain.

4. Receptors monitor the concentration of CO2 & O2 in the blood & the pH level.

5. When CO2 increases the receptors stimulate breathing to get rid of excess.

6. Thus the primary stimulus to breathe is to eliminate excess CO2 from the body.

“Preparatory practice for the yoga art of breathing”

Luise Wörle BSc(Hons) Osteopathy MA, Erik Pfeiff DiplPsych, in Yoga as Therapeutic Exercise, 2010

- Through oxygenization and elimination of carbon dioxide, respiration is connected with all tissues of the body which receive a blood supply. There are a number of special connections of the respiratory system with other systems of the body.

- The axial skeleton protects and surrounds the lungs; rib movements are important for inhalation and exhalation. The sternum is important for the production of red blood cells.

- Movement stimulates this production, too. Muscles actively control and generate the flow and movements of breath and the sounds connected with breathing.

- The nervous system controls the rhythm and volumes of respiration, and blood gas levels.

- Epinephrine and norepinephrine stimulate respiration.

- The cardiovascular system is particularly related to the respiratory system. The heart and lungs are connected through their veins and arteries. Red blood cells carry oxygen and carbon dioxide between the lungs and the tissues. In the alveolar capillaries converting enzymes, important for the regulation of blood pressure, are produced (Martini & Nath 2008).

“Preparatory practice for the yoga art of breathing” continued

Luise Wörle BSc(Hons) Osteopathy MA, Erik Pfeiff DiplPsych, in Yoga as Therapeutic Exercise, 2010

- The rhythmic movements of the diaphragm stimulate fluid movements in the arteries, veins, and lymphatic vessels by a change in pressure between the abdominal and thoracic cavities.

- The support of the venous flow back to the heart increases the volume of the heart and the blood supply to the coronary arteries, and decreases the heart rate (Roth 2008). This fluid movement improves the immune system and the health of the tissues in general. It also improves mobility and therefore the functions of the abdominal and thoracic organs.

- Respiration is both a conscious and an unconscious process, connecting these two areas.

- In conclusion, an understanding of these anatomical and physiological connections shows that breathing well and exercising connected with good respiration are beneficial for health, both in prevention and therapy.

- It is important not to force these processes, rather to communicate with them in a sensitive, mindful way.

Proper Breathing

1. If we ‘overbreathe’ (heavy, intense, erratic) we exhale to much CO2.

2. If we breathe better we deliver more O2 to our organs and muscles and importantly the heart and brain.

3. We simply enhance the natural way of breathing.

Oxygen

1. The blood is almost always fully saturated with O2.

2. O2 saturation (SpO2) is the percentage of oxygen-carrying red blood cells (hemoglobin molecules) containing O2 within blood.

3. Average at rest breathing volume for a healthy person (4-6 liters per minute) results in SpO2 of 95-99%. Some O2 is always diffusing into the cells. 100% SpO2 means the blood is not releasing the O2 to the cells.

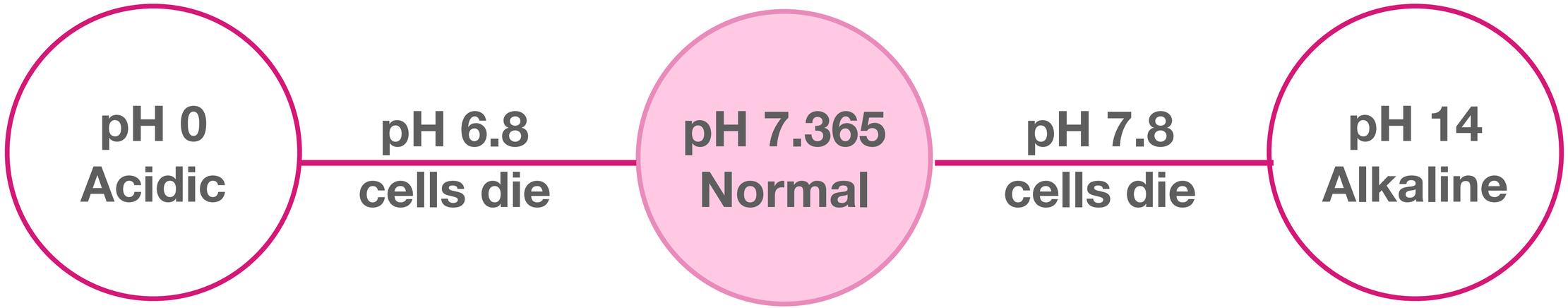
4. Humans carry surplus O2 in the blood.

5. Taking bigger breaths does not mean taking in more O2.

Regulation of Blood pH

1. CO_2 helps regulate blood pH. How acidic or alkaline your blood is.

2. Normal pH in the blood is 7.365. Maintaining normal level is essential for survival.



3. When blood become more alkaline, breathing reduces allowing CO_2 to rise and balance is restored.

4. When blood is more acidic (eg. processed foods), breathing increases to offload CO_2 and balance is restored.

Importance of carbon dioxide.

1. Essential element affecting every aspect of our body to maintain health and achieve our maximum level of endurance and strength.

    1. Regulates breathing.
    2. Optimizes blood flow
    3. Releases O2 to the muscles
    4. Maintains correct pH levels.

5 Reasons why we should increase CO2 tolerance

1. Decrease respiratory rate
2. Increase cellular O2 absorption
3. Increase red blood cell count
4. Increase parasympathetic tone
5. Lower blood pressure

Hypercapnia

- Hypercapnia is a buildup of CO2 in your bloodstream. It affects people who have chronic obstructive pulmonary disease (COPD).

- With COPD, you can't breathe easily. Inflamed airways and damaged lung tissue make it harder to breathe in the O2 you need and breathe out the CO2 that your body wants to get rid of.

- Hypercapnia changes the pH balance of your blood, making it too acidic.

Hypercapnia continued

- This can happen slowly or suddenly. If it happens slowly, your body may be able to keep up by making your kidneys work harder. Your kidneys release and reabsorb bicarbonate, a form of CO2, which helps keep your body's pH level balanced.

- A sudden rise in CO2, called acute hypercapnia, is more dangerous, because your kidneys can't handle the spike. This is most likely to happen if you have a severe case of COPD

Hypoxia

- When your body doesn't have enough O2, you could get hypoxemia or hypoxia. These are dangerous conditions. Without O2, your brain, liver, and other organs can be damaged just minutes after symptoms start.
- Hypoxemia (low O2 in your blood) can cause hypoxia (low O2 in your tissues) when your blood doesn't carry enough O2 to your tissues to meet your body's needs. The word hypoxia is sometimes used to describe both problems.
- Although they can vary from person to person, the most common hypoxia symptoms are: Changes in the color of your skin, ranging from blue to cherry red, confusion, cough, fast heart rate, rapid breathing, shortness of breath, slow heart rate, sweating, wheezing
- Hospital treatment for hypoxia can be needed and to keep a check on your O2 level.
- The most important thing is to get more O2 into your body. Via a small plug in your nose or through a mask that covers your nose and mouth. This can bring your O2 level up to normal.

ॐ सर्वे भवन्तु सुखिनः
सर्वे सन्तु निरामयाः ।
सर्वे भद्राणि पश्यन्तु
मा कश्चिद्दुःखभाग्भवेत् ।
ॐ शान्तिः शान्तिः शान्तिः ॥

oṃ sarve bhavantu sukhinaḥ
sarve santu nirāmayāḥ
sarve bhadrāṇi paśyantu
mā kaścid duḥkha bhāgbhavet
oṃ śāntiḥ śāntiḥ śāntiḥ

May all be happy, may all be free from disease, may all see goodness,
may none suffer from sorrow.

ॐ असतो मा सद्गमय ।
तमसो मा ज्योतिर्गमय ।
मृत्योर्मा अमृतं गमय ।
ॐ शान्तिः शान्तिः शान्तिः ॥ हरिः ॐ तत्सत् ॥

asato mā sadgamaya
tamasomā jyotir gamaya
mrityormāāmritam gamaya
Oṁ śhānti śhānti śhāntiḥ harih om tat sat

Lead me from changing existence to unchanging being,
lead me from the darkness of tamas to the light of knowledge,
lead me from death to immortality. Harih om that is truth.