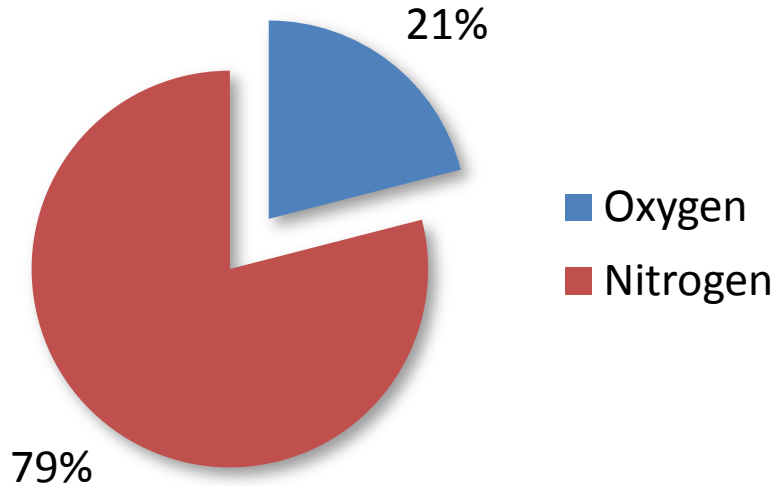


# Introduction to Dive Physics

# We will cover

- air
- pressure
- Boyle's law
- vision
- sound

# Air



- Oxygen ( $O_2$ )
- Nitrogen ( $N_2$ )
- Carbon dioxide ( $CO_2$ )
- others in trace amounts

# Pressure

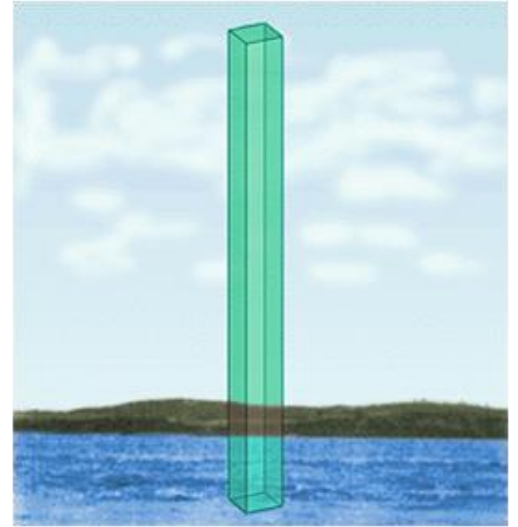
- Every medium exerts force on objects within it
- Force is exerted equally from all directions
- Divers are subject to pressure from atmosphere and water
- Divers measure pressure in bar
  - 1 bar = 100000 Pascal

# Pressure terms

- Atmospheric pressure
- Underwater pressure
- Absolute pressure

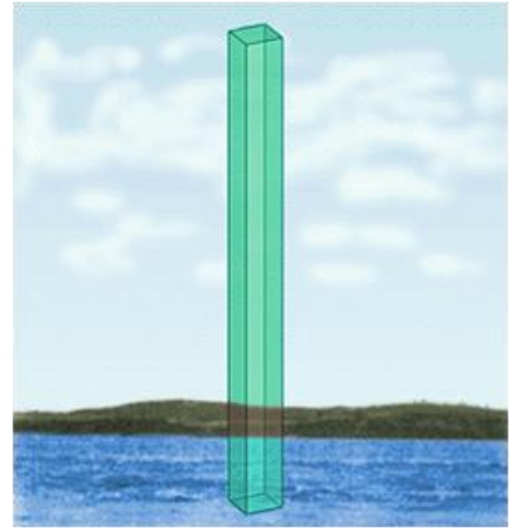
# Atmospheric pressure

- Pressure exerted by air at sea level
- Acts on divers both above and below the surface



# Atmospheric pressure

- 100 km x 1 cm<sup>2</sup> column of air weighs 1 kg
- Resulting pressure: 1 bar



# Underwater pressure

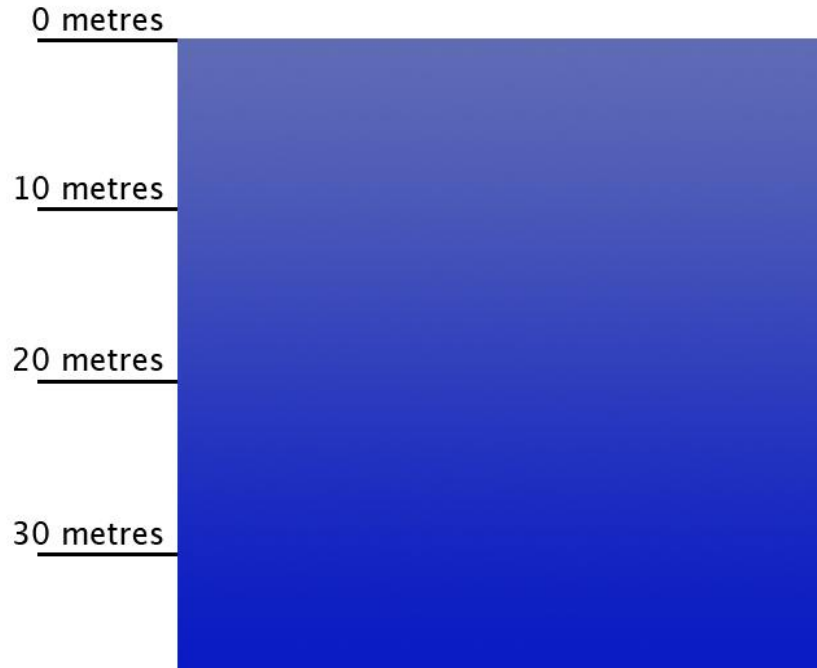
- Water is much heavier than air
- Pressure changes underwater are much greater
- Each 10 m depth = 1 bar pressure



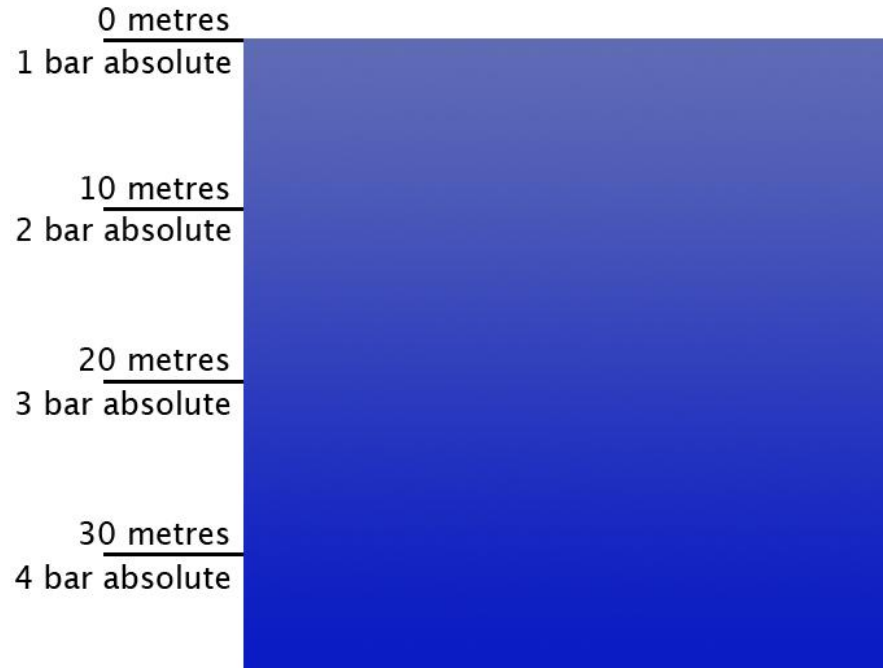
# Absolute pressure

- Total pressure experienced by diver
- atmospheric + underwater
- Absolute pressure at 10 m = 2 bar
  - 1 bar (atmospheric) + 1 bar (underwater)

# Pressure and depth



# Pressure and depth



# Boyle's Law

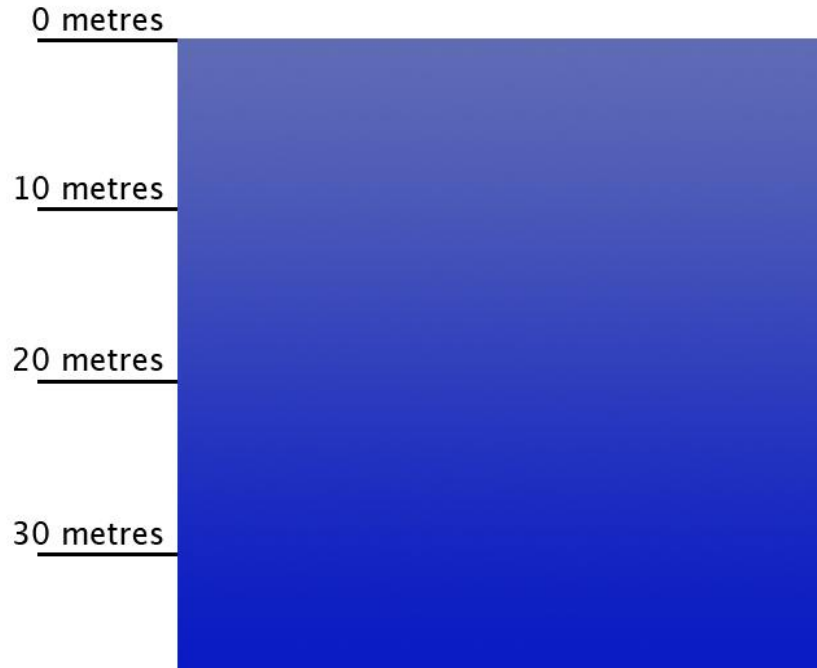
- describes the effect of pressure on gas volume
- the single most important gas law for divers
- explains most diving injuries

# Boyle's Law

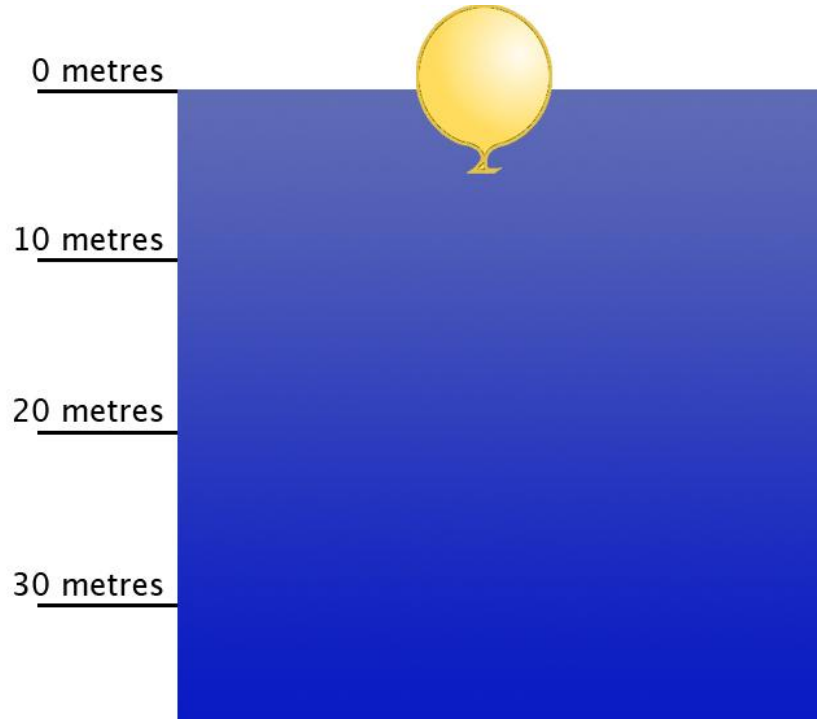
“At a constant temperature, the **volume** of a given mass of gas **varies inversely with** the absolute **pressure.**”

- If you double the pressure, you halve the volume

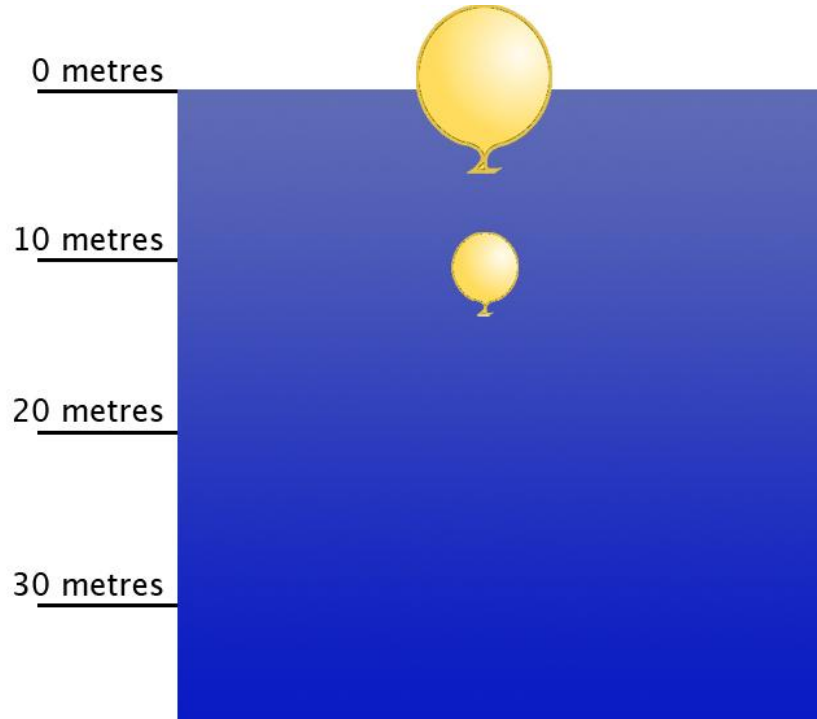
# Boyle's Law



# Boyle's Law

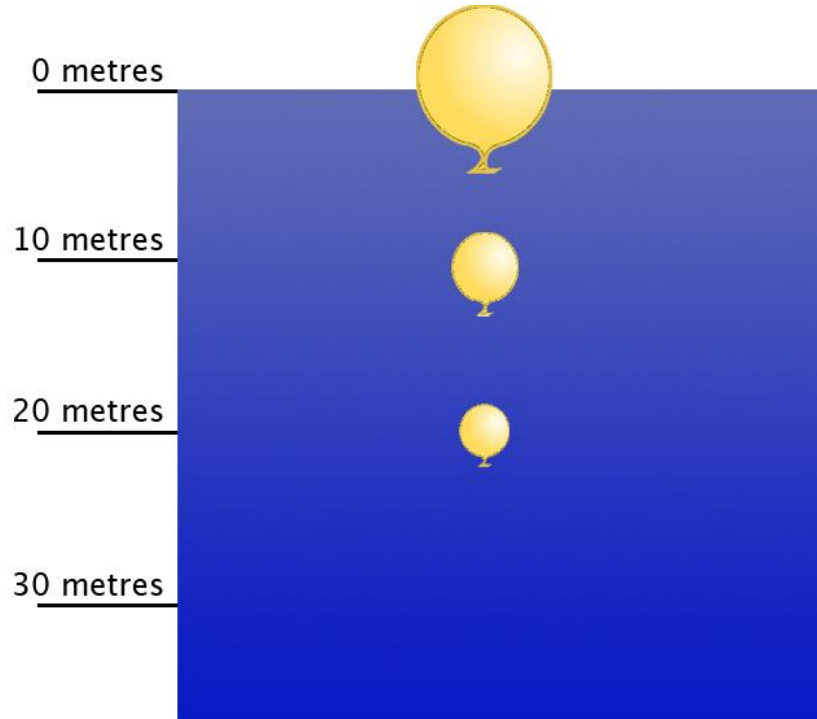


# Boyle's Law

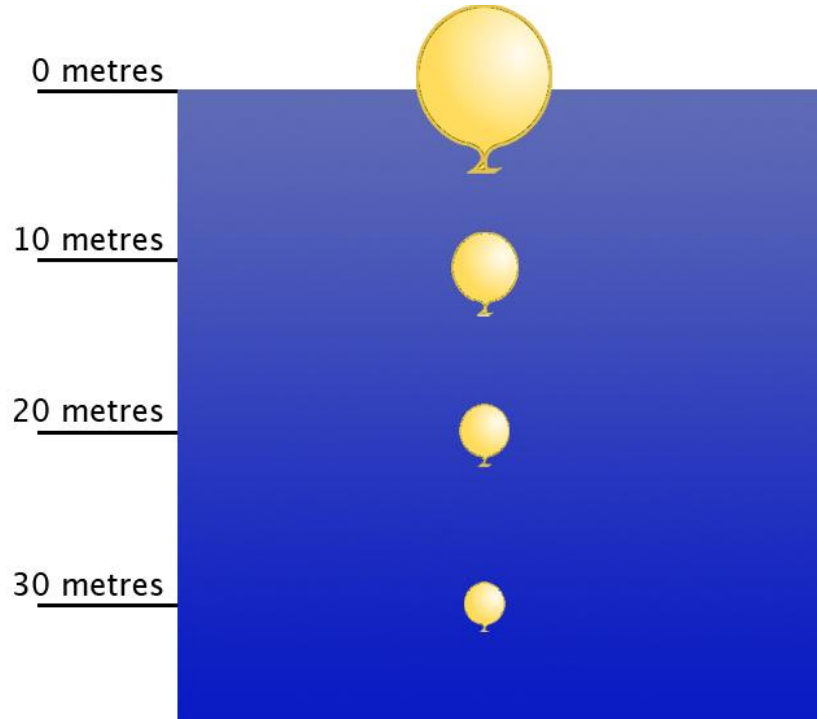




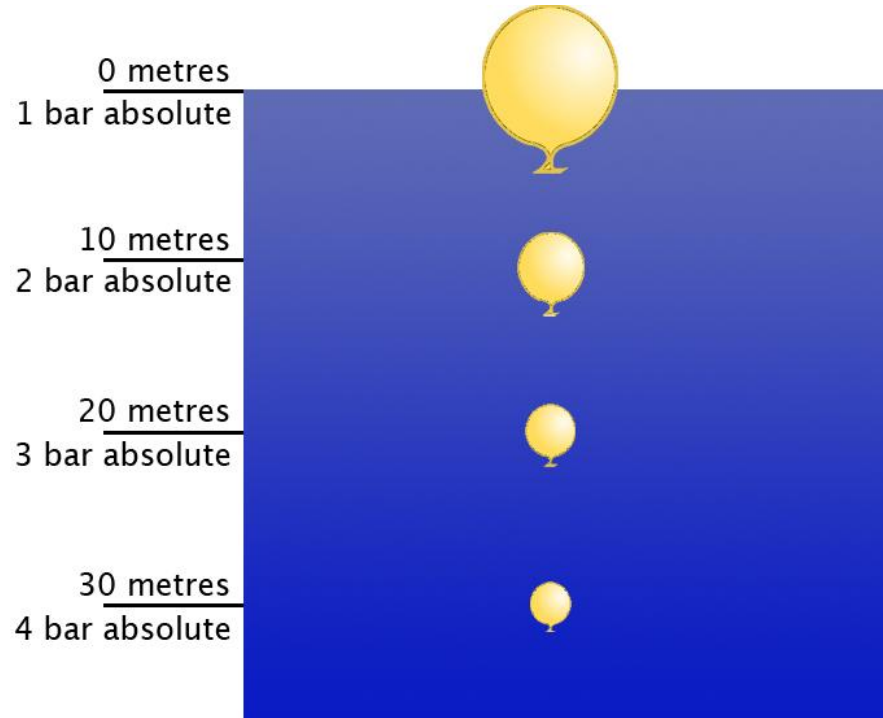
# Boyle's Law



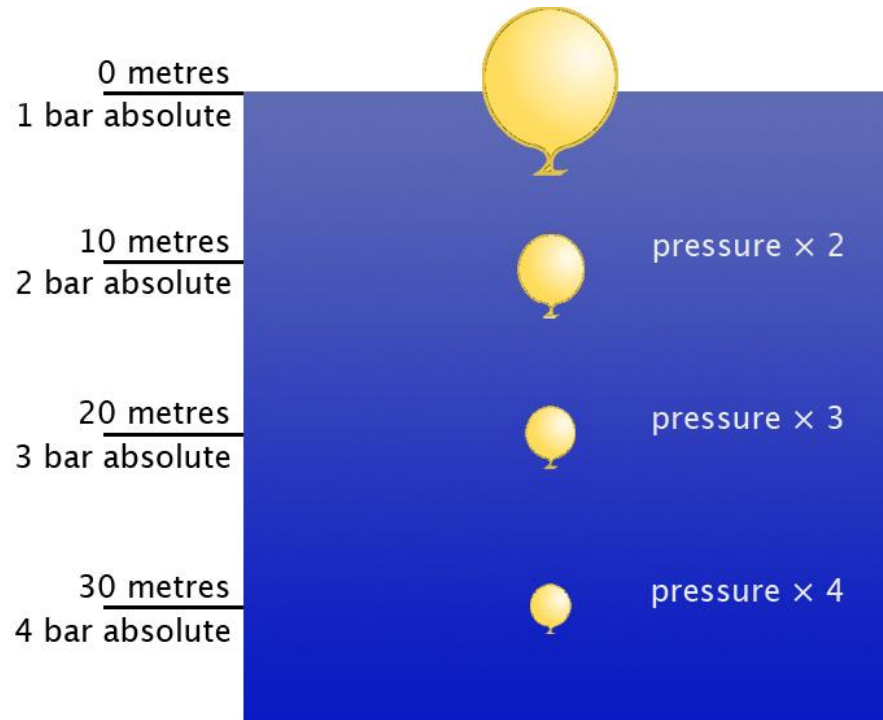
# Boyle's Law



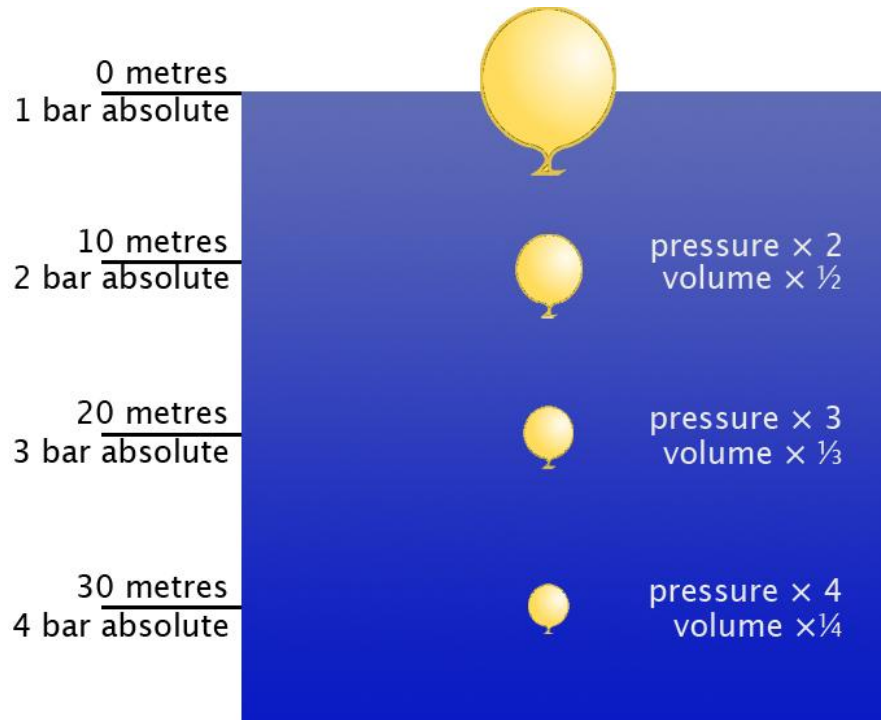
# Boyle's Law



# Boyle's Law



# Boyle's Law



# Boyle's Law for divers

- Any compressible air space will change in volume on descent and ascent
  - Equipment air spaces
  - Body air spaces
- We add and remove air from these spaces to equalise the pressure

# Equipment issues

- BCD
- Mask
- Suit

# Equipment issues

- BCD
  - Equalise with inflate/deflate valves
- Mask
  - Equalise by breathing out through nose
- Suit
  - Neoprene compresses at depth
  - Drysuit divers add/remove air from suit



# Physiological issues

- Ears and sinuses need equalising
  - Equalise with Valsalva manoeuvre, etc.
- Lungs can burst on ascent if you hold your breath
  - This can kill you
  - Never hold your breath on SCUBA

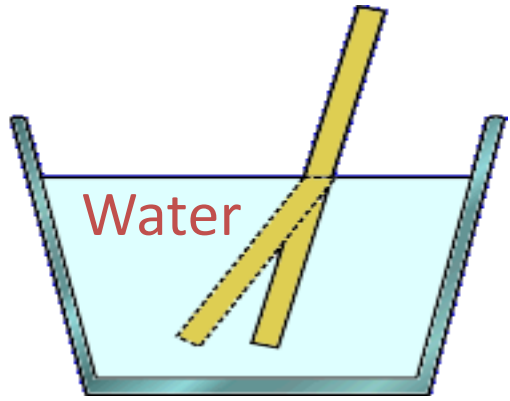
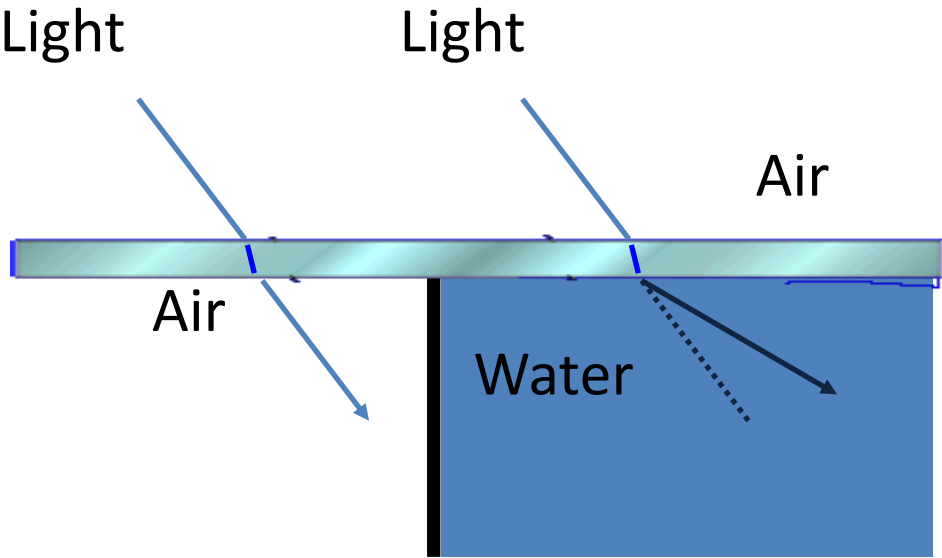
# Never hold your breath on SCUBA

- Never hold your breath on SCUBA
  - Never hold your breath on SCUBA

# Vision

- Human eyes can't focus underwater
- Masks trap a layer of air between our eyes and water
- Light rays bend as they move from one medium to another
- They appear to be coming from elsewhere

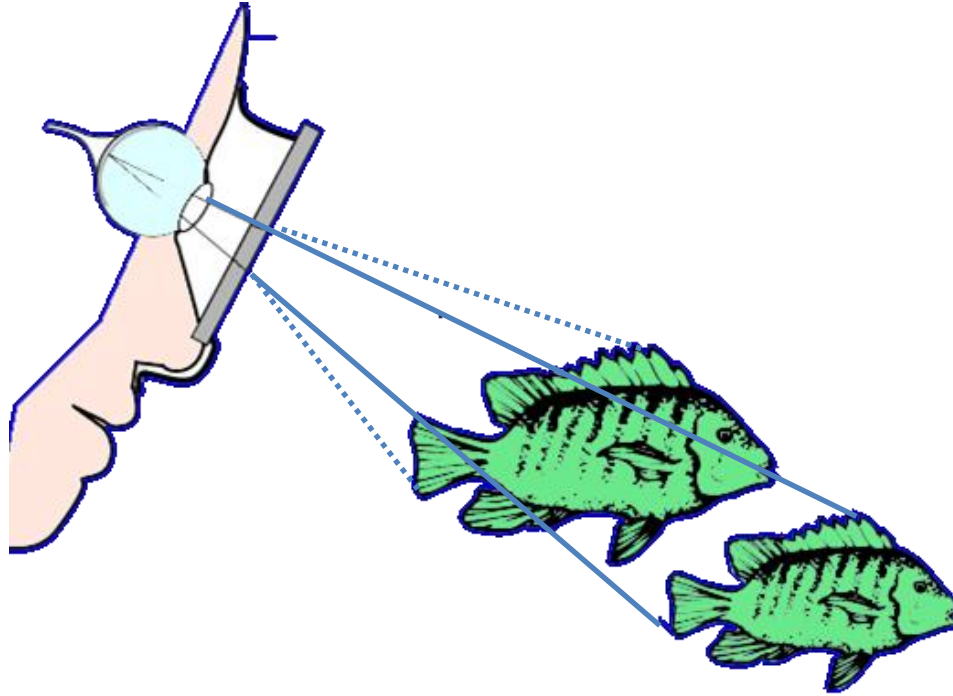
# Refraction



# Vision underwater

- Refraction changes our perception of objects
  - 33% larger
  - 25% closer

# Vision underwater



# Vision underwater

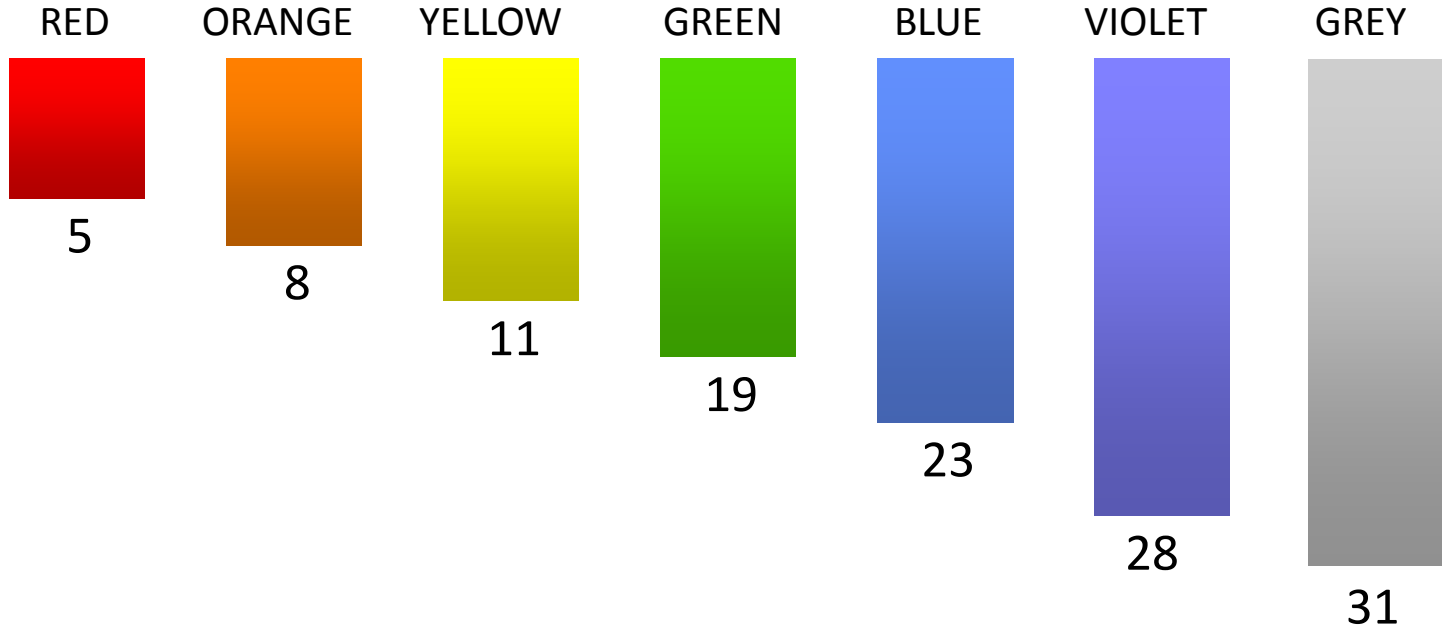
- Refraction changes our perception of objects
  - 33% larger
  - 25% closer
- Divers adjust with experience

# Colour

- Water absorbs light
- Rays are absorbed in order of frequency
  - Low-frequency light is absorbed first



# Colour



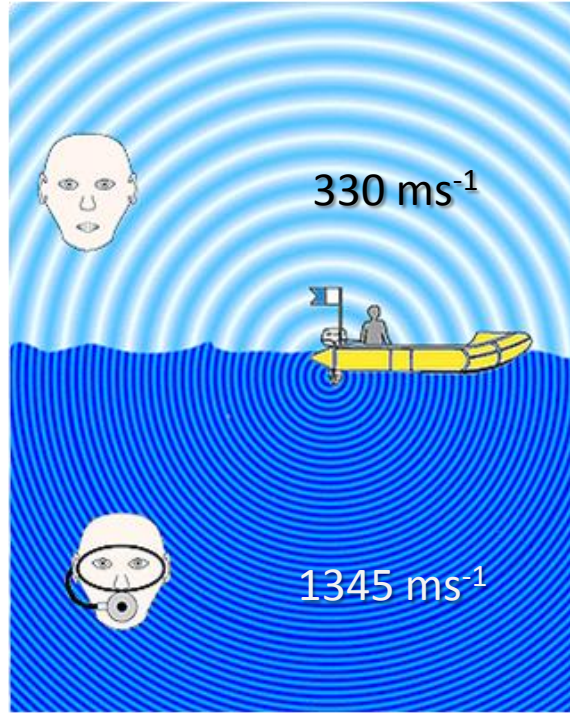
# Colour

- At depth everything appears grey
- Torches bring colour back

# Sound

- Speed of sound on land  
 $330 \text{ ms}^{-1}$
- Speed of sound underwater  
 $1345 \text{ ms}^{-1}$
- Four times faster underwater

# Sound



# Sound

- Humans use timing cues to localise sounds
- Determining direction of sound is almost impossible underwater
- Changes in loudness can tell you if something is approaching
- When in doubt, assume the boat is above you

# Summary

We discussed

- air
- pressure
- Boyle's Law
- vision
- sound

# Questions

# Questions

1. The composition of air is approximately  
(b) 21% Oxygen / 79% Nitrogen



# Questions

2. The pressure at sea level is
  - (a) 1 bar

# Questions

3. The effect of refraction on vision underwater causes objects to appear  
(b) larger and closer

# Questions

4. The pressure at a depth of 20 metres in sea water is
- (c) 3 bar

# Questions

5. The pressure at a depth of 40 metres in sea water is
- (c) 5 bar

# Questions

6. A flexible container full of air at atmospheric pressure is brought underwater. At a depth of 10 metres its volume will be
- (c) half its original size

# Questions

7. A snorkel diver takes a deep breath and fills his lungs with air on the surface and then descends to a depth of 20 metres. His lungs will be

(c) a third of their original size

# Questions

8. Effects governed by Boyle's Law are
  - (b) ear clearing and sinus squeeze