WHAT IS IT?

- A reversible alteration in consciousness that occurs while at depth (usually noticeable around 30 meters or 100 ft)
- Caused by the anesthetic effect of certain gases at high pressure
NITROGEN NARCOSIS

- Depths Beyond 100 Feet!
- Individual Variability
- Day-to-Day Variability
Signs and Symptoms of $N_2$ Narcosis

- Impaired performance mental/manual work
- Dizziness, euphoria, intoxication
- Overconfidence
- Uncontrolled laughter
- Overly talkative
- Memory loss/post-dive amnesia
- Perceptual narrowing
- Impaired sensory function
- Loss of consciousness > 300 ft
## Deep Scuba Dives Breathing Air

<table>
<thead>
<tr>
<th>YEAR</th>
<th>DIVER</th>
<th>DEPTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1943</td>
<td>Dumas</td>
<td>203 feet</td>
</tr>
<tr>
<td>1948</td>
<td>Dumas</td>
<td>307 feet</td>
</tr>
<tr>
<td>1967</td>
<td>Watts</td>
<td>390 feet</td>
</tr>
<tr>
<td>1968</td>
<td>Watson</td>
<td>437 feet</td>
</tr>
<tr>
<td>1989</td>
<td>Gilliam</td>
<td>452 feet</td>
</tr>
</tbody>
</table>
Dr. Dan Manion surfaces after his 491 foot dive in 1994 to beat Gilliam’s record.
Prevention of Nitrogen Narcosis

- Restrict diving depth to less than 100 fsw
- If affected, return immediately to surface
- Plan dive beforehand
  - Max time to be on bottom
  - Any decompression required
  - Minimum air required for ascent
  - Emergency action in event of accident
- Breathe helium/oxygen mixture
How to Beat Narcosis
(Francis 2006)

- Be sober, no hangover and drug free
- Be rested and confident
- Use a high quality regulator
- Avoid task loading
- Be over trained
- Approach limits gradually
- Use a slate to plan dive
- Schedule gauge checks and buddy checks
- Be positive, well motivated and prudent
Oxygen Toxicity
Oxygen

- **Characteristics:**
  - Colorless
  - Odorless
  - Tasteless

- **Disadvantage:**
  - Toxic when excessive amounts are breathed under pressure

Oxygen is the only gas metabolized by the human body.

Too much or too little oxygen is dangerous!
Oxygen Toxicity

- Oxygen toxicity is generally not a problem for routine air diving operations
  - A diver must dive deeper than 186 fsw before exceeding the 1.4 PO$_2$ limit
- However, a diver breathing a Nitrox mixture will reach the 1.4 PO$_2$ limit much shallower than a diver breathing air!

<table>
<thead>
<tr>
<th></th>
<th>AIR</th>
<th>NN32</th>
<th>NN36</th>
<th>100% O$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>186 fsw</td>
<td>113 fsw</td>
<td>95 fsw</td>
<td>13 fsw</td>
</tr>
</tbody>
</table>
## NOAA PO₂ & Exposure Limits

<table>
<thead>
<tr>
<th>ATA</th>
<th>CNS SINGLE EXPOSURE (MINS)</th>
<th>PULMONARY 24 HOUR EXPOSURE (MINS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6</td>
<td>45</td>
<td>150</td>
</tr>
<tr>
<td>1.5</td>
<td>120</td>
<td>180</td>
</tr>
<tr>
<td>1.4</td>
<td>150</td>
<td>180</td>
</tr>
<tr>
<td>1.3</td>
<td>180</td>
<td>210</td>
</tr>
<tr>
<td>1.2</td>
<td>210</td>
<td>240</td>
</tr>
<tr>
<td>1.1</td>
<td>240</td>
<td>270</td>
</tr>
<tr>
<td>1.0</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>0.9</td>
<td>360</td>
<td>360</td>
</tr>
<tr>
<td>0.8</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>0.7</td>
<td>570</td>
<td>570</td>
</tr>
<tr>
<td>0.6</td>
<td>720</td>
<td>720</td>
</tr>
</tbody>
</table>
Oxygen Limits Continuum

Hypoxia

0.08 0.16 0.21

Unlimited

5 hrs

1.0

150 mins

1.4

30 mins (EE only)

2.0

2.8

2.0

3.0

NA

Hyperoxia
Hydroxia

- Contributing Factors:
  - Primary
    - $\text{FiO}_2$
    - Depth
    - Duration
    - Physical exertion
  - Secondary
    - CO$_2$ retention
    - Cold stress
    - Heat stress
    - Individual physiology

- CNS Toxicity:
  - V-vision
  - E-ears
  - N-nausea
  - T-twitching
  - I-irritability
  - D-dizziness
  - C-convulsions

CNS toxicity varies from person to person and from moment to moment.
Unit Pulmonary Toxic Dose (UPTD)

1 UPTD = Pulmonary toxicity due to breathing 100% O₂ at a pressure of 1 atm for 1 min
Unit Pulmonary Toxic Dose (UPTD)

1 UPTD = 100% O₂ for 1 min at 1 ATA
USN 5 UPTD 336
USN 6 UPTD 646
USN 6A UPTD 693

UPTD 615 - vital capacity - 2%
UPTD 1425 - vital capacity - 10%
Lung Pathology Phase I

**Exudative Phase**

- Interstitial and alveolar edema
- Intra-alveolar hemorrhage
- Fibrinous exudate
- Hyaline membranes
- Capillary endothelial cell
- Swelling/destruction
- Type I alveolar epithelial cells destruction
Lung Pathology Phase 2

**Subcutaneous Proliferative Phase**

- Interstitial fibrosis
- Fibroblastic proliferation
- Hyperplasia Type II alveolar epithelial cells
Signs and Symptoms of Oxygen Toxicity

V.E.N.T.I.D.C.

- Visual Symptoms
- Ear Symptoms
- Nausea and Vomiting
- Twitching and Tingling
- Irritability
- Dizziness
- Convulsions
Visual Symptoms:
Tunnel vision, a decrease in the diver’s peripheral vision, and other symptoms, such as blurred vision, may occur.

Ear Symptoms:
Tinnitus is any sound perceived by the ears but not resulting from an external stimulus. The sound may resemble bells ringing, roaring, or a machinery-like pulsing sound.

Irritability:
Any change in the diver’s mental status; including confusion, agitation and anxiety.

Dizziness:
Clumsiness, incoordination and unusual fatigue.

Convulsions:
Seizures. Maybe no pre-convulsions indications.

Visual Symptoms:
Tunnel vision, a decrease in the diver’s peripheral vision, and other symptoms, such as blurred vision, may occur.

Twitching and Tingling:
Any of the small facial muscles, lips, or muscles of the extremities may be affected. These are the most frequent and clearest symptoms.

Nausea and Vomiting:
These symptoms may be intermittent.
Fig. 9.14. Perimetric measurements of visual fields in the same subject before and after 3.5 h of oxygen breathing at 3 ATA. Normal pre-exposure visual fields shown in A. Visual fields shown in B, C and D, respectively, were obtained 5, 25 and 50 min post-exposure. (From Behnke et al. 1935)
Nitric Oxide and Oxygen Convulsions

- Increase in NO overrides $O_2$ vasoconstriction
- Brain tissue p$O_2$ increases markedly
- Convulsion follows
EFFECTS OF OXYGEN TOXICITY

High Inspired Oxygen Pressure

- Chemical toxicity
  - Tracheobronchial tree
  - Capillary endothelium
  - Alveolar epithelium
- Pulmonary damage
  - Atelectasis
- Chemical toxicity and cell death
  - Anoxemia
    - Acidosis
    - Death
  - Hemolysis
  - Hepatic effects
    - Myocardial damage
- Retinal damage
  - Erythrocyte Hemolysis
  - Renal damage
  - Endocrine effects
    - Adrenal
    - Gonads
    - Thyroid
- Toxic effects upon enzymes and cells of central nervous system
  - Twitching
  - Convulsions
  - Destruction of neurons
  - Death
  - Chemical toxicity and destruction of any cell death
Factors Which Protect Against Oxygen Toxicity

- Intermittent exposure
- Pre-exposure to CO₂
- Tris buffer (tris [Hydroxymethyl] Aminomethane)
- Barbiturates
- Hyperventilation
- Adrenalectomy
- Factors decreasing the metabolic rate
Factors Which Increase Oxygen Toxicity

- XS $CO_2$ in mixture breathed
- Increased temperature
- Work or exercise
- Respiratory impairment
- Factors increasing the metabolic rate
- Adrenalin
Questions?