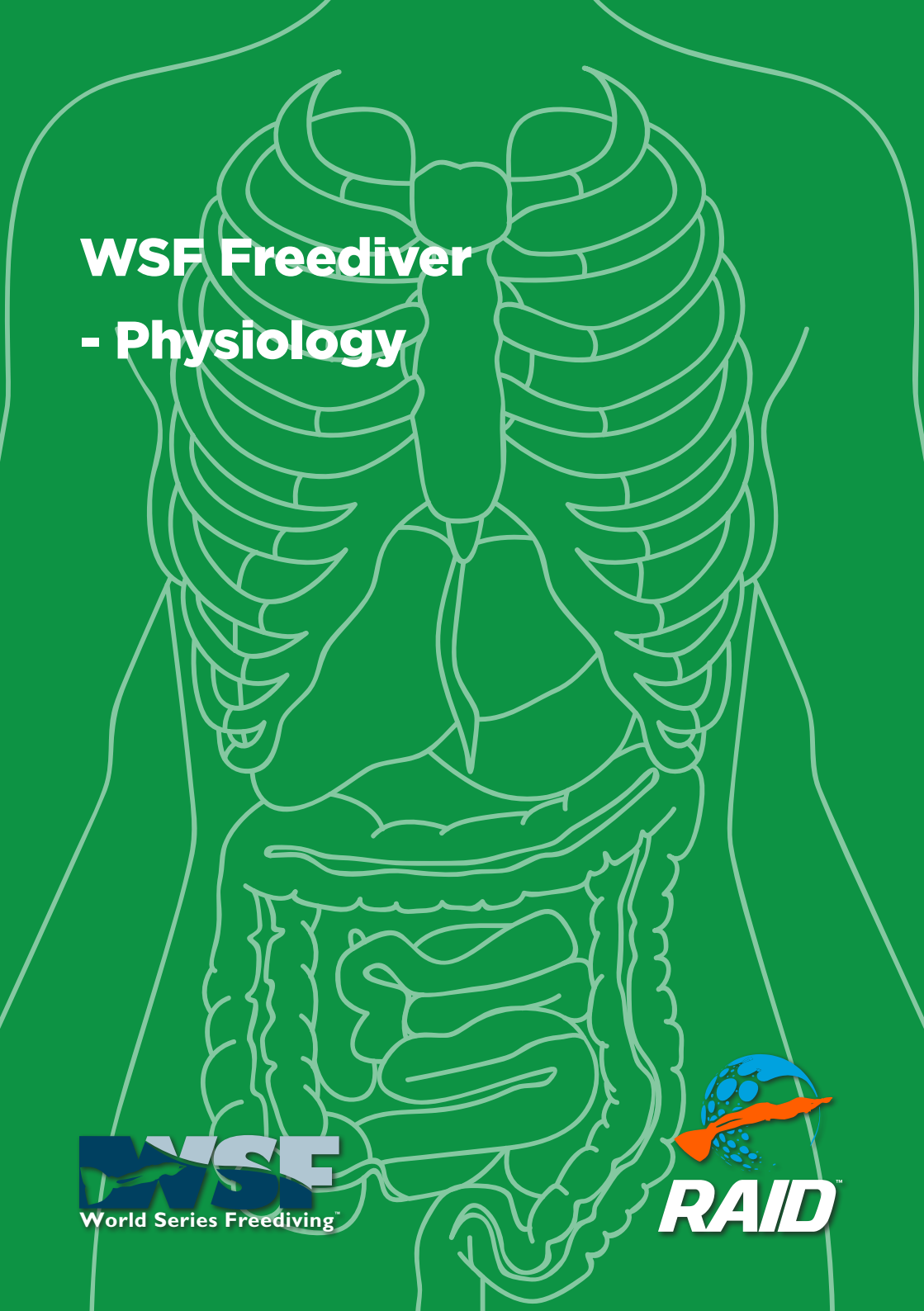
WSF Freediver - Physiology



World Series Freediving™

RAID™

WSF Freediver - Physiology

THE 4 FREEDIVING ELEMENTS

1. Conserving Oxygen O_2
2. Equalisation EQ
3. Flexibility FLX
4. Safety SFE

The 5th Element that is key to success is you, the freediver!

PHYSIOLOGY: THE DIVING REFLEX (DR) O_2

Objectives:

1. List the 4 main parts of the DR
2. List 2 ways to trigger the DR
3. List at least 5 animals that display a DR in nature

Value: Longer breath-holding, deeper freediving, safer freediving experiences.

Nearly all creatures on earth have evolved with some sort of mechanism for surviving submersion in water and, with a planet that has a watery surface area of 70%, it's no wonder.

The diving reflex is clearly present in many animals that use breath-hold as a means of survival. Many different species employ the skills similar to that of a freediver.

Snakes and lizards, birds, turtles, alligators and crocodiles all display great breath-holding talents. Even more interesting are species that share similarities to humans. Mammals like dolphins, whales and seals display a great diving reflex that enables them to dive deep for long periods of time to hunt and survive.

Humans also display a diving reflex – everyone is equipped with it – we only need to trigger the reflex and we are empowered with an almost super-human ability to freedive to great depths and hold our breath for seemingly impossible amounts of time.

There are 4 main parts to the DR.

Bradycardia: Triggered mainly by facial immersion in water. By immersing the face in water cooler than our own body temperature, the DR is initiated by a lowering of the heart rate – this can be up to 50% reduction, and even more with regular freediving training which will enhance your DR.

Nerves around the face react to this immersion and send signals to the brain which triggers bradycardia. This, in turn, conserves oxygen by reducing demand. Bodily immersion will also trigger bradychardia, but not to the extent of facial immersion.

Peripheral vasoconstriction: As the DR is triggered, the capillaries in the extremities will start to constrict. This reaction keeps oxygen rich blood in the core area where it is needed, as this effect happens we will experience cold extremities when freediving. This vasoconstriction is all part of the DR master plan, to keep oxygen rich blood where it is needed, at the core, heart, lungs and brain.

Blood shift: Blood starts to shift to the thoracic cavity. The capillaries around the lungs/alveoli will swell with this blood and compensate for the reducing lung volume. This effect offers the lungs protection from negative pressures exerted when freediving to depth. The blood shift is paramount to successful and safe freediving. It is a strong blood shift that can help prevent lung squeeze. Take time to develop your DR and maximise your safety.

The Spleen Effect: The spleen contracts and releases more red blood cells into the blood stream. With more oxygen carrying capability, the freediver gains precious 02 stores via this amazing effect of the DR.

Recent advances in science have discovered other effects of the DR. For instance, pruning of the fingers is a response to immersion that affords the person more grip when in water. Also, the effect of the blood shift can trick the body into thinking there is very sufficient hydration which can cause frequent urination. It is wise to stay well hydrated while Freediving.

WSF Pro Tip: Regular freediving is a great way to build a strong DR. Remember, even just holding the breath (C02) will trigger the DR. The human body is truly amazing, as the many receptors within the body send messages to the brain, triggering the DR effects, offering you oxygen conservation and greater times and depth underwater. Talk to your WSF Professional about freediving training techniques designed to enhance your DR.

LUNGS AND THE ROLE OF OXYGEN AND CO2 DURING FREEDIVING

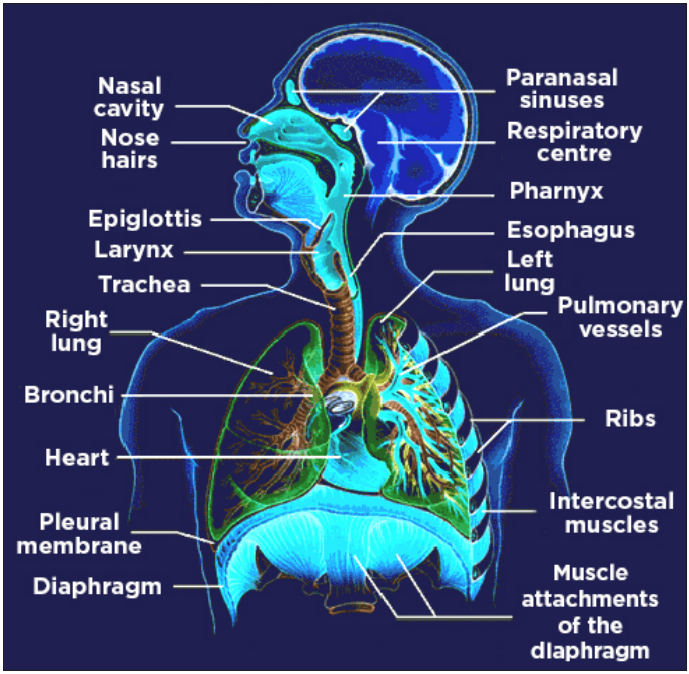
Objectives:

1. State which gas triggers the urge to breathe
2. Describe the process of diffusion
3. List the main parts of the upper and lower respiratory tract

Value: By developing knowledge of the lungs and respiration and how it functions in relation to freediving, you are empowered to become more aware of skill development, including proper breathing and risk management in relation to lung squeeze.

Take a breath and descend into the depths and discover the fascinating underwater world. The process of freediving triggers an amazing array of effects within the body.

WSF Pro Tip: The muscles use oxygen and, in turn, produce the by-product CO2. This CO2 is responsible for the urge to breathe which triggers our DR. When freediving, the urge to breathe is a good sign as we need these relatively high concentrations of CO2 to trigger our DR, thus providing a great way to conserve our O2 stores even further.



The urge to breathe can manifest as contractions of the diaphragm, a warming in the chest and an urge to swallow. The urge to breathe may feel uncomfortable at first, but with time it will become a normal part of freediving. Keep in mind, the urge to breathe is not an alarm or anything to worry about, but a very normal process that signals everything is working perfectly within your body. When you feel the urge to breathe, you should remain calm and prepare to start your surfacing routine. When using proper breathing for freediving, the urge to breathe happens long before your oxygen stores become low.

The lungs have 2 main functions: to maintain equilibrium of certain gases by diffusing these gases in and out of the body accordingly, and regulating pH of the blood system in accordance to O2 usage/demand.

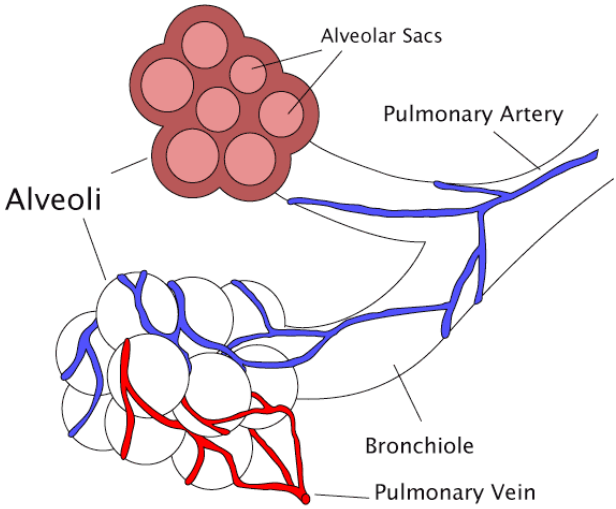
C02 is acidic, this acidic state promotes the release of oxygen into the tissues. If the blood becomes alkaline from over breathing (lacking C02) then the bond of haemoglobin and 02 becomes to strong and the oxygen is not released to the tissue, this is know as the bhor effect. As freedivers we need to avoid over breathing because of the risk this poses to blackout, the lack of C02 hinders the DR.

The human airway is divided into the upper and lower respiratory tract – the upper being the mouth, nose, sinuses and into the larynx. After the inhaled air moves through the larynx into the trachea, it reaches the lower respiratory tract.

The trachea is a semi rigid tube, about 4 - 5 inches long and around 1 inch wide. The walls of the trachea are C-shaped and largely consist of cartilage which gives the trachea rigidity and allows it to stay open without collapse.

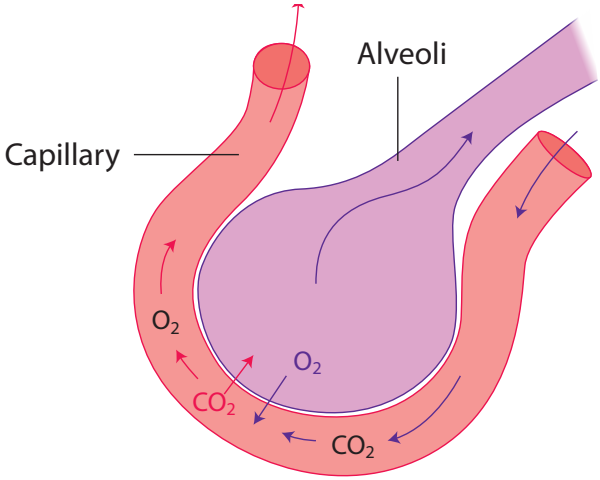
As air flows in from the trachea, it branches off to the two bronchi. Each bronchus leads to the right lung, and to the left lung respectively. The bronchi also consist of cartilage like the trachea.

Within the lungs, the bronchus divides into secondary and tertiary bronchi which continue to branch into smaller airways called bronchioles. The bronchioles lead deep into the lungs. They are more flexible than the upper airway and do not contain cartilage, they are more elastic. The bronchioles terminate into air sacs called alveoli.



Alveoli are bunched together into clusters to form alveolar sacs. This is where the magic of gas exchange happens between CO2 and oxygen.

On the surface of each alveolus, there is a network of capillaries carrying blood that has come through veins from other parts of the body. Here gas exchange occurs – carbon dioxide from the blood is exchanged for oxygen from the alveoli. After the blood is oxygenated, it goes to the heart (between the two lungs) where it is pumped out to all of the body tissues and extremities that require oxygen for proper function. When you breathe out, the carbon dioxide is exhaled and expelled from the body. Diffusion occurs when the gas molecules move from an area of high concentration to an area of low concentration.



This occurs during gaseous exchange as the blood in the capillaries surrounding the alveoli has a lower oxygen concentration than the air in the alveoli which has just been inhaled. Both alveoli and capillaries have a membrane wall which are only one cell thick (around 50 times thinner than a piece of paper) which allows gases to diffuse across them. The same happens with carbon dioxide (CO2) when the blood in the surrounding capillaries has a higher concentration of CO2 than the inspired air. Therefore CO2 diffuses the other way, from the capillaries into the alveoli where it can then be exhaled through the mouth.

A good example of this is to consider the air we breathe which contains approximately 21% Oxygen and 0.04% Carbon Dioxide. After inspiration and upon exhalation there is approximately 17% Oxygen and 0.3% Carbon Dioxide. This shows a decrease in Oxygen levels (as it is used by the body in producing energy) and an increase in Carbon Dioxide due to it being a waste product of oxygen usage. The human body really is fascinating!

PHYSICS – UNDERSTANDING PRESSURE SFE

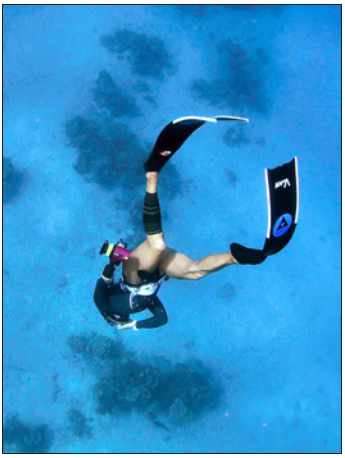
Objectives:

1. State Boyle's Law
2. Calculate the volume of an airspace at any given depth
3. Calculate the pressure at any given depth

Value: Equalising pressures and pressurisation strategy is a large part of your freediving knowledge and skills. This will help you refine your equalisation and provide you with necessary skills to go deeper safely. It is Boyle's Law that requires us to use equalisation skills due to the compression of air spaces.

Boyle's Law

A man known as Robert Boyle from Ireland studied the compressibility of gases in 1660. During his experiments, he observed that at a fixed temperature the volume of a gas is inversely proportional to the pressure exerted by the gas. Boyle's Law hence describes the relationship between the pressure and volume of a gas. According to Boyle, the pressure exerted by a gas held at a constant temperature varies inversely with the volume of the gas. A good example of this is if the volume is halved, the pressure is doubled, and if the volume is doubled, the pressure is halved.



As freedivers descend, the pressure will affect the volume of your air spaces. Within the body this includes the lungs, sinuses and eustachian tubes. Pressure will also affect the equipment – the freediving mask and the freediving wetsuit which is usually made of neoprene that is formed from many tiny, compressible air bubbles contained within the rubber materials.

Here, in this illustration, you can see the pressure and volume graphically explained.

Depth	Pressure	Lung Volume	
Sea Level	1 bar/ata/14.7 psi	4 lt	
10 m/33 ft	2 bar/ata	2 lt	
20 m/66 ft	3 bar/ata	1.3 lt	
30 m/99 ft	4 bar/ata	1 lt	

The pressure exerted on the sinus and eustachian tubes and mask need to be equalised. On the other hand, pressure exerted on the lungs needs to be dealt with passively by being flexible enough to handle the pressure and subsequent decrease in volume. If unable to equalise, the negative pressure in the mask or eustachian tube/sinus will result in barotrauma from squeeze. This can be unpleasant and harmful, so is best to be avoided. Your WSF Freediving professional will equip you with the skills and knowledge to compensate for these pressures safely and easily.

STRETCHING FLX

Objectives:

1. Perform 3 stretches that benefit freediving
2. State 2 benefits of stretching for freediving

Value: By developing the skills and knowledge of stretching for freediving, you will be empowered to start your flexibility regime. This will allow you to experience depth with greater safety and enjoyment. By being flexible in the body, we can move with more efficiency and handle pressure at depth with greater ease.

Being flexible is one of the WSF 4 elements of freediving. By being flexible in the body, we can move with greater efficiency. It also allows better circulation and optimum muscle movement. We use our flexibility in all aspects of freediving, for instance:

- When we duck dive
- Use finning techniques like flutter and dolphin kick
- Handle pressure at depth (chest area)
- Keep a relaxed head and body position (streamlining)

Stretching is a great way to relax the mind and lower our metabolic rate before we freedive. Just 10 – 20 minutes of stretching can unlock a multitude of calming sensations and lower our heart rate immensely. Starting a stretching routine may lead you to enjoy learning Yoga which can provide further relaxation and flexibility.

Stretching is a great warm up for freediving sessions. Make sure not to stretch to the point of feeling pain, avoid bouncing and practice passively without force – stretching should be a calming and relaxing experience. From the top of the head all the way down to the toes, your freediving will benefit.

Your WSF professional instructor will guide you through a stretching routine for freediving. This will encompass the entire body and develop the skills and knowledge you require to improve flexibility for freediving.

There are many benefits of stretching for freediving, including:

- Increased range of movement in the joints and soft tissue.
- Reduced muscle stiffness.
- Enhanced muscular coordination.
- Greater muscle memory (elastic).
- Increased circulation of the blood to various parts of the body.
- Increased energy levels (resulting from increased circulation).

WSF Pro Tip: By stretching passively, we prepare our muscles and soft tissue for exercise. By allowing blood flow to increase and muscles to develop more elasticity and strength, it will allow us to enhance any physical activity. Keep in mind, we do not need to be expert Yogis or as flexible as a rubber band to be successful at freediving. By regular freediving activity and simply keeping to a stretching routine, you will naturally develop the optimum flexibility for freediving. Enjoy, relax and breathe your way to a more flexible body and more successful freediving experience with the start of your flexibility regime.

LICENSE AGREEMENT

End User License Agreement (Non-transferable) and Limited Warranty. Read carefully before using the License Agreement and Limited Warranty.

Your use of this product must be within strict accordance of the License Agreement. This means you may not copy this programme for any purposes other than to maintain a backup copy for your own personal use. It is against the License Agreement to sell, give, or lend this programme, or a copy of it, to a third party.

ACKNOWLEDGEMENTS

Primary Author: Mike Wells

Contributing Editors: Mark McCrum, Jordan Young, Brendon Holliday

Images: Jacques De Vos

Graphics: Kristen Goldsworthy