PHYSIOLOGY OF DEEP SEA DIVING
LEARNING OBJECTIVES

• Introduction

• Hazards of deep sea diving: Oxygen toxicity, Nitrogen narcosis, Dysbarism, Air Embolism

• SCUBA diving
Introduction

- Pressure at sea level – 1 atm
- Pressure *increases by* 1 atm for every 10 meter depth of water.

<table>
<thead>
<tr>
<th>Depth (meter)</th>
<th>Pressure</th>
</tr>
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<tbody>
<tr>
<td>10</td>
<td>1+1 atm</td>
</tr>
<tr>
<td>20</td>
<td>1+2 atm</td>
</tr>
<tr>
<td>50</td>
<td>1+5 atm</td>
</tr>
</tbody>
</table>
• When human being descends beneath the sea, pressure around them increases greatly.

• To keep the lungs from collapsing, air must be applied at very high pressure to keep them inflated.

• Blood in lungs is exposed to high alveolar gas pressure called hyperbarism

• Beyond certain limit, this alteration in body physiology is lethal.
Hazards of Deep Sea Diving

- Acute oxygen toxicity
- Nitrogen narcosis
- Dysbarism
- Air Embolism
Oxygen Toxicity

• Extremely high tissue pO$_2$ occurs when O$_2$ is breathed at very high alveolar oxygen pressure – detrimental to tissues.

• Eg – breathing O$_2$ at 4 atm pressure of Oxygen cause brain seizures, coma in 30-60 minutes.

• Symptoms – nausea, muscle twitching, dizziness, disturbance of vision, irritability & disorientation.
Nitrogen Narcosis

• About 4/5 th of air is N2. At sea level, Nitrogen has no significant effect on body

• During deep sea diving, *gases are inhaled at high pressures for several hours*

• When Nitrogen is breathed at high pressure for several hours, it causes varying degrees of *narcosis*

• *Mechanism* – Nitrogen dissolves in fatty substance in neuronal membranes & due to its physical effect on altering ionic conductance through membranes, *reduce neuronal excitability.*
When diver remains beneath sea for 1 hour or more and is breathing N2 at high pressure, first symptoms appear at 120 feet - person feels cheerful

<table>
<thead>
<tr>
<th>Depth</th>
<th>Condition</th>
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<tbody>
<tr>
<td>120 feet</td>
<td>person feels cheerful (raptures or joys of the depths)</td>
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<tr>
<td>150-200 feet</td>
<td>Person feels drowsy</td>
</tr>
<tr>
<td>200-250 feet</td>
<td>Strength decreases, cannot work</td>
</tr>
<tr>
<td>Beyond 250 feet</td>
<td>may faint</td>
</tr>
</tbody>
</table>
• **Symptoms** of Nitrogen narcosis are similar to those of alcohol intoxication (*raptures or joys of the depths*)

• **Nitrogen narcosis** – can be avoided by breathing O₂-helium mixture under sea. As Helium is low density gas, less soluble in fat than N₂.
Dysbarism/Caisson’s Disease/ Decompression sickness / Bends/ Diver’s palsy

• A condition which occurs when diver exposed to high atmospheric pressure under sea, suddenly comes back to surface (low atmospheric pressure).

• Eg deep sea divers or workers in caisson (water tight chamber used for performing construction works under water) returning to sea surface rapidly from deep sea level.
Symptoms of Caisson’s disease

• when person come to surface suddenly, dissolved N₂ comes out and forms bubbles in tissues & blood
• Bubbles of N₂ when present in fat depot press the nerves producing sensory & motor disturbances.
• Myelin sheath of sensory nerves produce disturbance or loss of sensations, paraesthesia, itching etc.
• Myelin sheath of motor nerves produce motor paralysis called as Divers Palsy.
Symptoms of Caisson’s disease

- Bubbles of N_2 present in blood capillaries block them
- Blockage in Brain due to bubbles – produce sensory & motor disturbances
- In Lungs – produce dyspnea, pulm edema (chokes)
- In Heart – lead to myocardial infarction
- In Joints & muscles of legs & arms cause severe pain called Bends.
Symptoms of Caisson’s disease

- If person come to surface suddenly holding the breath, there occurs sudden expansion of gases in lungs causing rupture of pulmonary capillaries.
- Air enters blood circulation, producing air embolism.
Treatment of Caisson’s disease

1. Subject **should** come to surface slowly (slow ascent)

- a diver who has been breathing air and has been on the sea bottom for 60 minutes at a depth of 190 feet is decompressed according to the following schedule:
  - 10 minutes at 50 feet depth
  - 17 minutes at 40 feet depth
  - 19 minutes at 30 feet depth
  - 50 minutes at 20 feet depth
  - 84 minutes at 10 feet depth

- so, for a **work period on the bottom of only 1 hour**, the total time for decompression is about 3 hours.
2. SCUBA – Self Contained Underwater Breathing Apparatus

- Consists of cylinder & valve system for breathing that is carried by divers under the water.
- Compact arrangement to carry compressed air so that more air can be carried in less volume.
**SCUBA DIVING**

- *Self-Contained Underwater Breathing Apparatus*

- (1) one or more tanks of **compressed air** or some other **breathing mixture**,  
- (2) a **first-stage “reducing” valve** for **reducing** the very **high pressure** from the tanks to a **low pressure level**,  
- (3) a **combination inhalation “demand” valve and exhalation valve** that allows **air to be pulled** into the lungs with slight negative pressure of breathing and then to be **exhaled** into the sea at a **pressure level** slightly positive to the surrounding water pressure,  
- (4) a **mask and tube system** with **small “dead space.”**
- Cylinder of compressed air connected via mask and tube for breathing through valve.
- Valve permits appropriate amount of compressed air to be delivered to diver & expired air released into surrounding water.
Air Embolism

- As diver breathing from tank at increased pressure suddenly ascends to surface holding breath, gases in lungs expands rapidly & ruptures pulmonary veins. Air escapes into circulation & causes air embolism.