

COVER PAGE

FOREWORD

CMAS would like to thank the Belgian Federation FEBRAS / BEFOS for making this educational document to us. We invite you to visit our website "cmas.org" to better discover all the activities that our confederation offers.

The official and original document in french is on the website of the CMAS. It is available to you in all the CMAS (French Spanish).

This syllabus contains a lot of information that sometimes exceed the expectations of the 1 * diver. It is the monitor to inform the candidate on knowledge to master.

All constructive comments concerning this manual can be directed to tec@cmas.org



INTRODUCTION

Welcome to our Confederation that brings together people sharing a common passion : scuba diving.

This book, written by a team of passionate instructors will introduce you to the bases of theory needed to start our activity safely. Educational research, style, illustrations in this book will enable you to easily acquire the necessary knowledge for this purpose. All information and rules are standardized and defined by the World Confederation of Underwater Activities which includes more than 85 countries. Your first dive certification will be recognized worldwide.

Our confederation is for everyone, from the youngest (from 8 years) to the oldest, including people with disabilities. Our instructors are also trained in the respect of the world standards as well as conform to European Community standards.

This book is a first key that will give you the access to the wonderful world of silence, a three dimensional aquatic space.

Other keys will open the doors of various areas in which you can develop yourself more as per your interests: The underwater photography, archaeology, biology, freediving, hockey, teaching your passion ... are part of the range of activities offered by CMAS.

This approach will be rewarding for your mind and will bring a new complementary vision of the underwater world. Its beauty will amaze you, surprise you. Learn to respect and to discover the feeling of freedom when you will discover in a three-dimensional universe.

This book is the complement to the theory given by your instructor. The theory knowledge go hand in hand with the practice and will be essential for the training of the diver.

I hope that, in this society of zapping culture, you will take to heart your learning and you will discover a real passion for our activity. One day, certainly, you will transmit it to friends. Thus, the circle will be closed. Only the future will tell us if your efforts and those of the authors of this book will have borne fruit.

Share your passion and emotions will bring so much pleasure and satisfaction in this modern world where individualism is king. You will not be alone anymore, and you will have a fascinating topic to chat on Facebook, Twitter, ... whether you are "in" or "trendy" or, more simply, around a table with friends.

I wish you a wonderful experience with the discovery of the underwater world and this new lifestyle.

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1. FOREWORD

The desire to explore the sea may have been initiated from a shore by the observation of a small fish swimming on the bottom, after the visit of a marine aquarium or after watching a movie or a TV show, or simply by reading a book about the world of silence. Some may have had the occasion to contemplate this fascinating world during snorkeling. This desire can naturally lead to a greater adventure: the scuba diving practice.

1. A BIT OF HISTORY

Not so long ago, the underwater world was considered as an activity for adventurers braving many dangers. Scuba diving was born on the shores of the Mediterranean Sea and its followers did not have at this time very sophisticated equipment. The effects of pressure on the human body were quite unknown.

These people quickly regrouped in clubs and federations and laid the first foundations of underwater diving instruction binder rigor and seriousness needed to meet them in a friendly. Value quality over speed of access to the depths fell common sense and was essential to practice this discipline safely. This philosophy has remained the brand image of our teaching, faithful to the ideals of the pioneers.



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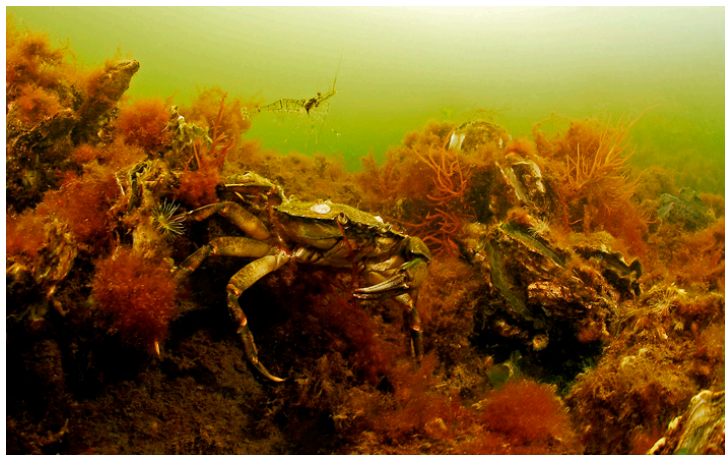
The development of tourism, sophisticated equipment as well as a better understanding of the physiological effects of pressure on the body allows addressing this discipline more quickly and avoiding routes considered before as too long and tedious. A few hours in a swimming pool and a theoretical course in an enchanting island followed by a first try dive in the shallow water of a lagoon are enough to train the recreational diver. This can satisfy many people as the practice of diving will be for them an occasional entertainment, which is very often limited to a guided tour of a shallow coral reef.



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2. IS DIVING LIMITED TO THE VISIT OF CORAL REEF?

“NO” is the answer to that question. If the coral seas offer a wide range of beautiful colours and fish galore, warm, translucent waters at will, other types of background, other creatures, and shipwrecks await you in all the world's seas. Diving conditions are often much harder, the water temperature may be low, the visibility very limited and the depth more important.



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3. SHOULD WE ALWAYS BE GUIDED BY A PROFESSIONAL?

Diving for beginners can be compared to a brief visit of a city or a museum, guided by a professional. Some are happy with that but others prefer to go to documenting and autonomously organize their visit. It's the same for scuba diving. What a joy to go discovering the wonderful underwater sites with friends or family and then discuss during the long winter evenings.

To do so, a good training is essential.



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4. DIVE ANOTHER WAY? WHY?

As already mentioned before, it may be interesting to dive deeper and therefore having a mandatory decompression dive. Diving with bad conditions requires a more developed self-control. All this can't be learned within days but only by continuous and rigorous training. It is also about entering a world of enthusiasts who like to gather together to talk about anything: their passion!

Sport fans like to get together and socialize, scuba diving is no exception.



5. SO WHAT ?

Anyone who fits into what has been described above, whether beginner or advanced, which is intended to make this an ongoing hobby discipline, will find in the CMAS what he's looking for.

We aim to focus on quality instead of the rapidity for teaching because our divers will become autonomous or maybe instructor. We rely on an experience of over 50 years of existence. We are scuba divers and instructors of the highest level.



6. CONCLUSION

If what you just read is what you seek, if you adhere to these principles and this concept, you are welcome in a wonderful world where it is very difficult to escape from.

2. ADMINISTRATION

2.1. HOW TO BECOME A DIVER?

The **World Underwater Federation** is present in more than 85 countries. His instructors will teach you perfectly all the modern techniques of this beautiful discipline which quickly will become a passion.



2.2. LICENSES AND LEVELS

CMAS issues :

4 diver CMAS Licenses meeting the international standards. The first three levels of diver meet the recreational diving requirements.

3 diving instructor CMAS Licenses meeting the international standards. All meet the high requirements concerning diving instructor training.

2.3. ADMINISTRATION

At the end of this course, you must receive a CMAS diver 1* card. To be valid, this card will have the CMAS logo as a hologram. It shall mention at least the following:

- Card holder's surname
- Names
- Nationality
- Postal address

- CMAS number of C-card

The following numbering system should be used on all C-cards "XXX / Y00 / ZZ / 99/888888"

The significance of this system is:

"**XXX**" is the Olympic acronym of the country of the federation or the dive center where the C-card was issued;

"**Y**" indicates whether the card was issued by a federation or a dive center. If it is a federation "Y" will be replaced by an "F" and if it is a dive center "Y" will be replaced by an "O";

"**00**" indicates the unique code given to the federation or CMAS diving center;

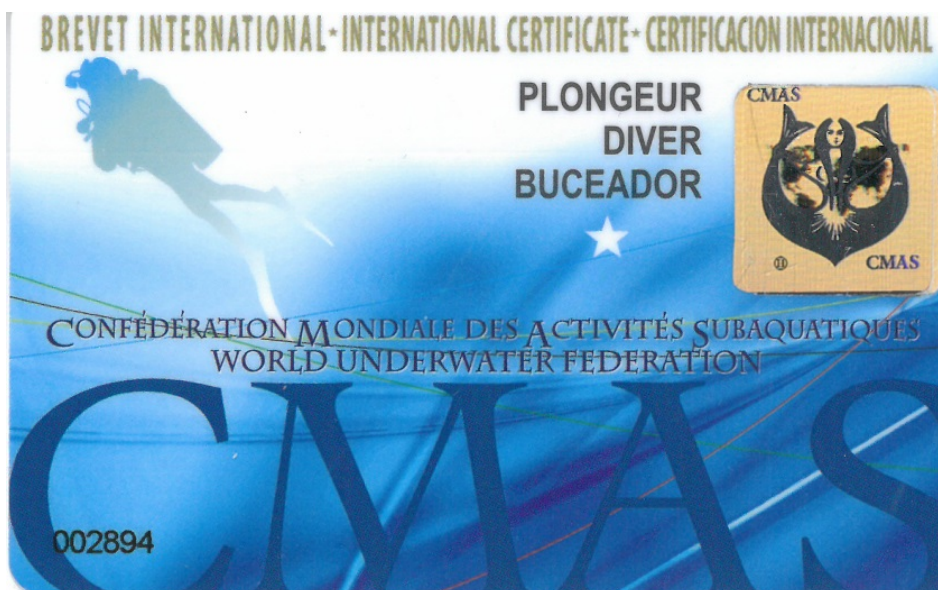
"**ZZ**" indicates the level of certification (i.e. P1, P2, P3 etc.);

"**99**" indicates the last two digits of the year during which the C-card was issued and

"**888888**" is a unique six-digit number of the C-card showing the level of certification awarded during a given year (it is mandatory to begin the number 000001 by January 1 of each year).

Examples of numeration: "ESP / F00 / M3 / 02/000025" means that: it is 25 3 * Monitor C-card published by the spanish federation in 2002

"ITA / F00 / P3 / 03/000169" means that it is the 169 3 * Diver C-card issued by the Italian federation in 2003.



2.4. INSURANCE

PUBLIC LIABILITY

It is highly recommended to have an insurance cover for the practice of scuba diving activity. Very often, it is a specific contract. Check with your instructor about whether you are covered in your structure.

Keep in mind to cover the responsibility of your actions in respect of another diver.

2.5. COMPETENCIES OF THE DIVER 1 *

The 1* diver is qualified to use air as a breathing gas, make dives which do not require mandatory in-water decompression stops. He is able to make dives during normal daylight hours and in an environment where direct vertical access to the surface is possible.

He will dive only when appropriate support is available at the surface. He will dive under conditions that are equal or better than the conditions in which he was trained. If he has received additional training he can dive to a recommended maximum depth of twenty (20) meters with other SCUBA divers of the same level.

2.6. CONDITIONS FOR INTERNATIONAL REGISTRATION

CMAS has developed an international certification system for training divers CMAS.

2.6.1.GET INTERNATIONAL LICENSE.

A diver can obtain an international certificate CMAS diver training from one of the following ways:

- A CMAS One Star Diver shall be trained such that when assessed by a CMAS Instructor, he shall be deemed to have sufficient knowledge, skill and experience to procure air, equipment, and other diving services and to plan, conduct, and log open-water dives that do not require mandatory in-water decompression stops, without the supervision of a CMAS Instructor or CMAS Dive Leader, when properly equipped and accompanied by another certified diver of at least the same level, provided the diving activities undertaken, the diving conditions and the diving area are similar, equal or better to those in which training was received.

- By attending a CMAS diver training program of a CMAS diving center, represented by a CMAS Instructor authorized to present this program on behalf of specific dive center; This is only valid in one hand that the dive center is in good standing with CMAS Technical Committee and secondly that the training program has been recognized by CMAS as equivalent to the standard of this specific training program .

2.6.2.PURPOSE OF THE REGISTRATION SYSTEM

The international certification system CMAS diver training aims to provide international recognition of each training certification CMAS divers. This means that the system is designed to provide recognition of the level

of skill and experience of a diver, regardless of where he / she has been trained (e), allowing him to dive anywhere in the world with its C -carte CMAS.

All federations or CMAS diving centres are forced to recognize the international CMAS certification of a diver, allowing him to dive within its CMAS certification and allowing access to higher education programs.

2.7. TEN GOLDEN RULES OF THE CMAS

Ten golden rules issued by CMAS are:

- 1 - Never enter the water through the reeds, live coral or water plants.
- 2 - Keep distance from corals and other animals and do not stir up sediment.
- 3 - Check the inflatable vest.
- 4 - Take care where you drop your anchor during boat dives.
- 5 - Do not chase, touch or feed wild animals
- 6 - Do not spearfish for fun and do not buy or collect any souvenirs such as corals and shells.
- 7 - Be very careful when diving in caves. Bubbles or any simple contact may destroy delicate life.
- 8 - HKeep diving places clean.
- 9 - Learn about the underwater life and avoid any destruction.
- 10 - Urge your buddies to follow these rules too!

3. PROTOCOLS OF LICENSE

A test protocol is a sequence of coordinated movements, handling equipment, exercise, mental discipline, self-management, group and / or space, ... required to acquire one or more technical and 'demonstrate mastery.

The protocol must be carried out with ease.

Tests shall be successfully performed.

3.1.CONFINED WATER SKILLS

- ✓ Use of mask, snorkel and fins
- ✓ Diving system assembly and disassembly (at water's edge)
- ✓ Pre-dive equipment inspection and in and out of water buddy check
- ✓ Entries and exits
- ✓ Proper weighting and trim
- ✓ Mouthpiece clearing - snorkel and regulator
- ✓ Regulator/snorkel exchanges at the surface
- ✓ Proper descent and ascent procedures (e.g. equalising pressure in ears and mask)
- ✓ Swim under-water efficiently with appropriate buoyancy and attitude
- ✓ Mask-clearing, including removal and replacement
- ✓ Controlled breathing underwater without a mask
- ✓ Buddy-system techniques (e.g. appropriate hand signals, staying close, monitoring buddy)
- ✓ Underwater and surface buoyancy control
- ✓ Underwater problem-solving (e.g. regulator recovery/retrieval, etc)
- ✓ Monitoring instruments
- ✓ Surface-snorkel swimming with full diving equipment. (The student shall be able to swim a distance of at least 50 m)
- ✓ Surface operation of the quick release/emergency function of the weight ballast system
- ✓ Underwater removal and replacement of SCUBA system
- ✓ Underwater removal and replacement of the weight/ballast system
- ✓ Out-of-air emergency procedures allowing a SCUBA diver to ascend to the surface in the event of an out-of-breathing gas situation, acting as both receiver and donor. This shall include both dependent and independent procedures
- ✓ Diver assistance techniques (self/buddy) (i.e. to assist a buddy to the surface and provide support on the surface)
- ✓ Equipment care and maintenance (at water's edge)

3.2.OPEN WATER SKILLS

- ✓ Use of mask, snorkel and fins
- ✓ Diving system assembly and disassembly (at water's edge)
- ✓ Pre-dive equipment inspection and in and out of water buddy checks
- ✓ Entries and exits
- ✓ Proper weighting
- ✓ Mouthpiece clearing - snorkel and regulator
- ✓ Regulator/snorkel exchanges at the surface
- ✓ Proper descent and ascent procedures (e.g. equalising pressure in ears and mask)
- ✓ Swim under-water efficiently with appropriate buoyancy and attitude control
- ✓ Mask-clearing, including removal and replacement
- ✓ Controlled breathing underwater without a mask

- ✓ Buddy-system techniques (e.g. appropriate hand signals, staying close, monitoring buddy)
- ✓ Underwater and surface buoyancy control
- ✓ Underwater problem-solving (e.g. regulator recovery/retrieval, etc)
- ✓ Monitoring instruments
- ✓ Surface-snorkel swimming with full diving system. (The student shall be able to swim back to the point of safe exit but no less than 50 m)
- ✓ Surface removal and replacement of SCUBA system
- ✓ Underwater removal and replacement of the weight/ballast system
- ✓ Out-of-air emergency procedures allowing a SCUBA diver to ascend to the surface in the event of an out-of-breathing gas situation, acting as both receiver and donor. This shall include both dependent and independent procedures.
- ✓ Diver assistance techniques (self/buddy) (i.e. to assist a buddy to the surface and provide support on the surface)
- ✓ Simple under-water navigation
- ✓ Equipment care and maintenance (at water's edge)

4. MANDATORY EQUIPMENT

4.1 BASIC EQUIPMENT

- FINS
- MASK
- TUBA
- DIVING SUIT
- WEIGHTBELT
- CUTTING TOOL

2. SCUBA DIVING EQUIPMENT

- TANK
- TAPS
- REGULATOR : PRINCIPAL AND SECONDARY (two air sources)
- PRESSURE GAUGE
- COMPAS
- WATCH OR TIMER
- GAUGE
- DECOMPRESSION MEAN

3. ADDITIONAL EQUIPEMENT

- FLASH LIGHT
- FLOAT AND FLAGS
- DIVING BAGS
- LOG BOOK

4. RESCUE EQUIPMENT

- EMERGENCY SIGNALLING DEVICE (ACOUSTICAL, OPTICAL)
- FIRST AID KIT
- OXYGEN KIT

4. EQUIPMENT

5.1 THE DIVING EQUIPMENT OR "SMALL GEAR"

This is how we call the snorkelling equipment (It won't allow you to breathe underwater) needed for the first diving lessons. Let's see what it is and how to choose it.

5.1.1 FINS

A fin consists of two parts: The fitting portion and the wing.

1. LETS EXAMINE THE FITTING PART FIRSTLY

There are of two types:

Models covering all the foot in the manner of a shoe. This model is more difficult to choose because it must fit perfectly the foot without over tighten. Nevertheless, it offers a significant comfort during the training sessions.

So you will try them at the shop, preferably without socks and with a hint of talcum powder. Indeed, a hard to shoe fin when dry will begin to slide and rub once wet. So you will choose them a little more tight than a pair of shoes, thinking that you will be barefoot and the lining of the liner cannot therefore present burrs or annoying seams.

There are also models covering only the front part of the foot, and fixed with adjustable straps. This model allows wearing isothermal socks for cold water dives.

LET'S CHECK THE WING PART

There are also several types.

Composed of a single material, black rubber, for example, simple and durable; they tend to disappear from the market in favour of more sophisticated models.

Composed of several various materials, sometimes two or three. For example, rubber or silicone to the shoes, a composite material for the blade, sometimes fitted with rubber ribs or provided with holes.

But all these details are a matter for specialists. We just need to know this: more a wing is large and hard surfaced and more it will be difficult to use fins. We therefore choose them according to our muscles, our level of training ... and our ambitions.



5.1.2 MASK

To see underwater, you will also need a mask, see here which one to choose. Whatever model you choose, it will have to absolutely have a "nose" or a bump to allow you to balance the pressures of both sides of the eardrum. You should know that the deeper you go, the more the pressure increases. Our body, consisting of 75% saline water, has a few cavities filled with air or gas (sinuses, middle ear). In these cavities, internal and external pressures must be balanced, so it's very useful to be able to pinch your nose if needed. (See Section 5.6)



To make sure mask fits perfectly to your face, place it on your face without using the strap and it will have to take with a slight suction through the nose. A too hard suction means that the mask is not suitable.

Single or double glasses is a matter of personal taste, the most important is that its volume is as small as possible.

The skirt material (transparent or coloured silicone, black rubber), is a matter of price, knowing that it is justified by a greater or lesser longevity and the comfort provided by some new silicones.

If you wear corrective glasses, be aware that the glasses masks can be corrected either by gluing lenses or by machining the glass.

5.1.3 SNORKEL

The snorkel will be also essential.

Here simplicity is king. Tubes equipped with exhaust valves are not useful.

Concerning the models with valves preventing water entering the top of the snorkel, just ban them, unless you want to "drink the cup" or even drown.



5.1.4 THE BELT

The weight belt also deserves a few words.

The most common material is nylon webbing; sometimes there are rubber straps that fit very well. The most important is that the buckle can be released quickly with one hand.

You will easily find on the market several forms of different buckles. Some buckles include a lug for attaching the crotch strap of the tank. This is a strap fitted to old models strapping suits. This strapping system, although disappearing in favor of back-pack (webbing system with a "back plate" which further increased stability also ensures greater comfort) is still used regularly. It is therefore worth your buckle is equipped with this lug.



There are also belts so-called "pockets". This type of belt to the advantage of being more flexible because they do not contain conventional seals (see chapter 3.1.5), but small bags containing pellets. They are much more comfortable.



Some stabilization jacket brands (see chapter 3.2.4.) also offer integrated ballast pockets in the jacket lining. This method is by far the most comfortable and has the advantage of getting totally rid of the weights as we remove the BCD.

5.1.5 THE WEIGHTS

1kg diving weights are essential. However, it is worth to buy a 500g let you weight yourself precisely. The weighting depends of course on your body size and your density. Knowing that the ideal weighting will allow the diver to stay balanced to 3 meters deep, BCD is empty, in the end dive when passed on "reserve» (More or less 50 bar pressure in the tank).



There are three types of ballast, the weights without protective coating, with protective coating, and bags of granules. Do not over-weight unnecessarily.



5.2 THE DIVING EQUIPMENT

5.2.1 THE TANK

The diving tank is an important investment and we can strongly recommend the tank provided by your club.

However, if the diving virus never leaves you, you will quickly wish to get your personal equipment to be more independent. So we will study here the main features and the user guidelines.

The tanks are characterized by their volume, which may be 7, 8, 10, 12, 15, 18 and even 20 liters. The volume of a cylinder is the equivalent of its water capacity. The choice of the volume of this tank varies from person to person and according to the main use that you will make of it.

In open water, a tank with a volume of 12 liters is sufficient for most of the dives you will make.

At sea, several options are available to you. There are cylinder capacities higher as that of 18 liters or carbon tank that have the advantage of having a much lighter weight and longer life. Also be aware that there are double-tank of 2 x 10 liters. All combinations are possible.

Eg. Bi 2 x 7 or 8 x 2 liters.



The compromises that are (very) widely adopted are the 15 liters cylinder (male) and 12 liters short (female). They are sufficient in our waters and allow most dives in the sea.

Diving tanks are also characterized by their strapping. There are one major types of straps to equip cylinders.

THE BACK-PACK SYSTEM

We mean by "Backpack" a small plastic case attached to the tank by a large metal hoop or a strap. This back plate has a single long strap that allows adjustment made fast.



However, it is loud and clear that the use of a stabilization system is mandatory from your first dives.

Before starting the dive, the tank should be tight but not to the point of annoying. The valve must be approximately to the top level of your lungs and you shouldn't touch it when pulling the head back.

To equip correctly the tank we will need to remind the following:

The acronym is OJA FIX CHE FUN:

- O** Examine the O rings of the regulators and tank
- JA** Mount the Jacket (BCD) on the tank.
- FIX** Fix/Screw the regulator onto the tank.
- CHE** Check the pressure each time you fix a regulator onto a tank
- FUN** Check that the regulator functions properly, try when in surface

Diving tanks are subject to specific regulations that your instructor will be happy to explain during a special session. Some safety rules are needed to put into practice.

Never leave your tank standing without supervision. It is a pressure vessel and a fall can be damaging, at least for your toes.

Protect the valve, which is more fragile than the tank itself.

Do not drag it on the ground to move it. Carry it rather in your arms, shoulder, or better, by wearing on the provided straps.

Do not expose to high temperatures, in the trunk of a vehicle or in direct sunlight, the temperature can rise up to 60 degrees Celsius.

Do not store lying for a long time.

5.2.2 THE REGULATOR

The air in your tank is generally pressurized at 200 bar. A regulator is required to breathe this air. A regulator is a device that allows you to breathe air under pressure by decreasing the high pressure to ambient pressure. It will provide air in sufficient quantities and at the right pressure.

It consists of three main parts:

1. The first stage, which you connect to the cylinder valve.
2. The second stage and its mouthpiece.

3. The medium pressure hose connecting the first stage and second stage.

The choice is large, and all regulators available on the market are reliable. The choice will be more a matter of personal taste. Nevertheless know the right questions to ask your dealer and your diving instructor. Be informed that all the regulators do not have the same flow or the same resistance to inspiration or expiration. Speed should be maximum and minimum resistance. You should also know that in cold water, a regulator with a high flow rate can ice up quickly. Do not hesitate to ask your instructor what he thinks; his experience is also precious.

It is mandatory to dive with two sources of breathable air and strongly recommended to be in possession of a second independent regulator. It allows to prevent a mechanical failure of your primary regulator, but also give air to your dive buddy if he were to run out for one reason or another.



5.2.3 THE BCD

The diving vest is designed to help you to manage your buoyancy throughout your dive. Your diving suit is made of air-filled cells; in accordance with the increase of ambient pressure these cells will decrease volume. (Boyle and Mariotte's Law)

If your volume decreases, your apparent weight increases (see Principle of Archimedes, Chapter 4). So you will fill your BCD with a little air to compensate this loss of volume. Obviously if you are in difficulty on the bottom, your once vest is inflated you will ascend almost automatically.

This is a "jacket" you will wear as such. The fact that it is attached to your tank completely removes the weight of it in water. His apparition on the market has caused a small revolution, try it and adopt it. All the sceptics who tested were convinced by its comfort and ease of use.



INFLATOR: This is a small device, connected by a hose to a low pressure port of your regulator, which can inflate the stabilizing-jacket (Also called "stab") or vest. Its flow can vary from one model to another. Some models are equipped with a hybrid system, combining emergency regulator and inflator.

5.2.4 THE ISOTHERMIC SUIT

The waters in temperate regions we know well have surface temperature variations ranging from 2 ° to 20 ° Celsius.

At the bottom, near 25 or 30 meters, these temperature differences fade to vary between 10 ° and 4 °. These temperatures will never allow you to dive with a usual swimsuit, it will be necessary first to buy a thick wetsuit.

The principle of a wetsuit is: a layer of neoprene (foamed rubber) under which water is trapped and circulates very slowly. It may thus warm the skin being in contact with the body warmth. The necessary time for the body to cool down, vary from + 20 minutes in winter to over an hour in summer and near the surface, depending on the water temperature and the thickness of the suit.

Beware if a thick suit provides better protection from the cold, it is also less flexible and requires more weights on your belt!. Also be aware that depending on the quality of neoprene, 7mm thickness sometimes worth some models 9mm. The neophyte will face a wide choice. For a beginner, the most important will be to choose the combination best suited to its morphology. That is to say that regardless of the movement effected, the combination will always stick as possible to the skin. The choice of colours should not be a criterion.



5.2.5 MEASUREMENT INSTRUMENTS

Although, throughout your training to get your first star, you will be supervised by a diving instructor, this does not exempt you from being in the possibility of assessing the duration and the depth at which you dived. Various instruments are available to you:

THE WATCH :

It is useful to know the length of stay in the water. The ideal is a watch with a 200m resistance. This indicates the maximum pressure at which it was tested.

The diving watch and dive tables are two mandatory accessories.



THE TIMER:

This instrument indicates the dive time, the maximum depth during the dive and instant depth.



© M. Hiernaux



THE COMPUTER:

The computer is the most complete solution but also the most expensive. This combines indeed a watch, a timer, a depth gauge and an instrument offering decompression. They come in different models and different brands, different prices for different features. Before purchasing this type of equipment, check with your instructor.

THE PRESSURE GAUGE

The gauge is a pressure measuring device. There are of 2 types: surface pressure gauges and underwater pressure gauges.

The gauge lets you know at any time during the dive, the air pressure remaining in the tank and so monitor the air consumption and autonomy.

The SPG offers the ability to the instructor at any time to check the level of air of his divers. This will enable him to manage diving, to shorten the dive if necessary (if the tank pressure is too low) or finish the exploration as it was intended.

The diving manometer is connected to a high pressure port of the regulator first stage. Graduated from 0 to 300 bar, it has the form of a simple dial or integrated in a console.



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5. DIVING PHYSIQUE

6.1 THE PRINCIPLE OF ARCHIMEDES

Any object, wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object

The apparent weight of an object (what it is weighing under water) = the mass of the object (in this scenario what it is weighing outside of the water) - the upward force (or buoyant force).

$W_{app} = \text{Mass} - \text{Upward Force}$

If : Apparent Weight > Upward force, Then : Object will sink

If : Apparent Weight < Upward force, Then : Object will rise

If : Apparent Weight = Upward force, Then : Object hovers at a constant altitude

Consider three divers wearing the same amount of weight (100 kg) but with different volume (120 dm³, 100 dm³ and 80 dm³) immersed in pure water (mass 1 kg /dm³).

These three divers will not have the same thrust:

The one with 120 dm³ will face 120 kg of thrust and float.

That of 100 dm³ will be in balance

That of 80 dm³ will sink.

APPLICATIONS TO DIVING

THE WEIGHTING :

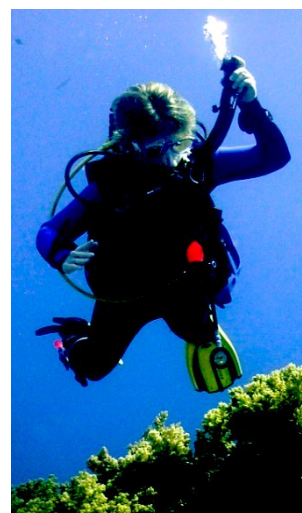
The human body density is very close to water density. For some people, it will be higher or lower. When the diver wears on floating equipment (suit, gloves, etc ...), its density will be mostly less than that of water, especially at sea (the sea water density is greater to that of fresh water). So as to penetrate the liquid element without having to fight not to float, the diver must wear a weight belt (See Chapter equipment).

THE DUCK TECHNIQUE:

In order to enter the water easily without being too weighted, a special technique called "duck technique" is used. This technique consists in immersing the upper body under water while keeping straight the bottom portion out of the water. The latter is no longer under the thrust of water (Archimedes' principle) and pushes on the submerged upper portion. Water penetration will thus be facilitated by movement of inertia induced by the manoeuvre.

BUOYANCY VARIATION IN DEPTH :

Diving clothes are usually made of neoprene. This polymeric material contains air bubbles. These bubbles will decrease volume (Boyle and Mariotte's Law) with depth. The thickness of the clothing will be reduced, thus decreasing the volume of the diver without changing the weight. Buoyancy will be less strong and the diver will sink more easily. It may follow an increased difficulty of progression under water.



USE OF THE VEST AS A MEAN OF BUOYANCY

We will be able to compensate for this loss of volume by increasing the volume of the vest by inflating it. If this practice has been well handled, the buoyancy will be kept the same at any depth.

6.2 THE PRESSURE



The pressure resulting from a force exerted on a surface. The unit of pressure is the Pascal (Pa).

The Pascal is the pressure exerted by a force of 1 Newton on a surface of 1 m². The use of Pascal is not very convenient and is often preferred to other units.

Instead of referring to relatively high pressures, use the bar which can be easily connected to Pascal to the following relationship:

$$1 \text{ bar} = 100.000 \text{ Pa}$$

Atmospheric pressure is expressed in several units such as kg / cm² or kgf / cm² (kilogram per square centimetre strength), the mm of mercury (Hg), the atmosphere (atm), and more recently the millibar and hectopascals (hPa). The relationship between these units is given here under:

$$1 \text{ kg/cm}^2 = 1 \text{ atm} = 760 \text{ mm Hg} = 1000 \text{ mbar} = 1000 \text{ hPa}$$

In order to be complete, we must point out the unit used by the Anglo-Saxons, the p.s.i (Pound per square inch). This unit can be connected to the bar as follows:

$$1 \text{ p.s.i.} \cong 0,07 \text{ bar}$$

In diving, we almost always use the bar, for example the air pressure of the bottle (200 bar) or deep pressure (4 bar to 30 m) etc.

Atmospheric pressure / barometric pressure (considered 1 bar at sea level)

Hydrostatic pressure (in this case the pressure of the water, increases with 1 bar every 10m)

Absolute pressure (Pabs) which is the sum of the atmospheric pressure (Patm) and Hydrostatic pressure (Phydr).

$$P_{abs} = P_{atm} + P_{hydr}$$

This means that at 20m below sea level we have an absolute pressure of 1 + 2 = 3 bar (1 bar Atmospheric pressure + 2 bar Hydrostatic pressure = 3 bar Absolute pressure)

While diving we are using Absolute pressure.

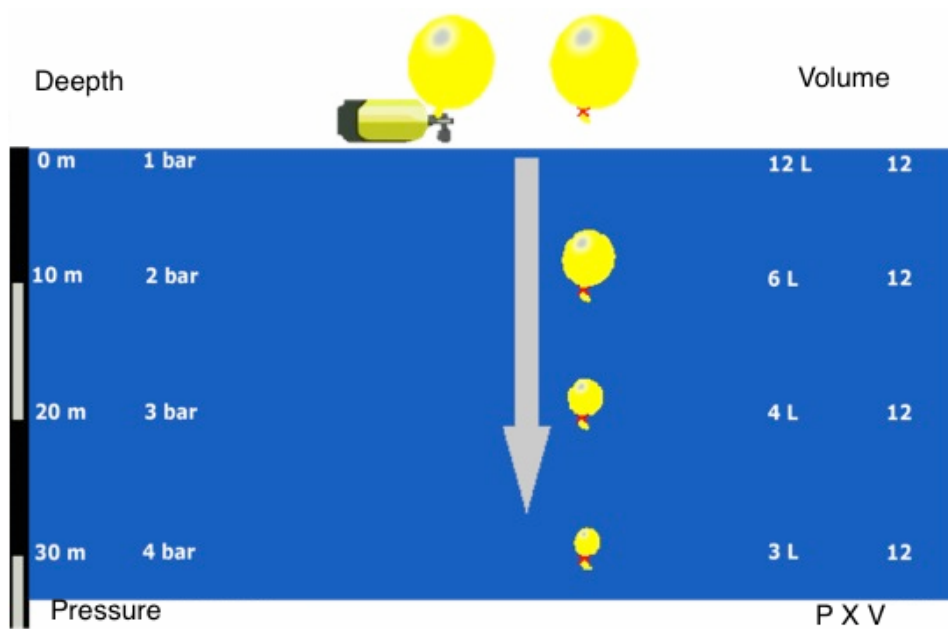
3. CONSEQUENCE OF BREATHING COMPRESSED GAZ

LAW OF BOYLE and MARIOTTE

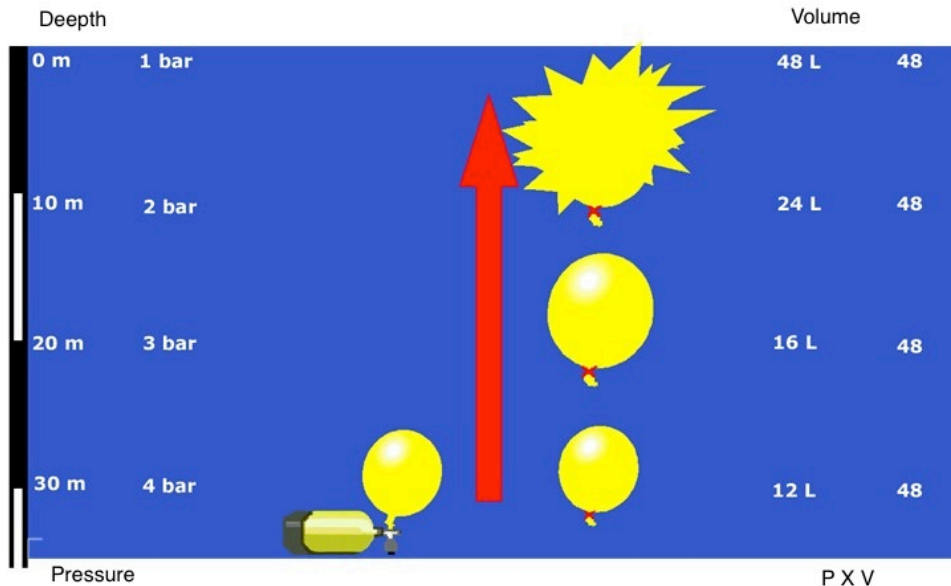


At constant temperature the volume of a gaseous mass is inversely proportional to its pressure

THE DESCENT



THE ASCENT



In other words, the more the pressure increases (in depth), the more the volume decreases. Conversely, in the ascent, the pressure decrease will cause the increase in volume of the gas.

In other words, the more the pressure increases (while going deeper), the more the volume decreases. Conversely, while ascending, the decrease in pressure will result in an increase in the volume of gas.

So: Pressure x Volume = Constant

$$P \times V = C$$

If I inflate a Diving Compensator (synonyms: Buoyancy Control Device/ BCD) with 2 litre of air at 40m it will contain 10 litre of air at surface.

At 40m, we have 5 bar of pressure and I add 2 L to my BCD. **5 x 2 = 10**

At surface there is only 1 bar of pressure. **1 x ? = 10** so **10 : 1 = 10 litres**

A diver using 20 L / minute at surface will use 4 times as much at 30m below surface. .

- 20 L / minute at surface : $P \times V = C : 1 \times 20 = 20$
- At 30m the pressure is at 4 bar : $4 \times ? = 20 \rightarrow 20 : 4 = 5L$
- My diver needs 20 L per minute so 4 times as much

APPLICATIONS TO DIVING

ASCENTS :

While ascending the air "expands" and it is absolutely necessary to get rid of this air by venting your BCD in order not to ascend too quickly and also to exhale in order not to risk Lung Overpressure (Pressure in lungs exceeds ambient pressure, see chapter 1.4.2.2.7.)

CONSUMPTION :

A diver uses more air while he or she is diving deeper. He or she will use twice as much air diving at 10m than at surface, and 4 times as much at 30m. His or her autonomy is a lot less important at 3m than at 10m.

6. MEDICAL PROBLEM IN DIVING

7.1 ANATOMY AND PHYSIOLOGY OF THE HUMAN BODY

DIVING IS NOT A DANGEROUS SPORT. HOWEVER INCIDENTS AND ACCIDENTS MAY OCCUR.

TO UNDERSTAND THE MECHANISM OF ACCIDENTS AND PREVENT THOSE, YOU MUST KNOW THE ELEMENTS OF ANATOMY AND PHYSIOLOGY OF THE HUMAN BODY AND HAVE BASIC KNOWLEDGE OF SPECIFIC CONDITIONS FOR DIVING.

7.1.1 THE BREATHING

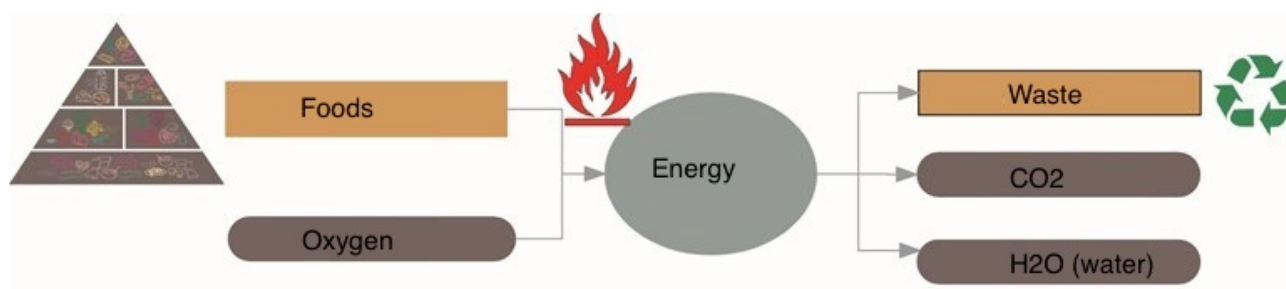
The air we breathe contains approximately:

- 21% oxygen (O₂) gas essential to our life, responsible for the oxygenation of blood and tissues, it allows the normal metabolism of cells.
- 78% nitrogen (N₂), an inert gas diluent, but which will also dissolve in the body without being used.
- The remaining 1% is represented by the carbon dioxide (CO₂), resulting among other cell metabolism and from the combustion of carbon, and water vapour and rare gas.

The purpose of respiration is to bring air in the air tracts and in the lungs in order to oxygenate the blood (blood gas) and to remove, during expiration, the carbonic gas (CO₂) produced by the cellular metabolism. The air / blood exchange happens at the level of the pulmonary alveoli.

Blood "absorbs" the oxygen (O₂) as well as nitrogen and is transported throughout the body. It "liberates" the CO₂ and nitrogen which are evacuated through the lungs during exhalation.

7.1.2 THE METABOLISM

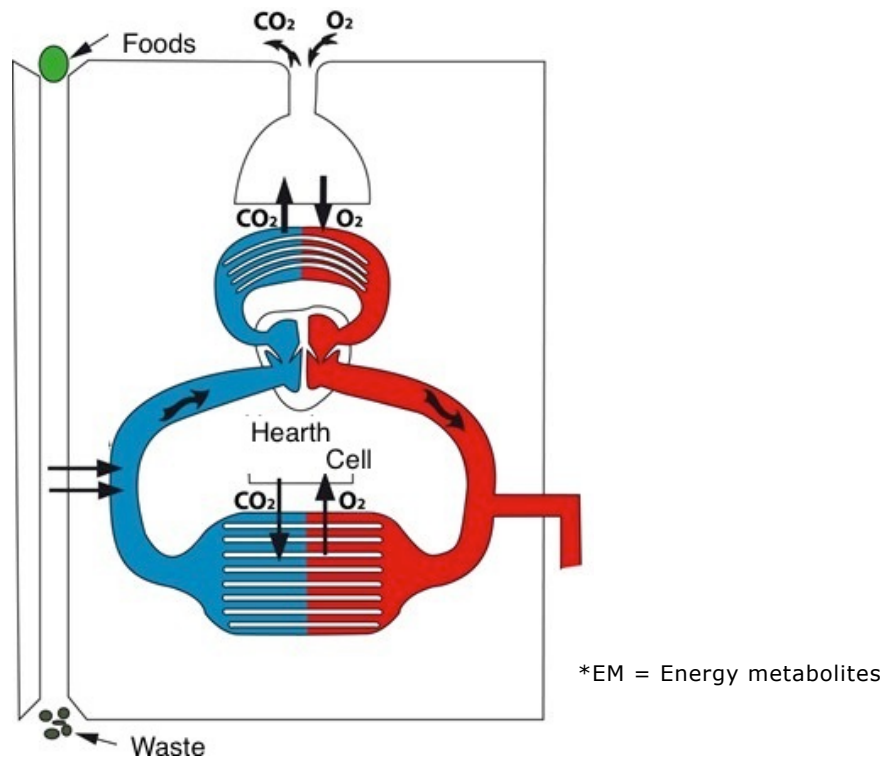


Muscles and organs need energy to function. This energy comes from the combustion of foods (especially sugars) in the presence of oxygen.

Fuel (sugars, fats, and proteins) enter the bloodstream via the digestive tract and are distributed in the body. Oxygen is carried by the same blood flow to the muscles and organs.

Furthermore, our body is functioning at an optimum temperature of 36 ° C. The energy required to keep also comes metabolism.

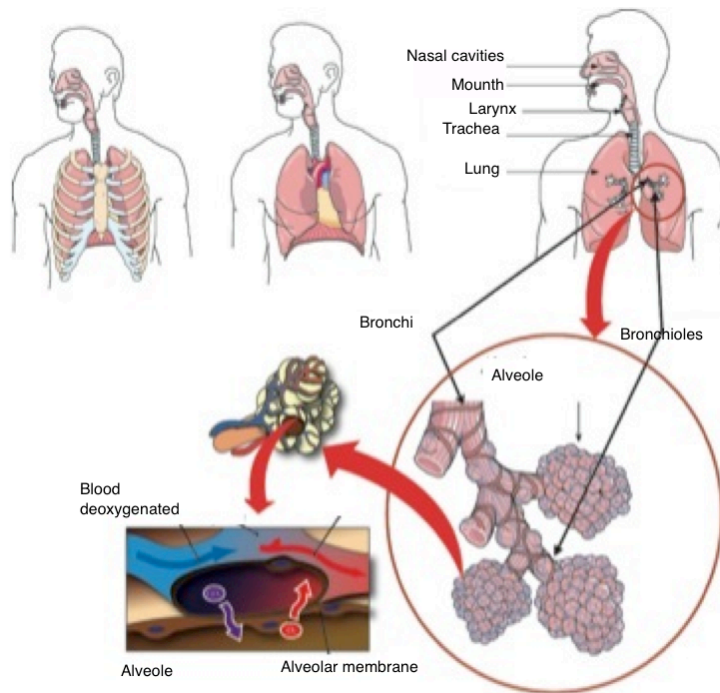
Waste, CO₂ and water products, should be eliminated. CO₂ transported by the bloodstream is eliminated through the lungs. In efforts we consume more oxygen and produce more CO₂. The produced water is eliminated through the urine, expired gases and sweating.



7.1.3 UPPER RESPIRATORY TRACKS

This is a dead space, space where no gas exchange and therefore not taking part in blood oxygenation:

- Mouth and nasal cavities.
- Larynx.
- Trachea.
- Bronchi and their divisions, bronchioles,...



We breathe through the nose or mouth. Breathing through the nose has the advantage to filter dust from the air through the nasal hairs. In addition, the air is heated and humidified in the nasal cavity. The mouth breathing is easier (less friction) and in case of breathlessness we automatically breathe through our mouth.

With a regulator we breathe with the mouth ... The compressed air is filtered, but, it is dehydrated. The air we breathe is thus very dry.

Food and air pass through the oral cavity and pharynx (throat).

Downstream, the larynx contains the organ of speech, the glottis (vocal cords) and is separated from the digestive tract (oesophagus) during swallowing, the epiglottis.

We should also mention the sinuses (frontal, maxillary, ethmoid) communicating with the nasal cavity and the Eustachian tubes, also in communication with the nasal cavity and that balance the middle ear.

While diving these dead spaces are added to the volume of the snorkel or regulator.

In the case of shallow breathing, there is a risk that not renew the air in these areas and therefore have an inefficient breathing.

7.1.4 LUNGS

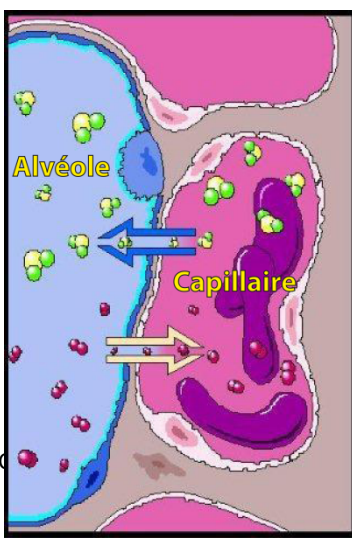
The ultimate bronchioles divisions lead to the alveoli, small "bags" where all exchanges happen.

Alveoli would occupy an area of 100 m² if they were spread out. It is estimated that there are 300 million alveoli by lung.

The cell wall is extremely thin and is surrounded by capillaries. Gas exchanges between the blood and air tracts are across the alveolar-capillary membrane. Oxygen is absorbed into the blood and carbon dioxide (CO₂) removed by the exhaled air.

The alveoli are lined with a substance that keeps open the surfactant (surface-active substance).

The lungs are enveloped in a sheet, the visceral pleura. The interior of the



chest is covered by the same sheet, the parietal pleura.

Between both pleurae is a virtual space where the pressure is lower than atmospheric pressure. This relative vacuum maintains solidarity lung to the chest wall in order to follow the movements of the latter.

7.1.5 RESPIRATORY MOVEMENTS

7.1.5.1 INSPIRATION

It is an active movement involving the respiratory muscles, the most important is the diaphragm. The respiratory muscle power is insufficient to provide inspiration beyond 0.3 to 0.4 meters. It is therefore essential to breathe air at ambient pressure.

7.1.5.2 EXPIRATION

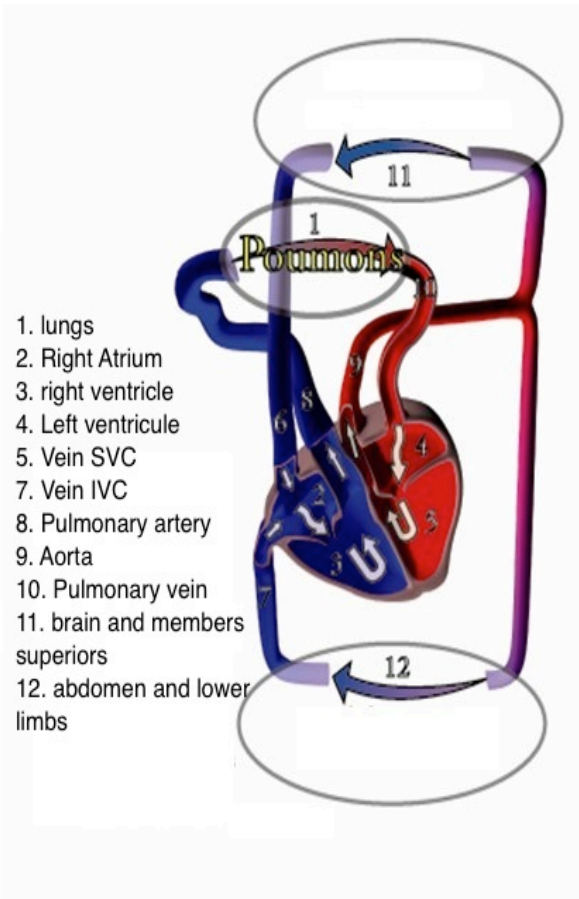
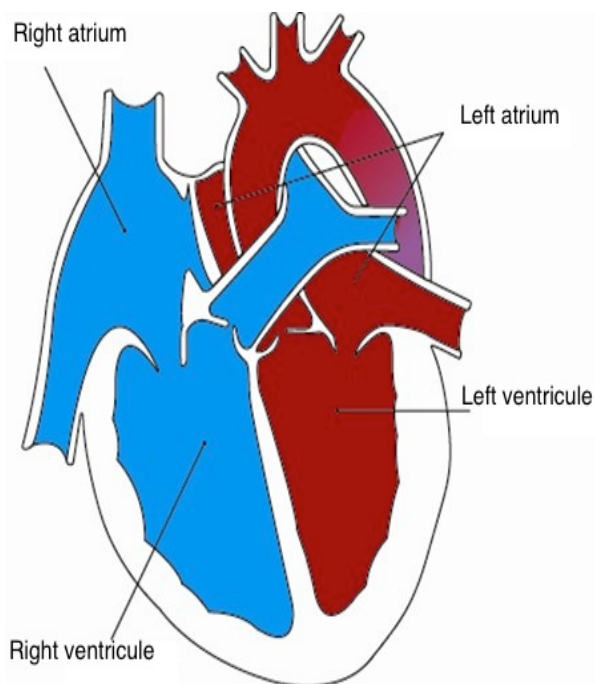
This is a passive movement, due to the relaxation of the respiratory muscles. Respiratory rate is automatic and controlled by the respiratory center located in the medulla. CO₂ is the essential chemical factor that controls our breathing center.

7.1.6 CIRCULATION

The circulatory system is a closed system consisting of the heart (which acts like a pump) and vessels, arteries, veins and capillaries (the pipes).

The blood in these organs, and which is circulated by the action of the heart pump, transport essential substances to ensure the metabolism (nutrients, oxygen, etc.) but also the substances to eliminate metabolic waste from, CO₂, urea as well as toxins, via the lungs, liver, kidneys, etc ...

The heart consists of a striated muscle, the most powerful of the body, the myocardium. It is divided into right heart and left heart, as well as four chambers: right and left atria and right and left ventricles.



The blood returns to the heart through the vena cava (upper and lower), and is collected in the right atrium and passes into the right ventricle. The right ventricle pumps blood into the pulmonary circulation also called small circulation through the pulmonary arteries.

The blood returns from the lungs through the pulmonary veins to the left atrium, goes into the left ventricle from where it is ejected under pressure throughout the body via the aorta and the systemic circulation. In the organs, arteries progressively divide and eventually form the capillary network that constitutes the trade area. Blood is then taken by the venous capillaries and collected by veins becoming larger towards the vena cava.

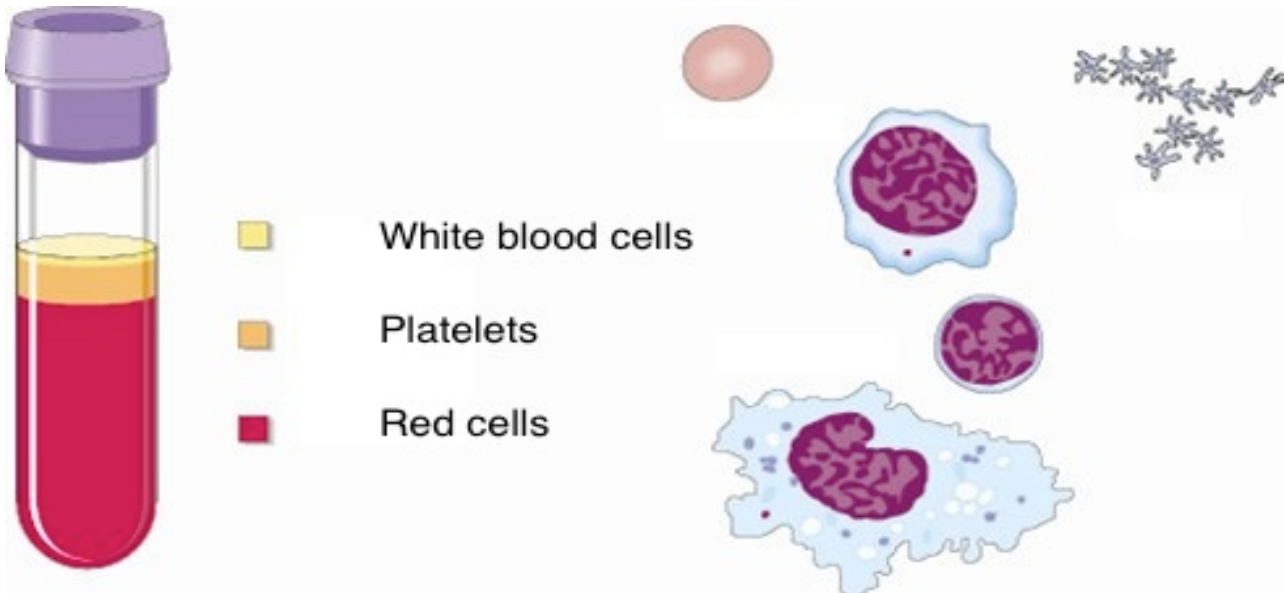
BLOOD

Plasma containing dissolved gases (O₂, CO₂, N₂ ...) and nutrients (sugars, fats, proteins), residues of metabolism and eliminate toxins.

Red blood cells: they contain haemoglobin that binds oxygen and transports it (and carbon dioxide).

White blood cells: they provide including defence against foreign bodies such as bacteria and viruses.

Blood platelets: they ensure the coagulation of blood



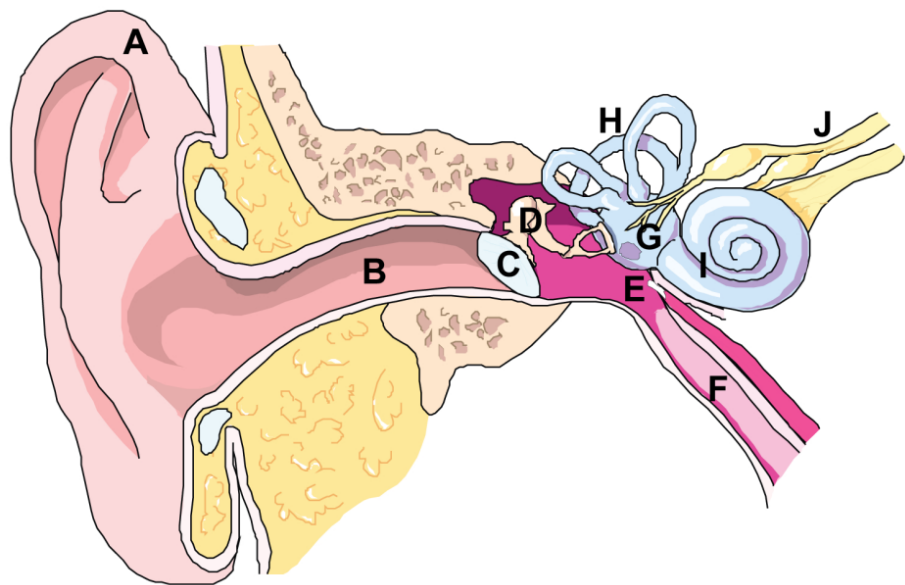
7.1.7 DESCRIPTION OF THE EAR AND OPERATION

The ear consists of the organ of hearing (cochlear) and the organ of balance (vestibular).

The ear is divided into three parts:

- The outer ear.
- The middle ear.
- The inner ear.

- A = Earflap
- B = Ear Canal
- C = Eardrum
- D= Hammer bone
- E = Stirrup bone
- F = Hammer muscle
- G = Eustachian tube
- H = Hall
- I = Semi-circular canals
- J = Cochlea's
- K = Auditory nerve



External ear consists of the flap, the external auditory canal and the outer surface of the eardrum.

Middle ear consists of the inside of the eardrum and middle ear including the chain of ossicles (hammer, anvil and stirrup) as well as the eustachian tube. It communicates with the inner ear through the oval window, which is articulated on the base of the stapes, and the round window.

The eardrum, is an aeric cavity and is in communication with the nasal passages by the eustachian tube, thus in communication with the ambient pressure.

Inner ear contains:

- The cochlea: organ of hearing.
- The vestibule, formed semi-circular canals: dedicated to balance.

The outer ear picks up sound waves allowing the eardrum to vibrate. These vibrations will make the ossicles vibrate, which are connected to the inner ear. There, the vibrations are transformed into nerve impulses that the brain decodes as sounds.

7.2 DIVING ACCIDENTS



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1. TOXICITY ACCIDENTS

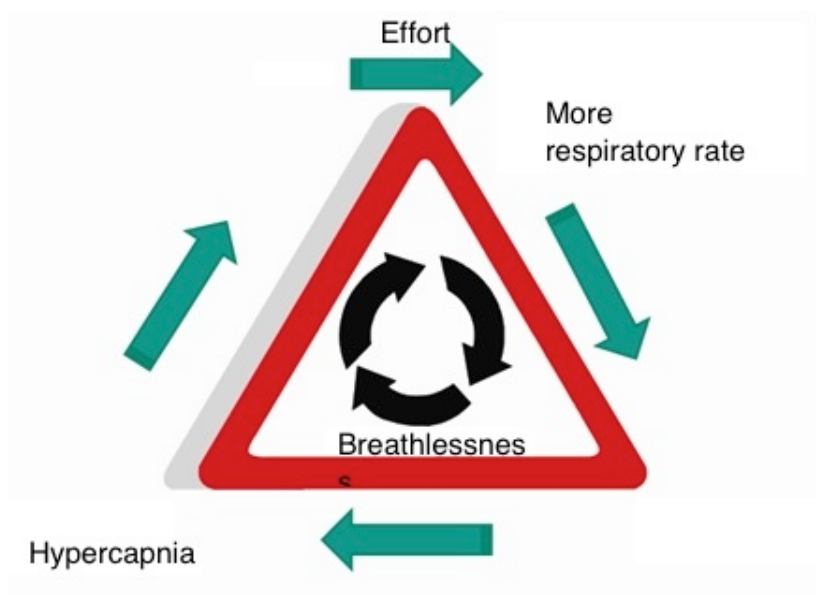
7.2.1.1 BREATHLESSNESS

While diving, our respiratory system is strained. The respiratory movements require more effort than in surface.

At a regular diving this is not a problem but during intense and / or cold water effort, the work of breathing can lead to shortness of breath with difficulty to evacuate the CO₂ produced.

Shortness of breath is CO₂ intoxication.

Stress and anxiety worsen the situation. The diver breathes faster and faster. Breathing becomes more superficial and ineffective. A vicious circle is created: poor ventilation of the cells, insufficient elimination of CO₂, insufficient O₂ penetration into the cells.



To recall, the carbon dioxide (CO₂) is present in very small quantities in the air we breathe. It is present in the body and is a metabolic waste product of cellular activity; it is carried by the blood and is excreted through the lungs during exhalation. An abnormal rise in CO₂ in the blood will be responsible for shortness of breath. The CO₂ is the essential factor chemical that controls our breathing center.

The origin of breathlessness may be related to several factors:

- Exertion or intense muscle activity (poor kicking technique, kicking against the current, overweighting,).
- Stress, emotion, fear, panic.
- Cold.
- Valve problems.
- Breathing CO₂ enriched air (wrong filling of the bottle).

The first sign of shortness of breath is rapid breathing, panting and superficial breathing. Anxiety, headaches, nausea and sometimes agitation or unconsciousness can be also symptomatic.

"The regulator does not give enough air"

This incident can quickly turns into a serious accident.

Shortness of breath is in most cases the origin of other tragic accidents. Its prevention is essential.

PREVENTION:

- Good kicking technique, accurate weighting.
- Avoid reckless effort.
- Correct and deep breathing, good expiration (do not hold breath).

At the first signs:

- Stop any effort.
- Find support.
- Control breathing.
- Report the incident to your partner.
- Go up slowly.
- Check the opening of the tank, pull the reserve.
- Calm, reassuring.

7.2.1.2 NITROGE NAROCIS

The nitrogen narcosis or "rapture of the deep" is the N₂ intoxication. It is manifested by similar problems to those of alcohol abuse but at depths inaccessible within your prerogatives. Indeed those disorders are noticeable from 30-40 m deep.



© G. Jones

2. MECHANICAL ACCIDENTS

7.2.2.1 MECHANISM

The gas cavities of our body (like the lungs), respiratory tracts, sinuses, stomach and intestines, are related to the air we breathe by more or less free communications. These cavities are normally so at any time in equilibrium with the air breathed as the descent to the ascent, and provided that the communications are not blocked by a pathological process.

Barotrauma is a pressure imbalance that causes pain or even damage to the concerned organs. At the descent external pressure is the strongest, while during the ascent the internal pressure is highest.

2. BAROTRAUMA TO THE EAR

2. BAROTRAUMA TO THE MIDDLE EAR

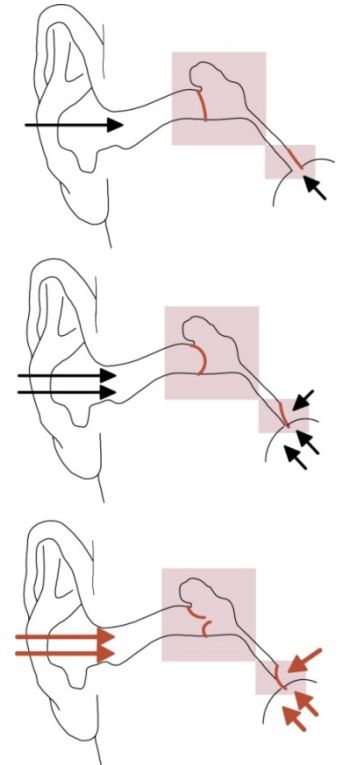
In diving, at the descent, the eardrum will be subject to external pressure greater than the pressure in the middle ear. The eardrum will then be deformed. The imbalance could lead to rupture of the eardrum. The deformation and / or rupture of the eardrum are very painful.

Normally, during the ascent, balance is achieved without the intervention of the diver. However, a pressure imbalance between the two middle ears can occur when an ear equilibrates more quickly than the other. This may cause a transient dizziness, feelings of unbalance (vertigo).

PREVENTION

During the descent it is essential that the breathing air enters in the middle ear via the Eustachian tube.

IT IS NECESSARY TO COMPENSATE, FOR BALANCING PRESSURE EXERCISED BY WATER ON TYMPAN! (Soft Valsalva maneuver, swallowing ...).



- Do not wait for the pain to compensate! If compensation is not possible, go back and possibly abort the dive.

- Do not dive if you have a cold or in cases of infections of the upper respiratory tracts (risk of obstruction of the Eustachian tube) or if you have an ear infection (otitis).

BAROTRAUMA TO THE INNER EAR

This is a serious accident resulting from brutal imbalances, intense, in bumper stroke, possibly secondary to sudden and untimely compensation manoeuvres. This type of barotrauma may cause deafness or less frequent dizziness, immediately out of the water.

PREVENTION

Balance, softly and effectively compensate the water pressure, and without waiting for the pain to appear.

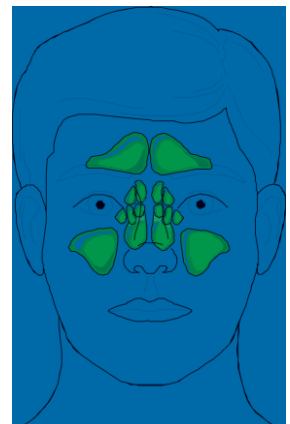
3. LE BAROTRAUMA TO THE SINUS

The sinuses are air cavities in the bones of the face in contact with the environment and the air breathed by small canals open into the nasal cavity. These channels can be thin and tortuous.

The sinuses will balance usually without the intervention of the diver from the descent to ascent. If they do not balance because of an infection or mucus, the diver will feel a sharp pain. In case of pain, stop the dive. If it appears during the ascent, it is necessary to go more slowly to allow the spontaneous balance of sinus



NO VALSALVA WHEN ASCENDING



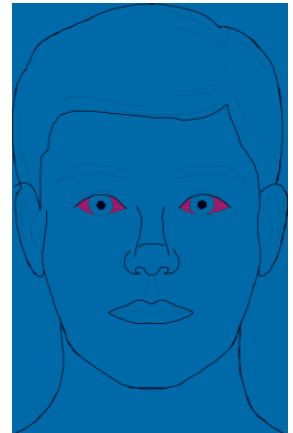
PREVENTION

Do not dive if you have a cold or infections of the upper airways or sinuses (sinusitis).
Stop diving at the onset of pain in the sinuses.

4. MASK SQUEEZE

The mask is of course not a natural cavity of the body, but it is, however, an aeric space that will be under the laws of pressure.

During the descent, the mask is going to squeeze on the face and cause an unpleasant suction effect, able to create eye injuries (hematomas, conjunctival haemorrhage, etc.)



PREVENTION

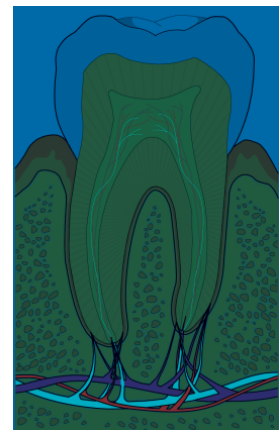
The nose is inside the mask, and to balance you just simply need to exhale into the mask through the nose. Similarly, tight costumes could also cause sucker effects, tweezers and other bruises on the skin.

5. DENTAL BAROTRAUMA

Normally, healthy teeth do not have aeric cavities.

Sometimes cavities can appear in teeth due to caries, inhomogeneous or incomplete fillings.

It is of course impossible "to balance a tooth".



PREVENTION

- ✓ Good dental hygiene.
- ✓ It is recommended to wait 24 hours before diving after dental treatment under anaesthesia and wait 7 days after dental surgery.

Moreover dentures can become painful from holding the tip of the regulator. You will need to find individually solution.

PS: Sinus barotrauma can cause pain in the neighbouring tooth roots near the concerned sinus.

6. THE SCUBA DIVER COLIC

Normally, digestive cavities containing air are just going to squeeze on the descent and resume to their normal volume during the ascent.

If gastric or intestinal gas is produced (by fermentation) or if air is swallowed while diving (due to faulty regulator), abdominal pain may occur in the ascent. They are due to distension of the viscera by gases (that tend to expand), if they are not evacuated by natural routes (oral or anal).

PREVENTION

- ✓ Avoid starchy food (cabbage, onions, and baked beans) and soft drinks before diving.

7. PULMONARY OVERPRESSURE (P.O.)

This is the most serious diving accident!

MECHANISM OF PULMONARY overPRESSURE

When diving or snorkeling, inspired air at the surface will compress during descent and expand during the ascent so that the lung volume will be the same on emersion in early diving.

This is different when scuba diving. The regulator delivers air at ambient pressure of the depth at which it is located. During ascent, the pressure decreases, the air will increase in volume and take more and more space.

If the air tracts are free and glottis open, the air will escape without problem.

If, for any reason, the air cannot escape, it will increase in volume, will stretch the cells and eventually cause lung pressure (breaking the cells). This rupture will occur during the ascent or when out of water.

CONSEQUENCES

The distension and rupture of alveoli may be serious. Pulmonary overpressure is responsible for various pathologies, ranging from breathing difficulties and chest pain with bloody sputum to death. The presence of air in the circulatory system can cause a stroke with loss of consciousness, convulsions and possible neurological disorders.

CAUSES

- ✓ Quick ascent, no breathing.
- ✓ Expiration blocked while ascending (consequence of intense exertion, stress or panic.)
- ✓ Reflex spasm of the glottis in response of water entering in the larynx.
- ✓ Pulmonary air-trapping, due to a malformation of the bronchi, bronchitis or lung disease.

PREVENTION

- ✓ Be medically fit, do not to dive if you have a lung disease, a cold, etc. (Asthma = contraindication for diving).
- ✓ No apnea during the dive.
- ✓ Exhale while going up
- ✓ Exhale and look up during the ascent in case of air failure.
- ✓ Looking up to clear the upper air tracts.



ATTENTION : The alveoli strength limit is low.

Overpressure may arise at pool training at a depth 2 to 3 meters!

Even during the pool training, it is necessary to expire.

3. DECOMPRESSION SICKNESS

Decompression sickness (D.S.) is related to scuba diving physical laws.

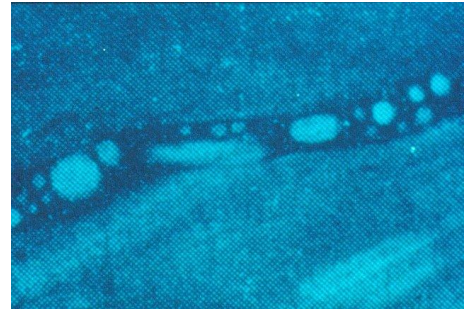
When we breathe on the surface, at "level zero" (sea level), our body is in balance, the gases dissolved in the blood and tissues are at the same pressure as in the air.

During the immersion we breathe air containing nitrogen (inert gas, un-metabolized) that will be dissolved in the body.

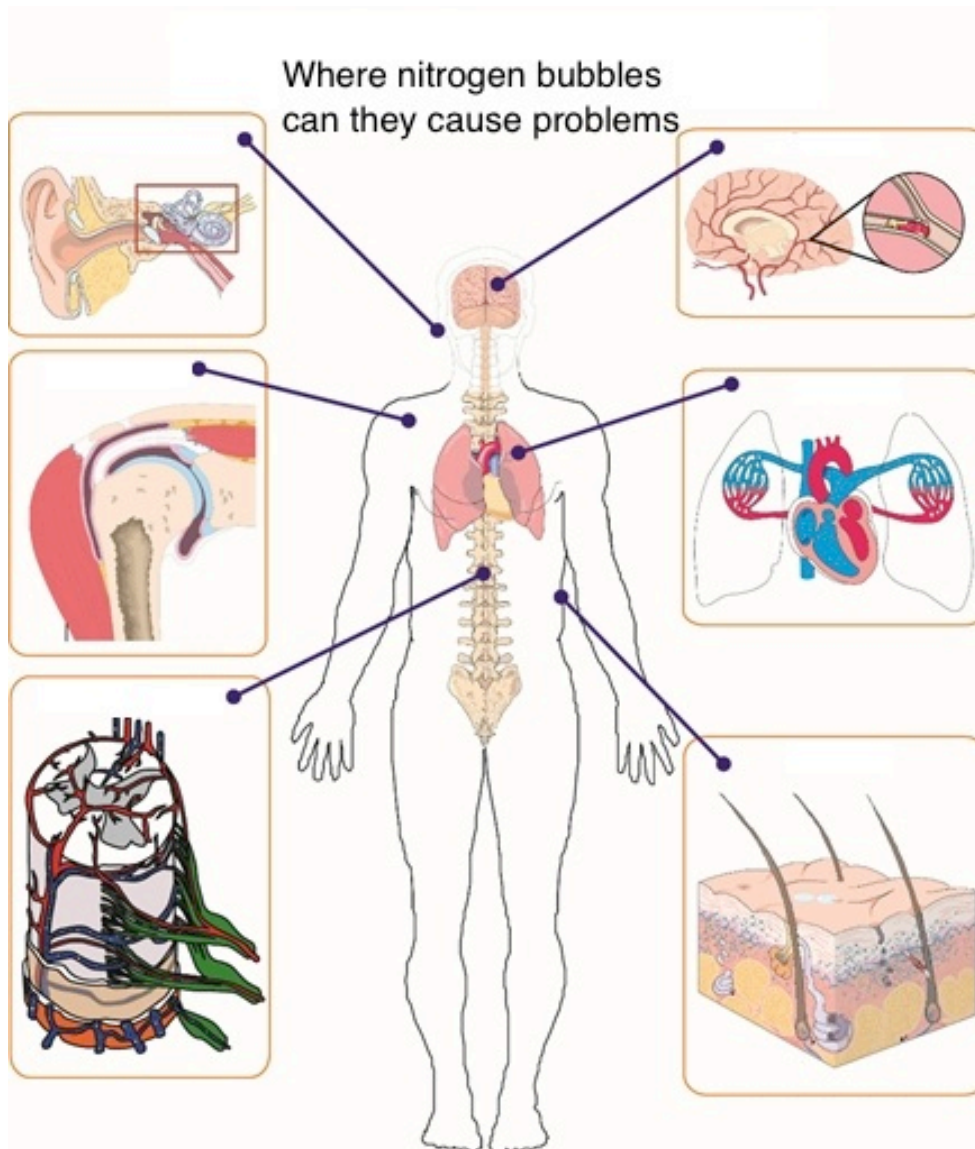
The amount of nitrogen dissolved is proportional to the depth reached and the dive time.

During ascent, dissolved nitrogen must be eliminated from the body. It can be done gradually, in compliance with the rules, or explosively (like a soda bottle) creating nitrogen bubbles responsible for decompression sickness in the tissues and in the bloodstream,

Tissues eliminate gas via the bloodstream. When the nitrogen-removal capacity through the lungs is exceeded, the excess nitrogen accumulates in the vessels and tissues. The nitrogen bubbles block the capillary and / or expand in the tissues.



Microbubbles in a rat capillary tube picture © DAN



It is interesting to classify the seriousness:

1. BENIGN INCIDENTS:

General ill feeling: Intense and abnormal fatigue (not related to the effort)

2. SERIOUS ACCIDENTS:

Cutaneous:

Formication: feelings of itchiness, tingling, pins and needles, burning, or even pain.

Edema: Swelling of the skin, accompanied by tiny scar-like skin depressions.

Bends: Musculoskeletal joint pain.

Audio vestibular accidents: severe dizziness, nausea and vomiting.

Cochlear deafness; hearing loss.

Cerebrovascular accidents: weakness or paralysis, altered sensation, visual abnormalities, confusion or memory loss, seizures, coma ...

Spinal cord injuries: the most typical, sharp back pain, ascending weakness or paralysis in the legs (paraplegia), ...

Pulmonary (by congestion of the pulmonary capillaries by bubbles): Chest pain, shortness of breath, persistent cough, sometimes bloody.

3. ONSET:

Half of cases occur within thirty minutes after the dive. 99% occur during the first hour, the few other cases occur within 12 to 24 hours. There is no relationship between the onset and severity of the accident.

4. PREDISPOSING FACTORS:

Health-related: age, obesity, physical or mental fatigue, poor general condition, overstrain, fatty meal before diving, alcohol, smoking, recent fractures, lung or heart shunts.

Related to diving conditions: snorkeling before or after scuba diving, significant muscle effort before, during and after the dive, shortness of breath, stress, cold, "yo-yo" profile, apnea, dehydration, insufficient surface interval, diving before flying.

7.2.3.5 PRÉVENTION:

-Strict compliance with the ascent rate.

-Strict observance of decompression procedures (bearings and other procedures).

Avoid yo-yo profile

Perform a safety stop if the condition and temperature of the water permit.

No snorkeling less than three hours before or after a diving.

Avoid unnecessary intense efforts.

Proper hydration before and after the dive.



6. TREATEMENT

If symptoms appear, oxygen should be given as quickly as possible, hydrate (1l of water per hour if the diver is able to drink autonomously), call for help and evacuate to a hyperbaric center.





Hyperbaric chamber Hospital Militaire Reine Astrid – Neder-over-Heembeek
© R. Houman

4. HYPOTHERMIA

1. MECHANISM

The diving environment is straining our thermoregulatory system. Water conducts heat 23 times better than air. Therefore, it cools much faster

in water. When the core temperature drops below 37 ° C, the body reacts by increasing the heat production (chills ...), this increases the metabolism and the diver will consume more nutrients and oxygen (from his tank!)

We talk about hypothermia when the core temperature is below 35 ° C.

Hypothermia decreases gradually metabolism. Numbness, trouble concentrating, fainting. Cardiac and Respiratory rhythms fail when the core temperature drops again (under 30 ° C).

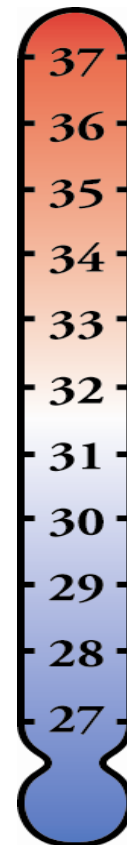
2. PREVENTION

Avoid hypothermia onset:
Dress according to diving conditions.
Adapt dive time conditions.

Advise your partner of the first signs of cold because it is usually impossible to get out of the water immediately!



© E. Van Dijck - Vodelée 1963



2. DROWNING

Drowning is to die underwater or suffocation.

Pre-drowning is used for resuscitated.

The presence of water (a small amount is enough) in the air tracts compromises the transfer of oxygen to the tissues. This is called "hypoxia".

Drowning is the ultimate cause of death in the majority of fatal diving accidents. Syncope, hypoxia, fatigue, cold or an accidental medical cause (e.g. cardiac arrest) are primary causes of death. Failure of diving equipment can also be the cause for drowning.

Coughing and gasping are the earliest possible signs of drowning. This can lead to convulsions, unconsciousness and respiratory and cardiac arrest.

8. INTRODUCTION TO FIRST AID

LIKE ANY CITIZEN, A DIVER SHOULD KNOW THE FIRST AID AND MUST BE ABLE TO PROVIDE VICTIM ASSISTANCE PRIOR TO THE ARRIVAL OF THE MEDICAL AID.



© Ch. De Greef

In water, a simple incident can very quickly turn into a serious accident, so the presence of people trained to aid; will significantly reduce the risk of injuries. The administration of first aid is essential.

Save a life involves a series of steps. Each step in the chain of survival is important and influences survival. The strength of the chain depends on the weakest link.



Schema ERC

7.2 THE FOUR STEPS ARE:

1. EARLY RECOGNITION OF THE SERIOUSNESS OF THE SITUATION WITH **QUICK CALL FOR AID**.
2. **CARDIOPULMONARY RESUSCITATION** (CPR) EARLY BY A HELPER, IN ORDER TO SAVE TIME.
3. **EARLY DEFIBRILLATION**. (SEE BELOW)
4. **RESUSCITATION** BY SPECIALIZED HEALTH PROFESSIONALS TO RESTORE QUALITY OF LIFE.

WHATEVER THE LEVEL OF THE DIVER, EVEN WITHOUT AID SKILLS, IT IS IMPORTANT TO UNDERSTAND WHAT HAPPENS DURING RESUSCITATION. A WITNESS MAY HELP THE RESCUER CALLING CALMLY, CORRECTLY AND QUICKLY RESCUE, LOCATING AND BRINGING OXYGEN AND FIRST AID KIT AS SOON AS POSSIBLE. THESE IMPORTANT TASKS CAN BE ENTRUSTED TO A NOVICE DIVER, NON-RESCUER. IDENTIFY AND MARK OUT THE WAY TO FACILITATE THE ACCESS TO AMBULANCE IS ANOTHER IMPORTANT TASK THAT CAN BE PERFORMED BY A NON-RESCUER WITNESS.

8.1 EMERGENCY CALL



© J. Servais

THE CALL IS ESSENTIAL.

Beside the first effective treatments made by a rescuer, the victim will need specialized medical care (hyperbaric oxygen therapy, medication, specific techniques for maintaining an effective ventilation ...). The aim is to improve long-term survival chances of recovering a healthy life with a minimum of sequelae and restore quality of life.

Ask about the emergency call number in your country.

The call-out should be concise, clear and structured:

- ✓ Caller's name
- ✓ Precise address and access
- ✓ Nature of the accident
- ✓ State and number of casualties.
- ✓ Age (adult, child, baby).
- ✓ Presence of a possible danger.
- ✓ People blocked?
- ✓ Call confirmation.

In an accident occur in the sea, rescue shall be called by the captain of the ship by VHF radio channel 16.



© M. Van Espen

8.2 ADMINISTRATION OF OXYGEN

100% at a rate of 15 liters / minute minimum, so constant flow.

Or better yet, 100% with a demand valve.



© Ch. De Greef



OBJECTIVES:

- ✓ To facilitate breathing.
- ✓ Increase elimination of nitrogen.
- ✓ Reduce the volume of the bubbles.
- ✓ Improve tissue oxygenation.
- ✓ Reduce risk of sequelae after hyperbaric treatment.

8.3 HYDRATION

If the diver is conscious and able to swallow and drink autonomously, make him drink 1 to 1.5 liters of plain water or an isotonic drink in an hour. This will help to reduce dehydration due to immersion, improve circulation and eliminate nitrogen.



© DAN



Resuscitation concepts summarized in the following paragraph are indicative only and do not replace a basic resuscitation training (Basic Life Support - BLS)

8.4 BASIC LIFE SUPPORT (BLS)

AS RECOMMENDED BY THE ERC (EUROPEAN COUNCIL LIFE SUPPORT) OF 2010.

Text and pictures provided by Guy Thomas, DAN Europe Training.



8.4.1 ASSES THE SAFETY ON THE PLACE OF THE ACCIDENT (S-A-F-E)

S STOP

Stop.

Think.

Act.

A ASSESS SCENE

Is the accident site safe?

Is this a proper place to treat the casualty safely?

Are there hazards?

Are there other elements presenting a risk to the rescuer?

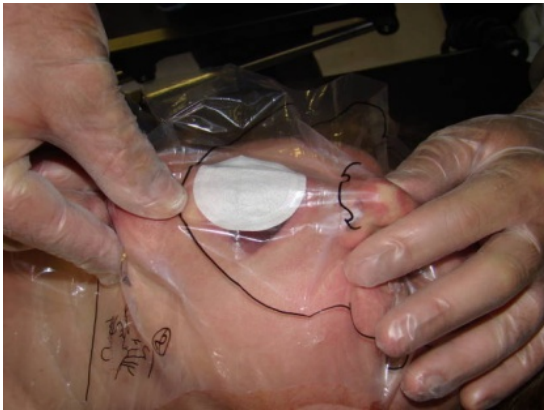
F FIND AND LOCATE FIRST AID KIT

Find the 1st aid kit, O2 and AED (**Automated external defibrillator**)

E EXPOSURE PROTECTION

Use protection such as gloves and devices serving as a barrier between the mouth of the rescuer and the victim.

Facial Protection



Pocket mask



8.4.2 ASSESS THE STATE OF CONSCIOUSNESS

Say name, mention training and mean that you want to help.

Request permission to help.

Tap lightly on the shoulder of the injured diver and shout "Are you okay? "

If the person answers:

Leave the victim in the current position as there's no more danger

Try to find out what happened to him/her and ask for help if necessary.

Regularly assess his/her condition.

If the person does not answer:

Shout for help.

Place the injured diver on the back and open the air tract by tilting his head back and pulling on his chin:

Place one hand on his forehead and gently tilt his head back while keeping the index finger and thumb free to stuff his nose, if artificial respiration is necessary.

Place the fingers of the other hand on the end of his chin and pull up to open the air tracts.



© DAN



© DAN

8.4.3 ASSESS THE BREATHING

While holding the air tract open, look, listen and feel if the injured diver is breathing normally; this operation must last more than 10 seconds:

Observe any movement of the chest.

Look for a breathing sign near the mouth of the diver.

Feel the air on your own cheek.



© DAN

If he is breathing normally:

- ✓ Place him/her in the safety position.
- ✓ Call for help / ambulance or have someone to do it.
- ✓ Check if breathing is maintained.

If he is not breathing normally :

Send someone to search for help or, if you are alone, leave the injured diver time to alert emergency then return to perform chest compressions as follows:

- ✓ Kneel close to the injured diver.
- ✓ Place the palm of one hand in the center of the chest.
- ✓ Place the palm of your other hand on top of the first hand.
- ✓ Cross your fingers and make sure not to put pressure on the ribs of the injured diver. Avoid also to exert pressure on the upper abdomen and the cartilage at the base of the sternum (xiphoid).
- ✓ Take position vertically above the chest and arms outstretched, press in the sternum about 5 to 6 cm.
- ✓ After each compression, release all the pressure on the chest while keeping the hands in contact with the sternum. The compression must be made at a rate of about 100 per minute (a little less than 2 compressions per second).
- ✓ The compression and release should last the same time.
- ✓ After 30 compressions, open the air tracts of the diver, tilting his head back and pulling on his chin.
- ✓ Use an oro-nasal resuscitation mask or noses of the injured diver, pinching his nostrils with the index finger and thumb of the hand placed on his forehead.



© DAN



© DAN

- ✓ Open the mouth of the victim while maintaining the position of his chin.
- ✓ Breathe normally and placed your lips on the nozzle of the oro-nasal resuscitation mask or around the mouth of the victim by ensuring tightly shut his mouth.
- ✓ Blowing air gradually while observing the chest of the victim lifting. To be effective, this insufflation should take about 1 second as in the case of normal breathing.
- ✓ While holding back her head and pulled her/his chin, pull back from the mouth of the injured diver and watch his/her chest down during exhalation of air.
- ✓ Take again a normal breath and blow air in the diver's mouth (or mask), reaching a total of two effective rescue breaths. Then replace without waiting hands in proper position on the sternum of the diver and perform 30 compressions again.
- ✓ Continue CPR at a rate of 30:2.
- ✓ Stop to check the status of the injured diver only if (s)he starts breathing normally. If not, continue resuscitation without interruption.

If the initial blow did not cause chest rise as in normal breathing, the next steps to make a new test:

- ✓ Check the diver's mouth and remove any object that could obstruct it.
- ✓ Be sure to observe the position of the head back, chin up.
- ✓ Do not make more than 2 breaths before each series of chest compressions.

Remarks:

In the first minutes after cardiac arrest, it is possible that the casualty irregularly breathe and noisy way. Do not confuse this with normal breathing. When in doubt, act as if breathing was not normal.

If several rescuers are present, another rescuer should take over CPR every 1-2 minutes so that everyone gets tired less quickly. Make the change as soon as possible between rescuers.

For victims of drowning: Administer 5 initial rescue breaths followed by one minute of CPR before calling for help.

8.5 CARE ADMINISTRATION WITH AED (IF AVAILABLE)

REMINDE THE S-A-F-E

DO NOT ANSWER

Shout for help

NOT BREATHING NORMALLY

Go get an AED or ask for one.

Perform CPR to the rhythm 30:2 until the AED is fixed.

Fix the electrodes on the patient and AED.

Allow the AED to analyse the heart rhythm.

Do not touch the patient.

IF SHOCK IS NECESSARY:

Follow the instructions on the AED unit.

Visually and physically prepare the patient.

Tell: "I'm ready. Are you ready? Everything is ready "

Administer a shock.

Resume CPR to the rhythm 30: 2 for 2 minutes.

IF UNECESSARY SHOCK:

Resume CPR to the rhythm 30:2 until the diver returns to normal breathing.

Note :

If the DEA can be used in an aquatic environment, it is necessary to dry the patient's chest before fixing the electrodes. The electrodes must be placed on the casualty's chest as shown in the diagram; the rescuer must then follow the instructions displayed on the unit.

Complete instructions and recommendations of the ERC can be downloaded from the Belgian Resuscitation Council website (BRC).



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9. PSYCHOLOGY AND DIVING

1. DIVING AND TAKING MEDICATION, DRUGS OR ALCOHOL

Alcoholism and drug addiction are diseases causing inability to dive.

Alcohol and drugs can lead to panic or reckless behaviour endangering the safety and lives of the diver but also members of the dive group.

Some medications can have a negative effect on the central nervous system.

Whatever the substance is, it's necessary to consult someone with diving medicine expertise.

2. ANXIETY AND STRESS

Evolving in an unusual environment may cause a feeling of discomfort.

In case of unexpected or difficult situation, the tension can be scary and disproportionate. We talk about stress. Anxiety is a feeling experienced before and during the dive.

Anxiety can be beneficial by increasing vigilance is positive stress but if it increases it can become harmful and lead to panic.

When we can no longer think or act, anxiety evolves into panic. Panic is the worst enemy of the diver. A panicked diver only think going up as soon as possible, out of the water and no longer respect the basic rules. There is no more communication with the buddy.

Stress is caused by too much pressure and can start in case of:

Physical problem during the dive : difficulties to balance the ears, cooling, shortness of breath, fatigue, pain, etc.

Psychic tension: by lack of information about diving, in case of error (loss), too much to handle, by irrational feeling of discomfort and threat, if bizarre or reckless behaviour of the buddy.

Inappropriate equipment: Diving with equipment that does not work optimally or is not suitable for diving can be extremely irritating. Freedom of movement may be hampered and instruments readingness difficult. In short, confidence in the equipment is broken.

Environmental factors such as currents, poor visibility, darkness, cold, wave, encounter with a strange animal, the lack of reference points, especially if these situations were not expected.

Accumulation of small problems.

Stress management is essential; you must talk with your buddy and adapt the diving accordingly.

If "you do not feel it," it is better to cancel the dive.

Diving is not a competition. A macho behavior is incompatible with safe diving. The only goal is to set a nice diving. This is only possible if you trust your buddy.

10. DÉCOMPRESSION TABLES AND DIVE COMPUTERS

3. GENERALITY

When descending and during its stay under water, the diver's body will absorb an additional amount of inert gas (nitrogen in case of air) He will have to get it back when surfacing. This return to normalcy or the saturation of origin is called the decompression process.

This process is very complex.

The management of decompression will be done by using a decompression table or a decompression computer.

This latter system is the most commonly used currently.

4. DECOMPRESSION TABLES

Diving Tables were the primary means of prevention of decompression sickness. They are still used today although more and more are replaced by dive computers.

There are several models that result from various study groups and decompression simulations: US Navy, French Navy (MN 90) Swiss tables (especially suitable for high altitude diving) and table used by the British Federation BSAC, this list is not exhaustive.

The principle of using a table remains in the same general rule. If you are used to type of table, it will be therefore not difficult to use another after learning the instructions.

Buhlmann Table

MN 90 Table

BSAC Table

CMAS does not require the use of a particular mean and therefore leaves the diver care to choose its own way of decompression. Nevertheless the choice involves thorough knowledge of the chosen medium and its limitations. We do insist on the fact that no means can guarantee zero risk but that the proposed means, especially the newer ones, will provide more than satisfactory prevention. It also goes without saying that compliance with procedures required by the chosen model does not suffer extrapolation or adjustment by the diver, otherwise the risk of decompression sickness would greatly multiplied.

4.1. NO DECOMPRESSION DIVING

In this type of diving, both depth / time allow direct ascent to the prescribed speed toward the surface. The depths shown in the table are the maximum depth reached during the dive. If the depth reached is not reflected in the table, we will take the next higher depth. The procedure is exactly the same for the time.

4.2. REPETITIVE DIVING

A dive is called repetitive if it takes place earlier than 10 minutes after a first dive and some time later depending on the protocol of the selected table (ex USN 2008 3:50 p.m.).

In order to estimate the maximum bottom time without doing safety stops, we will use the table to determine the penalty that will reduce the maximum time that you can spend in the bottom without a mandatory decompression.

4.3. SAFETY STOP

When diving does not require a decompression stop, it is recommended to do a safety stop 5 minutes at a depth of 5 m. This stop is also known as recuperation stop. It should not be done if the conditions are bad such as when strong currents conditions or when it's too cold.



© S. Marcotty

10.2.4 USING THE TABLES

The one star diver does not have the prerogative to make decompression dives. However, knowledge of decompression tables is a great way to approach decompression.

The goal in this chapter is to learn to read, understand and use a table so you can use underwater.

On a table appear different columns:

In the horizontal line shows the maximum depth reached. Otherwise the next higher depth when the depth reached is not there.

In the vertical column on the left is the dive time. Without choosing the time directly higher when the exact time is not in the column.

Couple time / depth determines the stress of the bearing. This same couple also determines a coefficient or letter representing the state of nitrogen saturation (residual nitrogen).

It is useful to insist on respect of the prescribed ascent rate used by the table. This is the first bearing.

15 m		18 m	
15	B	12	B
21	C	17	C
28	D	22	D
34	E	28	E
41	F	33	F
48	G	39	G
56	H	45	H
63	I	51	I
71	J	57	J
		60	K

Example: Diving in 16 m for 25 min.

In the Table: 18 m - 28 min. residual saturation symbol E

The time taken into account begins to immersion and ends when one decides to go back to the set speed.

5. DIVING COMPUTER

Nowadays divers use more and more computers to manage their decompression. The beginner diver will necessarily follow a profile that does not require compulsory deco stop. To do this, he will ensure that the computer is never displaying a safety stop.

A dive computer is an electronic device designed to provide the most accurate indication of the evolution of nitrogen absorbed by the diver.

It is so composed:

- ✓ An internal clock running permanently (even out of the water).
- ✓ Sensors (local pressure, air pressure, temperature,...).
- ✓ A fixed memory containing the program (algorithm).
- ✓ A microprocessor.
- ✓ A power supply.
- ✓ A basic keyboard.
- ✓ A display/screen.
- ✓ A sound device.



It provides at least the following indications during the dive:

- ✓ The immersion time.
- ✓ The current depth.
- ✓ The maximum depth.
- ✓ The remaining time without deco stop (NDL: No Deco Limit) or the total time to surface (TTS: Total Time to surface).
- ✓ The time and depth of the first stop or the next stop.

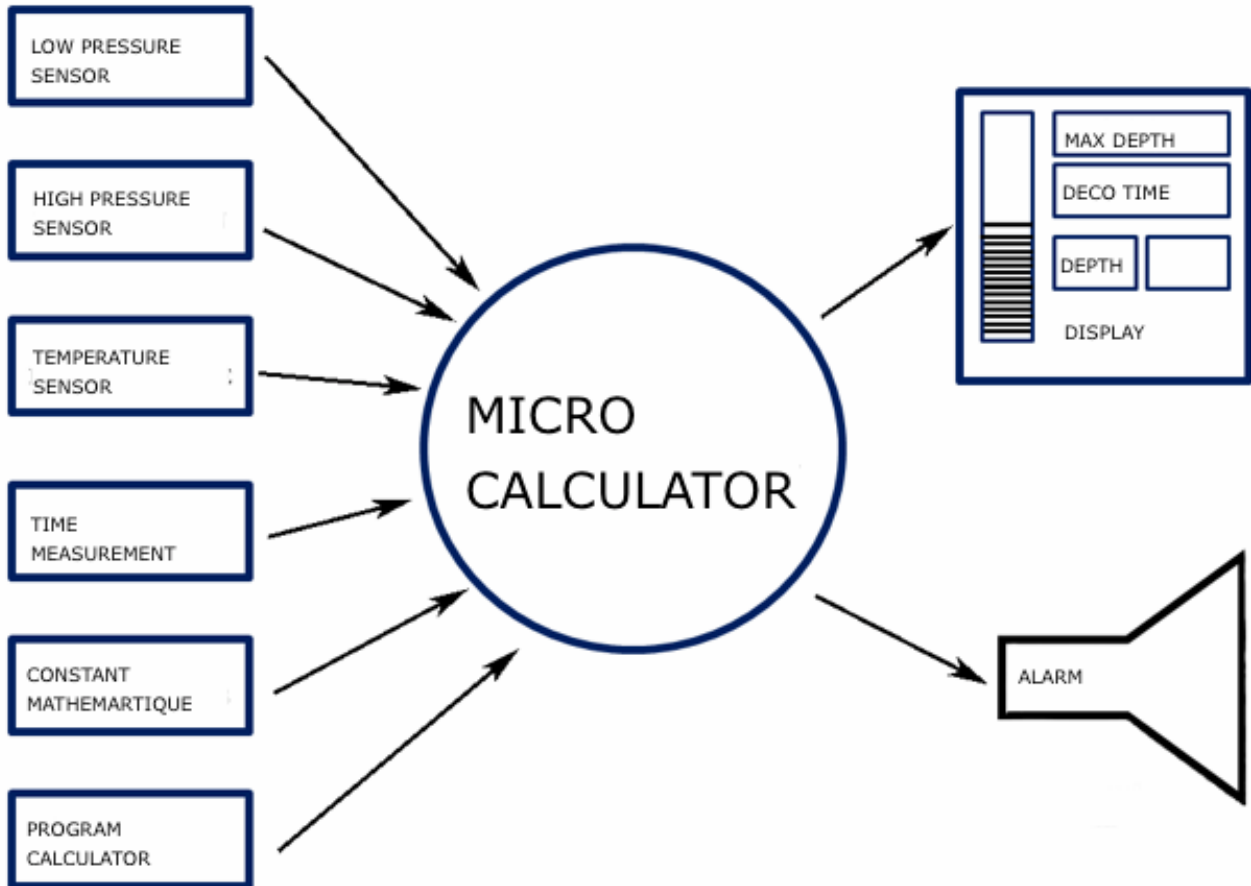


Figure 1 : basic fuctions of a dive computer

Additional information may complete the picture above, depending on the model.

The following information is helpful:

The ascent speed/rate.

The audible alarms when exceeding a set value (speed, depth to a stop, exhaustion time without landing, air consumption ...).

The temperature.

Out the water, it can display:

The exit time.

The surface interval time before the dive.

The total desaturation time.

The "no flight" time (pressurized cabin).

However, the use of a dive computer requires basic precautions

in order to prevent so-called decompression sickness. The beginner diver always dives in non-deco limit (NDL). We

therefore prohibit the display of a decompression stop by the machine. Some dive profiles are also to be avoided even if the

computer will propose a solution for decompression.



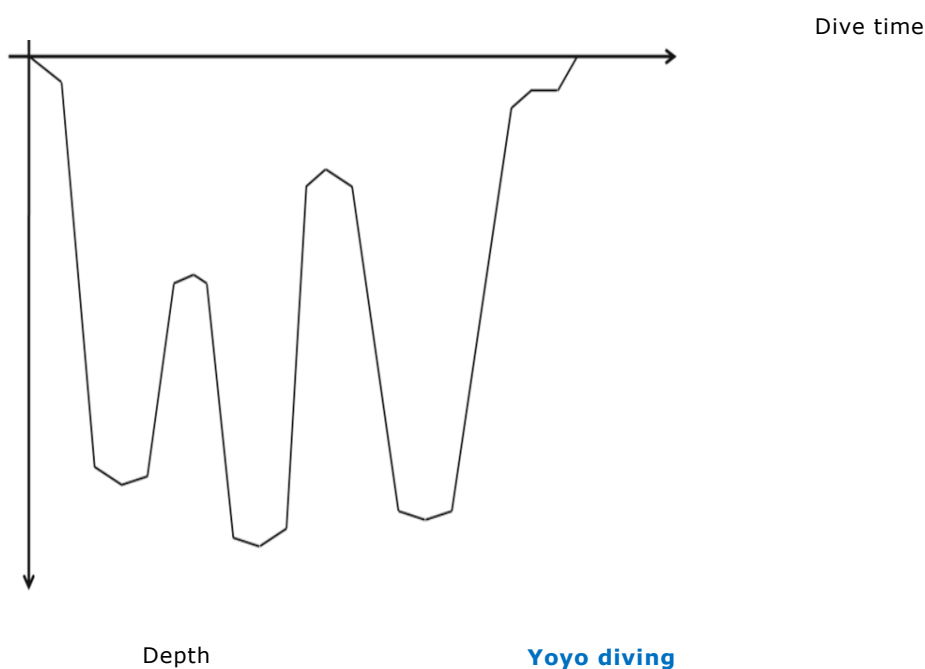
4. YO-YO PROFILE

Although often mentioned, the "yo-yo" (also known as the "saw tooth" profile) is not defined in the literature. Here is a proposal for a very general definition.

The "yoyo" profile is a dive profile where repeated dives to depth interspersed with short periods of time at the surface.

The phenomenon is even more important when:

- The amount of ascents / descents is important.
- The amplitude (the difference between the bottom and the surface) is large.
- up / down speeds are important.
- The movement is done close to the surface.
- The movement is done at the end of the dive.



The "yoyo diving" is a disaster for Haldane's algorithms, because "on average" the depth is more or less constant, so that they can give an "average" result. The greatest danger is of course when the diver is quickly

at the lowest depth without the machine could "follow".

According to independent tests, it was demonstrated that the sequence of these profiles accumulates the "lag" of the machine, so that after some time the -well displayed- data that are no longer in correspondence with reality.

It has been proven that nowadays no machine gives a good response to this type of profile. The diver will therefore have to act knowingly.

5. « BOUNCE » PROFILE

A "bounce" dive is a profile that keeps the time displayed without deco stop (NDL) at the limit of zero or close to it.

It then works at the limit of what the model allows, without any safety margin.

What's the margin between "no deco" and "bounce" profile, since both are similar?

The no-stop time depends on the depth. At deep dive (e.g. around 50 m), this time can be reduced to a few minutes (about 6 ... 8 minutes). In shallower depth (e.g. around 20 m), no-stop time is more important (it can be of the order of 180 minutes).

A profile that is more "bounce" leave at any time by a significant margin between time spent at a given depth and no-stop time displayed at this depth.

If it is considered to have been too long too close to the limit, nothing forbids making a safety stop.

11. ORGANISATION

In scuba diving, use of words is of course impossible. There are a number of internationally recognized signs that allow the exchange of information underwater; we will discover the main below.

1. INTERNATIONAL CODE OF COMMUNICATION

11.1.1 UNDERWATER



Descent



Ascent



Ok



No



I don't understand



Me

You

Get with your buddy

STOP

Speed up



Slow down

That direction

I'm cold

Compensate - Inflate



How much air do you have left?

Time up/
half of starting air
remaining

I'm on reserve

2. IN SURFACE



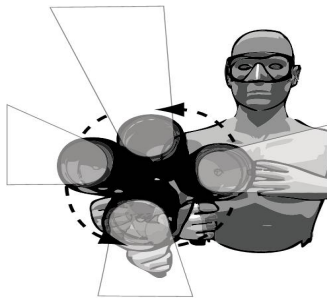
OK (close)



OK (far)

Emergency signal

3. NIGHTDIVE



OK



Something is wrong

2. BINOMIAL DIVING

For your safety you should always dive with others, your companions remaining near you, even during pool training sessions. It is indeed important to get used to this practice from the early trainings. You prepare several diving's. You help someone to gear up you and check your equipment. You share your experiences and sensations. You bring assistance in the event of an incident or accident. Diving in groups enhances the pleasure and safety. When diving in big groups, we form pairs of two. Each of divers of each team works in tandem with the other.



© M. Hiernaux

3. BEHAVIOUR AND SAFETY IN WATER

With suitable equipment, theoretical and practical knowledge and proper guidance, diving is a safe sport accessible to all.

Physically, there is no need to be an Olympic champion. An average swimmer at ease and relaxed in the water will come out very well. It is especially important have an healthy respiratory system. Regular training will allow you to further increase your comfort in the water.

4. THE UNDERSTANDING

You decide before the dive your goals and wishes. You talk about your diving experience, the depth and you can go, the maximum time you want to stay underwater. You double check your knowledge of the diving Communication Code.

5. YOUR FIRST DIVES

You will complete successfully the first 5 open water dives to a depth of between 5 to 20 meters with a minimum duration of 15 minutes. You will be accompanied by an instructor to get your first star.

From that moment, you can dive up to 20 meters and do not require decompression. For these dives, you will always remain under the supervision of an instructor who will compose the groups of divers based on different levels.

6. YOUR BEHAVIOUR BEFORE THE DIVE

Dive only when you feel good and you feel like it. Diving should be fun.

Listen to the briefing of your divemaster about the following points:

- ✓ Description of dive site: characteristics and potential hazards.
- ✓ The goal of the dive, depth and immersion time.
- ✓ Presentation of the members of the group of divers.
 - The place and role of each.
 - The equipment presentation.
 - The communication code.
 - "Low on air" signal.

- The procedure in case of loss.
- Emergency resources Dive spot.

7. YOUR BEHAVIOUR DURING THE DIVE

You jump into water after the divemaster and its signal you set all your computers/watch on the surface.

You form a tandem with your buddy.

You do not descent quicker nor lower than your divemaster.

You stay at the same depth as your divemaster.

You report your air gauge on the agreed reserve pressure at the briefing.

You do not go up faster than the divemaster.

You do the safety stop at the depth of the divemaster.

You go out of the water before the divemaster.

8. DEBRIEFING

Note the dive parameters (time, depth, out time, decompression parameters).

Discuss the remarkable points as well as your possible fears.



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12.MILIEU

1. INTRODUCTION

Scuba diving is not limited to just go beneath the water surface, you must get prepared.

Especially the sea, weather conditions, type of background, the purpose of diving should be known.

Respect for marine life and the environment is also part of the diver's training.

Although the organization is not for the novice diver, he must be informed of the correct practice of diving.

2. WEATHER

Meteorology can strongly influence the state of the sea. When the sea is rough or very rough, it will be very difficult to get the divers back on board safely. Rough seas can indeed cause discomfort on board and lead to falls and unpleasant seasickness.

The beginner shouldn't be surprised that the dive site announced is cancelled even if at first sight the sea looks calm.

Knowing the weather and its evolution will guide the choice of the site and the road to be taken.



3. TIDES - CURRENT

Divers may face strong current, making the diving arduous or impossible.

The sea currents are always present in the seas to the tides but direction and intensity are generally predictable. We can thus determine the time slots during which these currents are weaker or non-existent. However, there are cases where strong currents are unpredictable. The organizer therefore deems onsite feasibility diving or cancellation.

4. FAUNA AND FLORA

A major goal of the diving is the encounter of living creatures (especially animal species, as plants are rare and poorly diversified under the sea). The breeding and feeding but also the organization of the safety of the animal determines the most suitable way to meet individual species locations. It is therefore essential to know the fauna and flora to be able to organize an encounter focused on the diving species previously determined. This is of course the responsibility of the monitor but a knowledge of the subject by the beginner diver will allow him to spot the coveted animal. Different cardboards showing different species exist; they will help you identify and thus improve your knowledge.



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5. ECOLOGY

The CMAS diver must be involved in the protection, conservation and "sustainable" aspects of the aquatic environment. This in order to keep the enjoyment of future generations. It's very important to comply with local laws, both national and international, established to protect and preserve the aquatic environment. The underwater environment is a rich but fragile ecosystem. The diver must behave as a guest and has an obligation to respect it. Taking of animals or plants, harassment of living creatures are strictly prohibited. Touching living creatures should be avoided as it could remove their protective layer and thus make them weak.

Finally, we will refrain from taking the sea as a bin and will then throw garbage in a bag or a suitable container.

Behave as guests and not as conquerors!



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13. COMPETENCIES REQUIRED FOR DEEP SEA DIVING

6. THE FINNING

Finning is not just wearing a pair of fins and kicking. It's not the purpose to become Olympic champions here, we will try to teach the basics to help you effectively fin without getting cramps after a few effort.

During the first lessons of kicking, as weird as it sounds, the hardest part is refraining from using the hands. Indeed, many beginners use them to stabilize and this gives parasites gestures that, in fact, hinder their progress in water.

The second big fault of divers apprentices is overly bend the knees when fatigue is felt; which has the effect of "doggie paddling". It's a totally ineffective movement that will make you much more fatigued.

Leg movement when swimming must start from in the hips.

Then, the thrust produced by your fins should be as close as possible to the direction given by your trunk. (See figures below)

Once you have gained enough ease, you can start training kicking with diving. We will not forget to control our weighting and remove the superfluous weight if necessary. The kicking hen quipped with tanks is obviously more difficult but closer to real diving conditions.

But let your instructor teach you on-site practically. Be ensure that you'll never do too much training. This exercise is indeed the basis of scuba diving and must be regularly maintained. This practice could one day pull you out of trouble, (you or your buddy).



© P-B

7. USE OF THE TUBA

The tuba is an innocuous appearance accessory; however this small accessory can be very useful. It allows you to swim on the surface and watch down under simultaneously. Also during long trips on the surface, it avoids a lot of fatigue by allowing the whole body to undergo buoyancy while breathing. (See lesson concerning of physical laws).

However if you have never used a snorkel, read this:

At each immersion, the air in your tuba will escape and snorkel will fill with water. But when you come back on the surface, your first instinct is to inhale the air immediately, which will result in making you drink a "cup" equivalent to the capacity of your tuba.

To breathe, you must blow hard into the tuba to remove the water before inhaling. This implies that you have kept a minimum of air to surface, so you do not have "pushed" your apnea a too long. Train yourself in the use of this accessory followed by short recovery on tuba apnea. Another aspect of the use of the tuba is the inertia of its dead volume. This device extends indeed your respiratory tracts and when you inhale, you first inhale a few cm³ vitiated air contained in it. So use a snorkel with a limited capacity and particularly monitor your expiration by forcing it to the maximum.



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Mistakes to avoid:

- ✓ Inspire before the snorkel comes out of the water.
- ✓ Remove the snorkel from the mouth to clear it in the surface.

3. APNEA (FREEDIVING)

Apnea is staying under water without breathing for some time. Most mammals are able to do it. Few seconds for dog or cat; to a few tens of minutes for marine mammals such as whales. A beginner diver will struggle to stay underwater longer than 30 seconds; however with training and after a longer or shorter time he will do easily 1 to 2 minutes of apnea.

Keep in mind that the records in this area are about 7 or 8 minutes, but they are the prerogative of talented and well trained athletes.

The first apneas are often stressful for the new divers. However if you know the next few safety rules, you will be able to practice apnea safely.

Never practice apnea on your own. Do it under the supervision of a competent instructor, or at least of an experienced diver. Indeed, at the end of too long apnea syncope is stalking and that is where a good instructor will help you to progress without entering the danger zone.

You will learn how to "ventilate", to expire the largest possible volume of air at each breath (When you think you have all expired, force slightly and see what's left!); in order to lower the amount of CO₂ in your lungs as possible.

The amount of air is less inspired.

Here's how to do so safely: Watch your timer from the commencement of ventilation, as soon as you feel mild disorders (Eg. dizziness, tremor in the lips or eyelids), then hold the time taken to get to this stage and divide by three. When ventilate again, do not exceed this time (the maximum time ventilation divided by three). This is called the rule of thirds time.

Any apnea, mobile or not, must end with a belt drop. This gesture must become automatic so in case of emergency you will be no longer looking for your loop.

At the end of each apnea, especially when you go up and in shallower water, exhale the air contained

in your lungs. Again this should become a reflex, indeed when scuba diving, not expiring while ascending can be extremely dangerous.

To perform a static apnea, you must ventilate the same way as explained above. There are no point over-fill your lungs, you must ensure to be as relaxed as possible. Next, if you immerse yourself by using the duck technique, or feet down, a little kick given for declining, exhale the air in your lungs, pull out the trunk as much as possible out of the water, at the same time, arms are lifted above the head and their weight will make you descend without effort. (See previous chapter: Principle of Archimedes). Once on the bottom, the correct position is: one knee and the foot of the other leg to the floor, one hand on the belt buckle (Ready for a quick release), the other arm up and is showing the OK sign (see code of communication).

To perform a mobile apnea, you will start your descent using the duck technique. Your kicking will be as "flexible" as possible. Indeed, not being relaxed will make you produce CO₂ and decreases your apnea performance. Keeping the neck and arm flexible will help you to keep relaxed. A few meters before the end of the breath, exhale and stop kicking to land on the bottom. Remove your belt and finally taking up a raised arm. Surfacing, go to get your belt at instructor signal and put it back at the surface.

4. BREATHING ON A REGULATOR

An air cylinder, for use by a diver, must have been "filled", that is to say, filled with pressurized air. Be reassured, the volume occupied by your tank has not changed, we will simply breathe 200 times more air into the tank than its initial capacity. So a tank with a capacity of 15 liters will contain, after filled with a compressor, 3,000 liters of breathable air. The pressure was 1 bar increased to 200 bar.

You will normally see during your first dives, and to your dismay, you consume much more air than your fellow buddies. Be reassured, this is quite normal. Indeed, breathing on a regulator is not done anyhow. However, do not hold your breath during the dive in order to spare your air; this will have the effect that you get headaches. The best way to breathe on a regulator is to breathe normally, i.e. to breathe as deeply as possible and inspire normally. The only allowed apnea during diving is to wait a second or two before inhaling. If this little apnea control was difficult to hold, it would mean that you start shortness of breath and force you to act accordingly. Breathe on a regulator, by putting the demand valve in your mouth out of the water, is one thing. Do the same down under is different. One day or another, you will ask for air to one of your buddies or give air to someone. It may also happen that you lose your mouthpiece because of an unfortunate gesture. Be reassured, this rarely happens in reality because in this case is that something has been overlooked in the organization of diving.



However, given their usefulness, the "buddy breathing" is often practiced and repeated during your trainings and your dives.

In practice:

At the time of breathing, you put the regulator in your mouth, breathe out and then you inhale. This exercise is repeated often and early, always in the company of a qualified instructor. It will bring you the comfort you need for enjoying your underwater explorations.



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5. MASK CLEARING

Sometimes during the dive, the mask fills with water. This may be due to uncontrolled movement of your hand or your buddy but also laughter.

(In this case, be reassured the water inlet is not sudden and the mask is rarely completely full).



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When your mask is filled with water, you can obviously not surfacing to clear it and continue diving. However, you can thanks to a technique called the "mask clearing" easily remedy this little incident. You probably know all that if you press a bucket or empty glass and returned to the water, the water does not penetrate to the bottom of the container. Indeed the remaining air prevents water to occupy the entire volume.

What you maybe less know is that if we inject air in the same container but this time filled water, as air is than water gets into the bucket and it's CHASING THE WATER THEREIN.

Apply this principle to the mask as follows:

Pull the mask looking down to fill it with water.

Leave the mask back to its normal position.

Raise the head slightly and press the top of the mask.

Blow gently through the nose into the mask, you will notice that it's clear.

Also note that as a result of the increase in external pressure, mask can act as a suction cup, we call it mask squeeze. You will exhale through the nose to restore balance to both sides of the glass by injecting air into your mask.

6. VALSALVA MANOEUVRE

You saw in the previous chapter, the more we sink into the water, the more the pressure increases. Our body, composed of 75% saline water, has a few cavities filled with air or gas (Sinus, middle ear). In these cavities, both internal and external pressures must be balanced. The most common method is to hold your nose by sealing the mouth and gently blow like to blow, it's the Valsalva manoeuvre. We hear the eardrums getting back to their normal position, this is called "compensate". However, there are other softer balancing methods but unfortunately more difficult to achieve, your instructor will be happy to explain them.



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7. PROPER USE OF THE BCD

To understand the text below, we will speak only about the jacket, the term indiscriminately designating a "stabilizing-jacket" or any other model of "balancing buoy."

Equipped with your suit and vest, you let yourself sink to the bottom. At the instructor signal, you will inflate your jacket. This can be done using the "direct-system" or by blowing with the mouth in the corrugated hose. It will inject air slowly and in a well-controlled manner in the vest.

When you "take off" from the bottom, you will start deflating your vest so as to remain floating just beneath the surface without kicking, sinking or surfacing. You'll have to control your immersion level using your lungs. When you inhale, you tend to ascent.

Then exhale quickly, you stop back and start to sink. Inhale and you go up a few centimetres, etc.

This technique is called "lung-ballast". By practising this exercise, you will get the needed ease to progress.



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14. QUESTIONS

To facilitate your learning, we created a series of questions listed below. They should allow you to assess your understanding of the course.

1. What does CMAS mean?
2. The weather is important for the organization of diving. What are the negative influences of weather on diving?
3. True/false quiz on "ecology"
 - a. Respect the environment
 - b. Local regulations
 - c. Acting like conquerors underwater
4. How to evaluate the proper weighting?
5. What are the different volumes of scuba tanks?
6. What does OGI SER PREFON?
7. Where is the regulator first stage?
8. Is it Mandatory diving with two respirable air sources?
9. What is the gauge
10. What is the diving vest (BCD)?
11. Name the different diving instruments?
12. Quote Archimedes' principle?
13. What are the applications of the Archimedes principle in diving?
14. Explain the pressure concept?
15. What is the result of compressed air breathing?
16. Explain the law of Boyle & Mariotte?
17. What is the Valsalva manoeuvre?
18. What are two means of decompression?
19. What does "no-stop" mean?
20. What is a repetitive dive?
21. What are the depth and duration of a safety stop?
22. Determine (using the table) the index given for a dive of 15 meters for 40 minutes?
23. What are the indications displayed on the dive computer?
24. Draw a YOYO profile?
25. How do we communicate....
26. Why we dive with a buddy (binomial)?
27. What are the points of the dive group leader at the briefing?
28. What are the rules to follow when diving in group with your divemaster?
29. What 's the composition of the air we breathe and in what quantity?
30. True or false:
 - a. Inspiration is an active movement
 - b. It is essential to breathe air at ambient pressure
 - c. Expiration is an active movement
 - d. CO² controls breathing
31. What makes up the blood?
32. What are the three parts of the ear?
33. How to avoid shortness of breath?
34. What is the behaviour in case of shortness of breath?
35. Briefly explain the barotrauma of the middle ear?
36. How to prevent barotrauma of the inner ear?
37. Why wouldn't the sinus balance normally?

38. How to avoid a mask squeeze?
39. How to prevent tooth barotrauma?
40. How to avoid diver colic?
41. Explain the pulmonary pressure mechanism?
42. What are the consequences of a pulmonary barotrauma?
43. What causes a pulmonary barotrauma?
44. How to prevent pulmonary barotrauma?
45. Can a pulmonary barotrauma occur in the pool?
46. What are the differences between pulmonary barotrauma and decompression sickness?
47. Explain briefly decompression sickness?
48. Define the area of the body that may be affected by ADD?
49. What are the signs of benign decompression sickness?
50. Define the serious decompression sickness?
51. What are the contributing factors of ADD?
52. How to prevent ADD?
53. How to treat decompression sickness?
54. How to prevent hypothermia?
55. Define drowning
56. Explain the nitrogen narcosis?
57. What causes stress in diving?
58. Name the four steps in the chain of survival?
59. Organize the call for help. What to communicate?
60. What percentage do we deliver oxygen and because of how many liters per minute minimum?
61. What are the objectives sought by the providing of oxygen?
62. BLS, that means S A F E?
63. How to assess the state of consciousness of a victim?
64. How to assess the respiration of a victim?
65. How many chest compressions and how many insufflation do we deliver to a victim in cardio respiratory arrest?
66. How many insufflations are done in a suspected drowning?
67. What are the different levels of divers?
68. What are the instructor levels?
69. What are the competencies of the 1 * diver?
70. Describe the diver basic equipment?
71. What is the emergency equipment?
72. What's the website address of CMAS?
73. Why we have to hydrate before and after the dive?

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