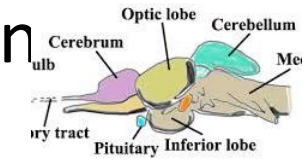
Physiology: An Introduction

Physiology

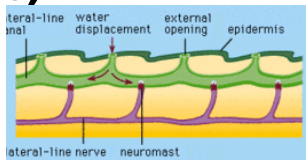
- **Physiology is the study of the functions of organisms**

- It includes the study of an organism's individual cells, tissues, organs, and systems function

1. **Nervous system**—The nervous system regulates functions of the body and senses stimuli from various sources. It is important in locomotion



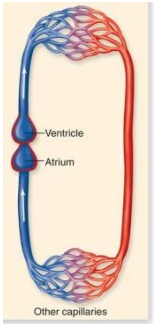
2. **Sensory system**—The sensory system is comprised of organs that receive stimuli from the environment of an organism. With finfish, these include the eyes, ears, skin

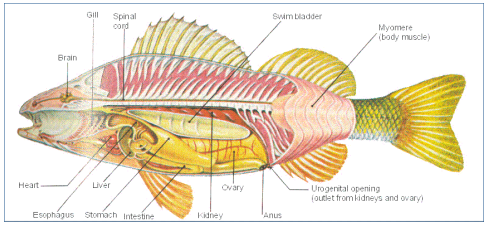


Physiology cont'd……..

3. Circulatory system

Responsible for circulating blood throughout the body. The circulatory system transports digested nutrients from food, oxygen from the gills, and other substances throughout the body and transports certain wastes to be excreted





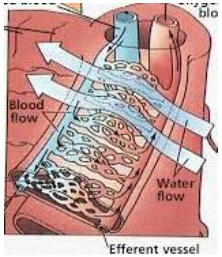
4. Skeletal system

The skeletal system is the bony structure that gives the body shape and form. Some structures protect the internal organs and allow locomotion to occur

Physiology cont'd……..

5. Muscular system

The muscular system is comprised of the strong tissues of the body the promote movement and locomotion. With finfish, the major muscles involved with locomotion are on each side of the tail.



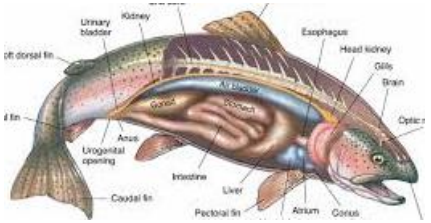
6. Respiratory system

The respiratory system of finfish consists of the organs that intake oxygen from the water and release certain wastes. With finfish, the gills and associated structures intake oxygen from water and release various wastes from the circulating blood.

Physiology cont'd……..

7. Digestive system

The digestive system digests the food materials that are ingested by the organism. It also prepares wastes from digestion for elimination from the body of the organism



8. Reproductive system

The reproductive system assures that the species perpetuates itself. These systems vary by gender, with the males of a species producing sperm and the females producing eggs

Physiology cont'd……..

9. Excretory System

It control the osmolarity and the volume of blood and tissue fluid by excreting solutes that are present in excess. Give out nitrogenous wastes, Keep homeostatsis and Balance blood pH

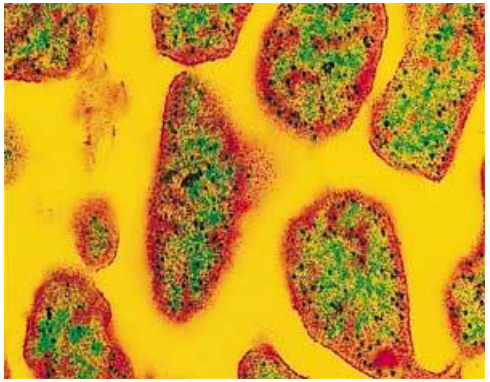
10. Endocrine System

It deals with production, secretion of hormone and regulatory function of hormone.

Water as a Biological Medium

Life has originated in aquatic medium

- ✓ **Water covers 71% of the Earth's surface.**



Oceans hold 97% of surface water
Glacier and polar ice caps 2.4%
1.6% of water below ground
Rivers, lakes and ponds 0.6%.
0.001% in the air as vapour, clouds(formed of solid and liquid water particles suspended in air)

A very small amount of the Earth's water is contained within biological bodies and manufactured products.

General Properties

- **Water is a simple molecule, yet it is fundamental to life**
- **In active living cells, two-thirds, or often more, of the area is occupied by water**
- **It is the only substance which can be found naturally in all three states - solid (ice), liquid and gas (water vapour)**
- **It has high melting and boiling point**
- **Water is also very good at ionizing substances and a good solvent**

Property of water

A.Physical property

Density
Buoyancy
Wave and current
Temperature
Salinity
Light and turbidity
Colour etc.

B. Chemical property

DO
pH
Hardness
Alkalinity
CO_2 etc.

Study of water

Hydrology: The scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere

Hydrography: **Hydrography** is the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and river

Limnology: the study of bodies of fresh water or inland with reference to their plant and animal life, physical properties, geographical features etc

Lentic water: Stagnant water

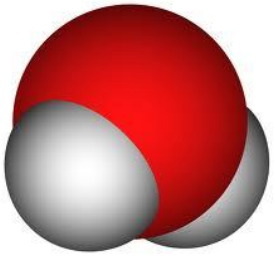
Lotic water: Running water

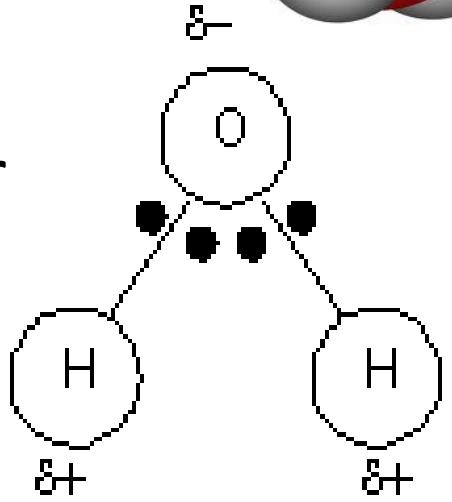
Oceanography: The scientific study of oceans, the life that inhabits them, and their physical characteristics, including the depth and extent of ocean waters, their movement and chemical makeup, and the topography and composition of the ocean floors

Water as a *Major Cell Constituent*

- In most organisms there is 60-90% water
- The lowest water content can be found in plant seeds (20%), and the highest in jellyfish (99%).
- In cell, water is found mainly in the protoplasm and here it plays vital roles in ***metabolism***

Water as a *Solvent*





- Formula H_2O
- Atoms are covalently bonded together
- ***Oxygen electronegative***
- ***Hydrogen electropositive***
- The molecule is said to be ***polar***
- Hydrogen atoms of one water molecule are weakly bonded to the oxygen atoms in adjacent water molecules. These weak bonds are called ***hydrogen bonds***
- This is the reason behind the unexpectedly high melting and boiling points of water

Water the Universal Solvent

- Convert food in soluble form (like **from starch to glucose**) that can be transported and taken by various cells/tissues
- Helps in **removal of metabolic waste products** in the form of urine, sweat etc
- Helps in **respiration** like supply of oxygen from heart to tissue and intake of CO2 from tissue to heart via blood
- Helps in **gas exchange,** In aquatic habitat oxygen is dissolved in water which is taken by the aquatic organisms

Water in the process of *Transport*

- ***Blood*** is used to transport food, hormones, oxygen, waste products etc and similarly in plants, ***sap*** is used to transport food and other substances. Both of these mediums for transports (blood and sap)are mainly water

Water as a *Reactant*

- The most basic example of this is ***photosynthesis***

- The equation for photosynthesis shows that water is a vital reactant in the reaction

$$6H_2O + 6CO_2 = C_6H_{12}O_6 + 6O_2$$

- **Condensation**, during conversion of glucose to starch water releases

- **Hydrolysis**, during digestion water require like conversion of starch in to glucose

Water as a mechanism of Support

- Aquatic organisms have weaker skeletons than organisms living on land, as the water's '***buoyancy effect***' makes them '***lighter***', thus giving them extra support

Water as a *Lubricant*

- Bones meet at ***joints***, and at these joints lubrication must be provided to make sure the bones do not scrape against each other causing damage, and enabling free easy movement by reducing friction

- A ***synovial membrane*** at joints encloses a fluid called ***synovial fluid***, which acts at the lubricant. Water is a major part of this fluid

- ***Cerebro-spinal fluid*** *(Brain)*
- ***Pleural fluid*** (Lungs)
- **Aqueous and vitreous humours** (eyes)
- ***Amniotic fluid*** *(fetus)*
- ***Mucus*** (gut)

Provides support, lubrication and some possible function

Water in *Sexual Reproduction*

- In most of the fishes, **external fertilization** takes place in water

- During fertilization, the sperm is often transported in a fluid medium known as ***semen***, which contains mostly water.

Water as *Temperature Controller*

- Water has a **high specific heat** capacity approximate value is **4200J/kg°C** so the temperature of water is not easily changed. A large mass of water, such as an ocean will heat up slowly during the day, and cool slowly at night, so its temperature does not change much. This provides an ideal habitat for marine organisms with only small variations in temperature.

- The high water content of cells gives them insulation, and protects them from rapid temperature changes, thus helping to keep cells at a fairly constant optimum temperature

Water as a Habitat

- **Freshwater Ecosystem**
  Ponds, river, lakes, beels etc.

- **Marine Ecosystem**
  Ocean

- **Survival of aquatic life in winters**
  water has highest density at 4 degree Celsius

Dissolved Oxygen

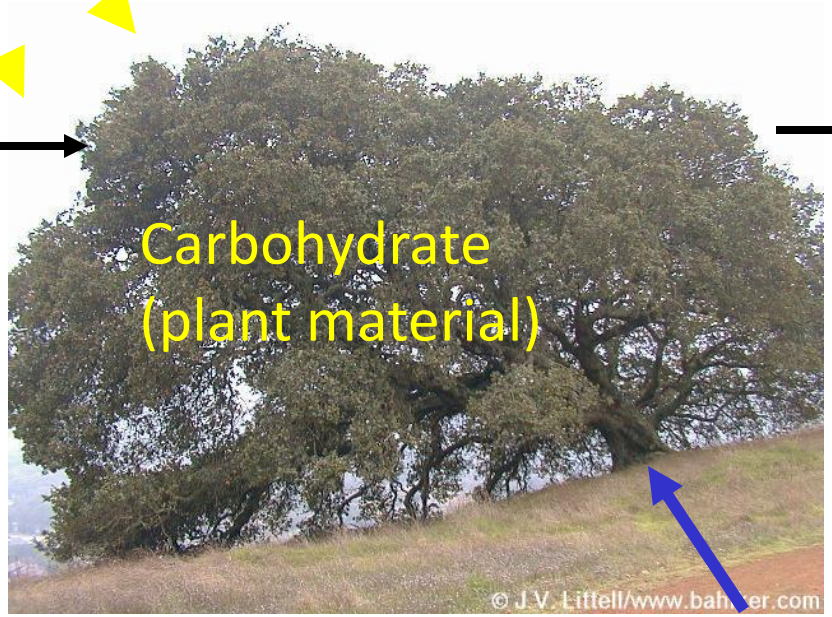
The Good Gas

Photosynthesis: Your one-stop shop for all of your oxygen needs!

Solar energy + $6CO_2$ + $6H_2O$ → $C_6H_{12}O_6$ + $6O_2$

Happy Rays of Sunshine

Carbon Dioxide (from air)

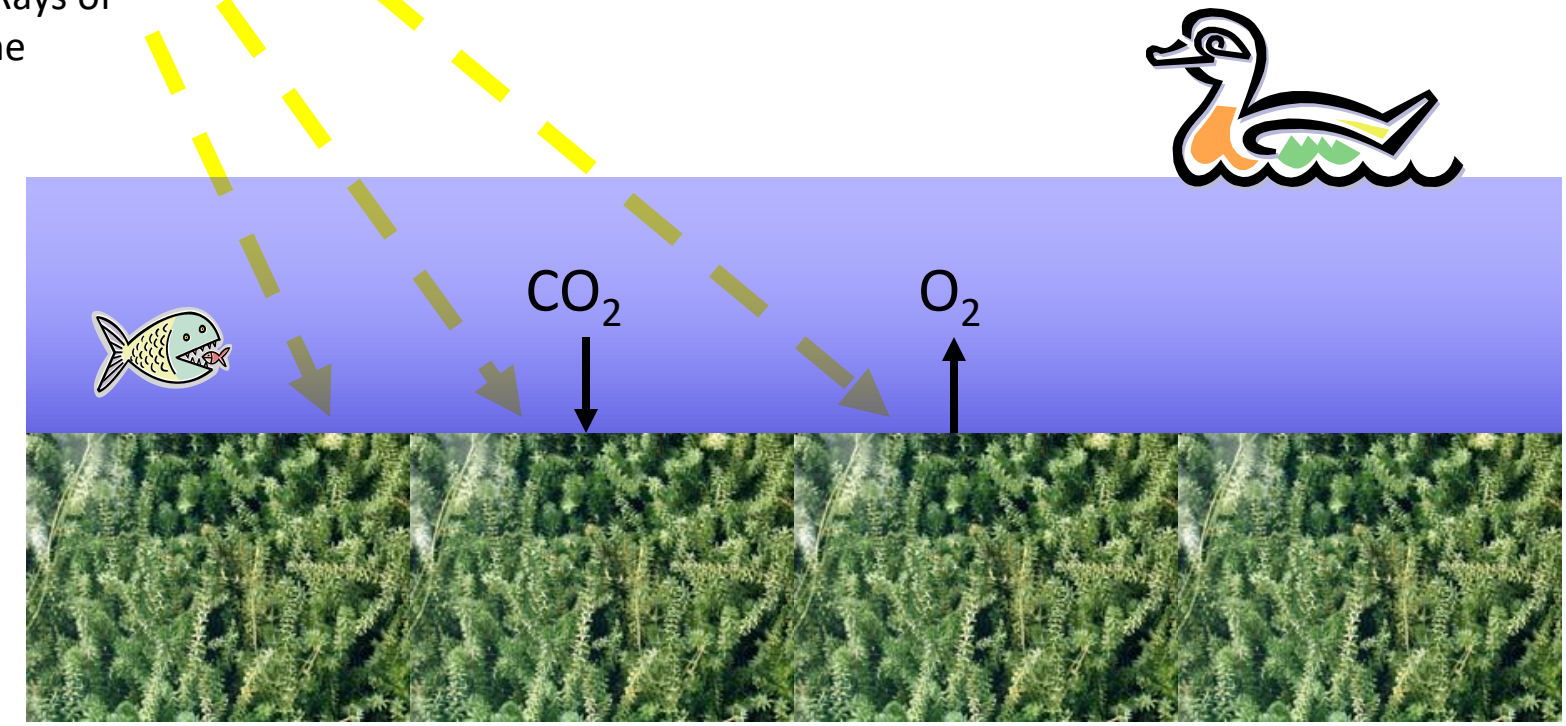


Oxygen (to air)

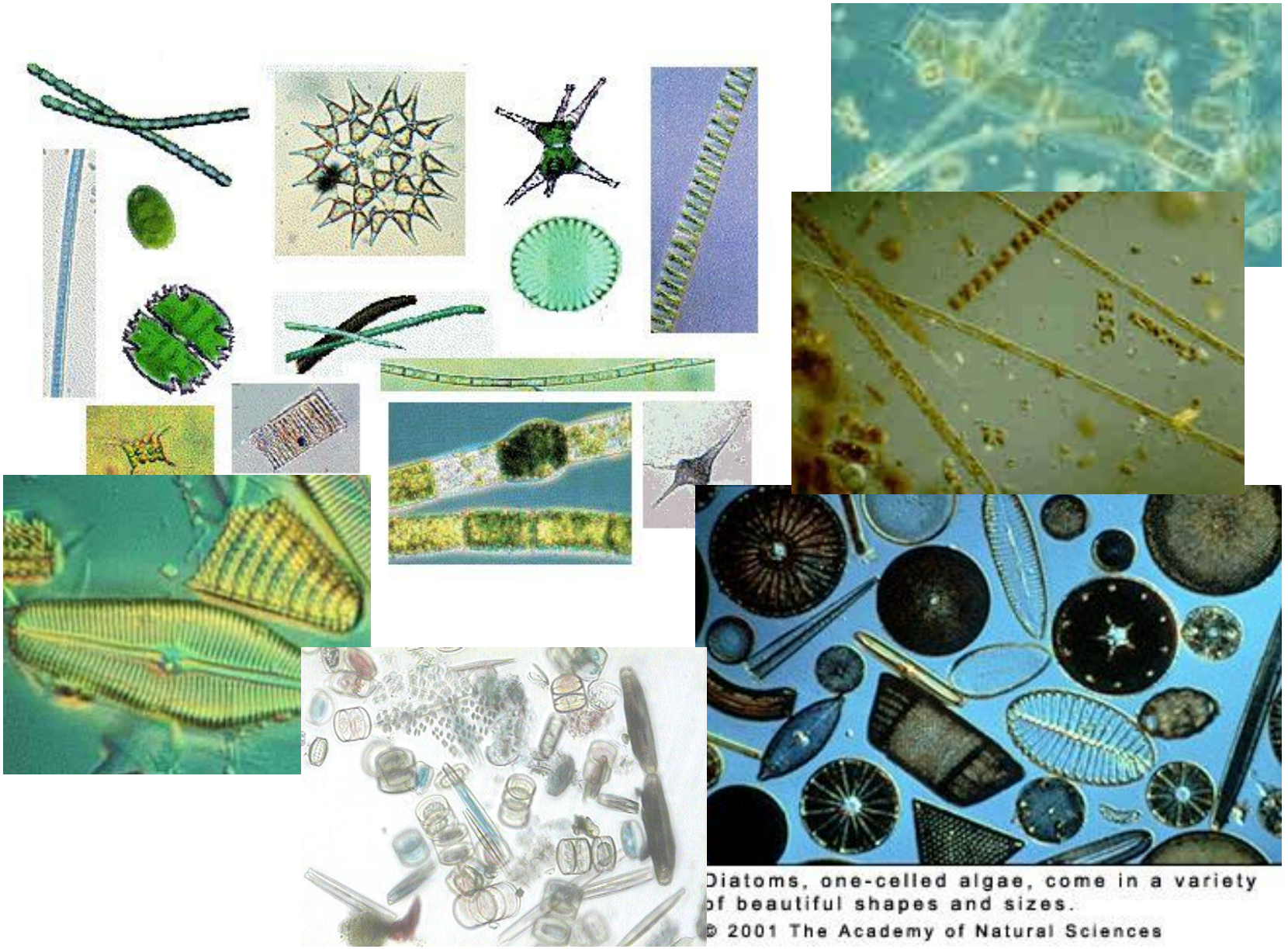
Water (from ground)

Aquatic plants and phytoplankton (single cell floating plants) release oxygen into the water as a product of photosynthesis

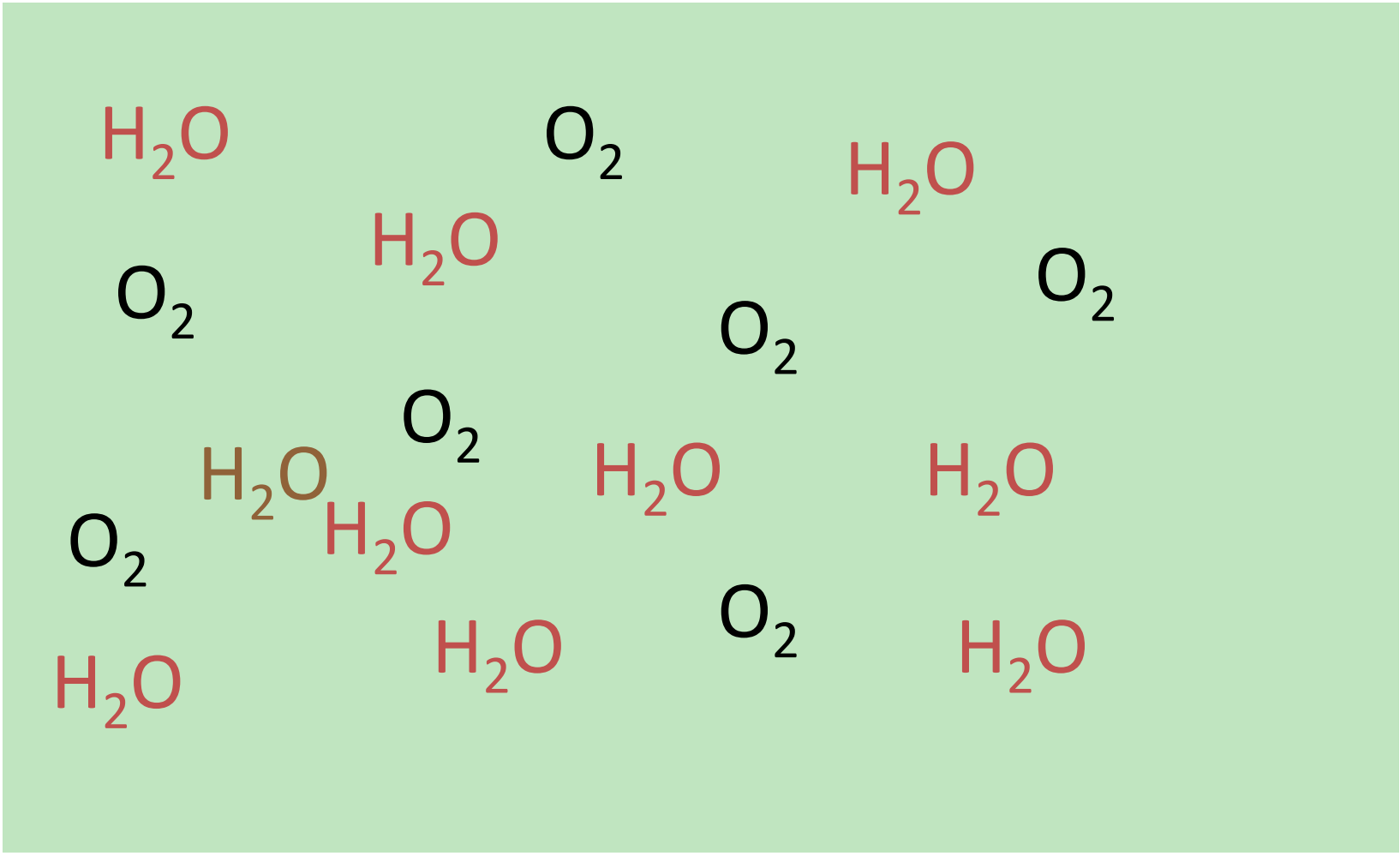
Happy Rays of Sunshine



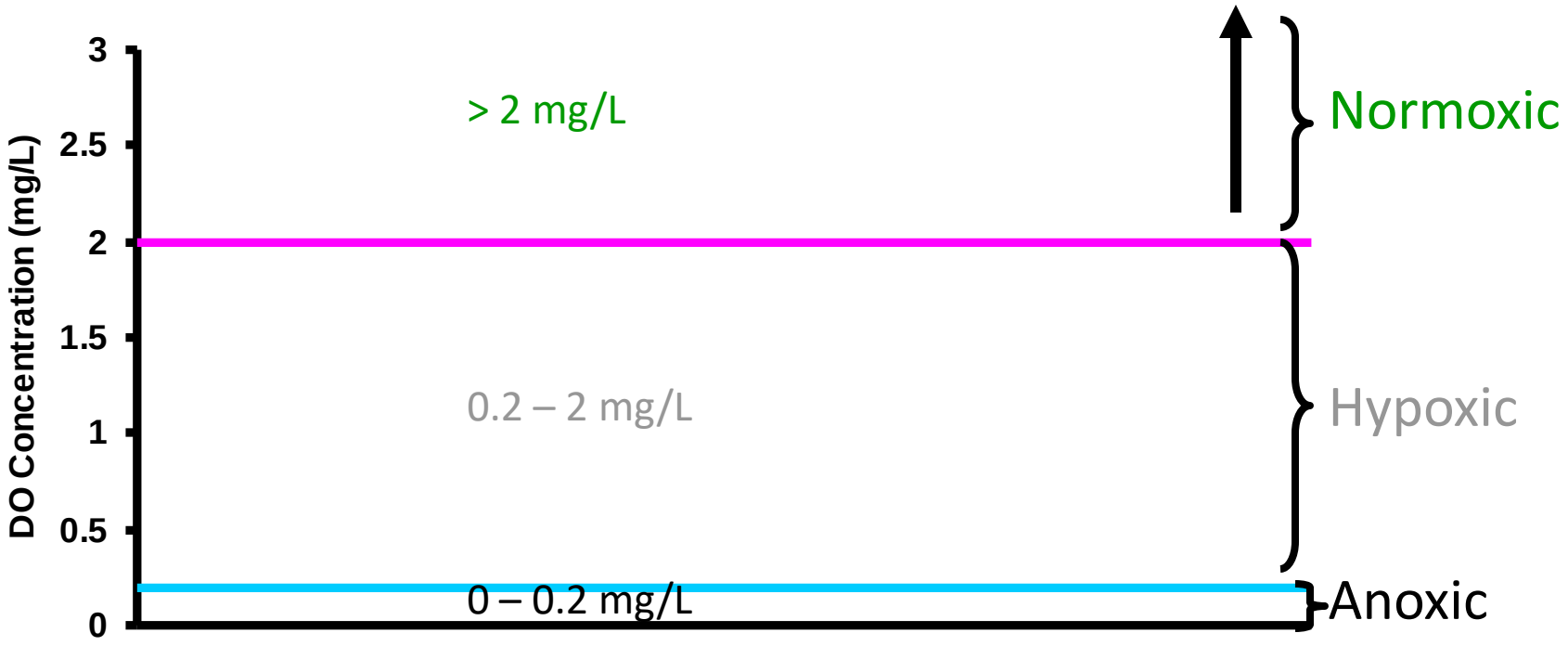
Phytoplankton (single cell plants) – are the base of the aquatic food web and provide most of the aquatic oxygen.



Oxygen: A Soluble Gas

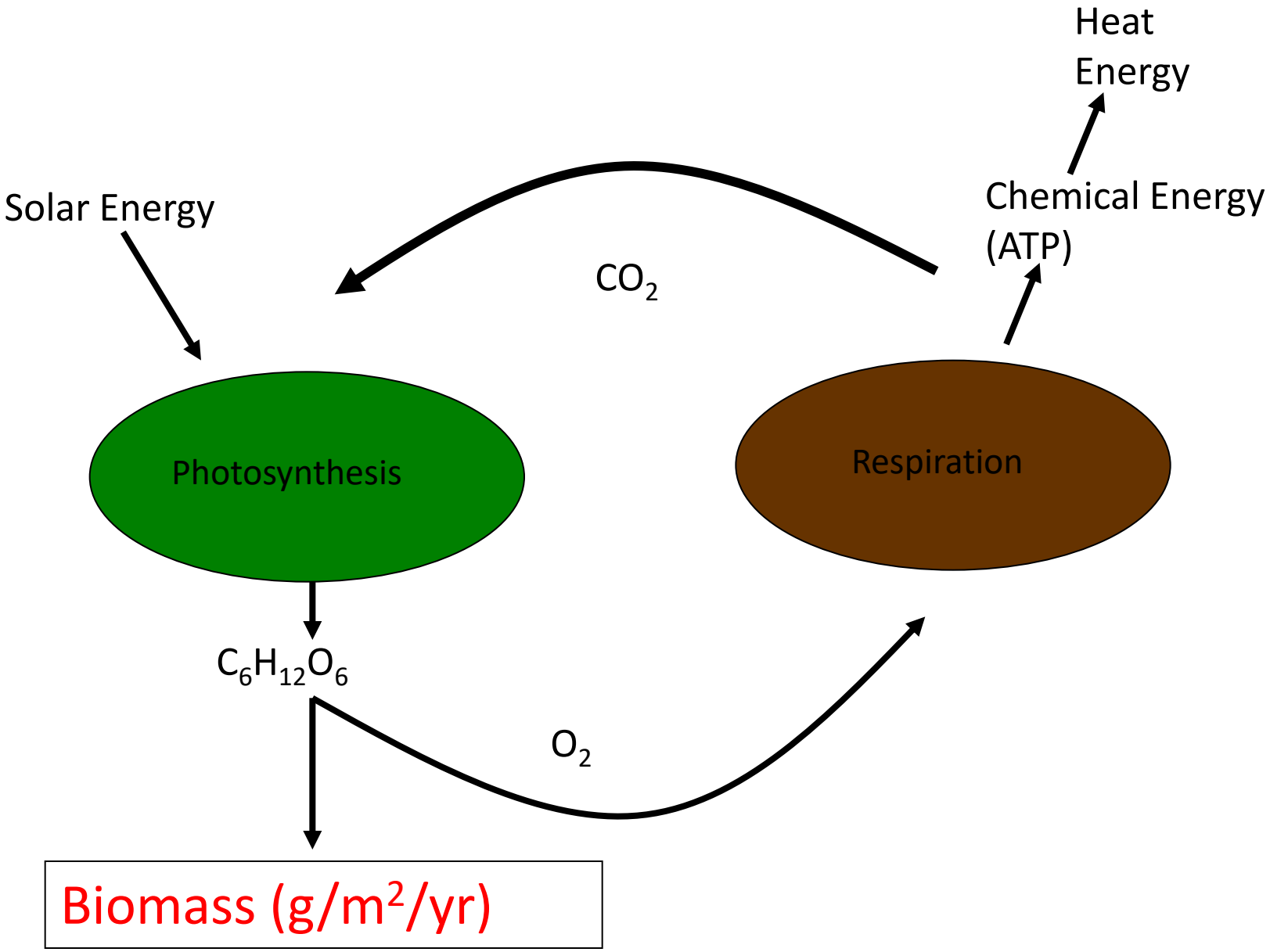


Habitat Classification Based on DO Concentration

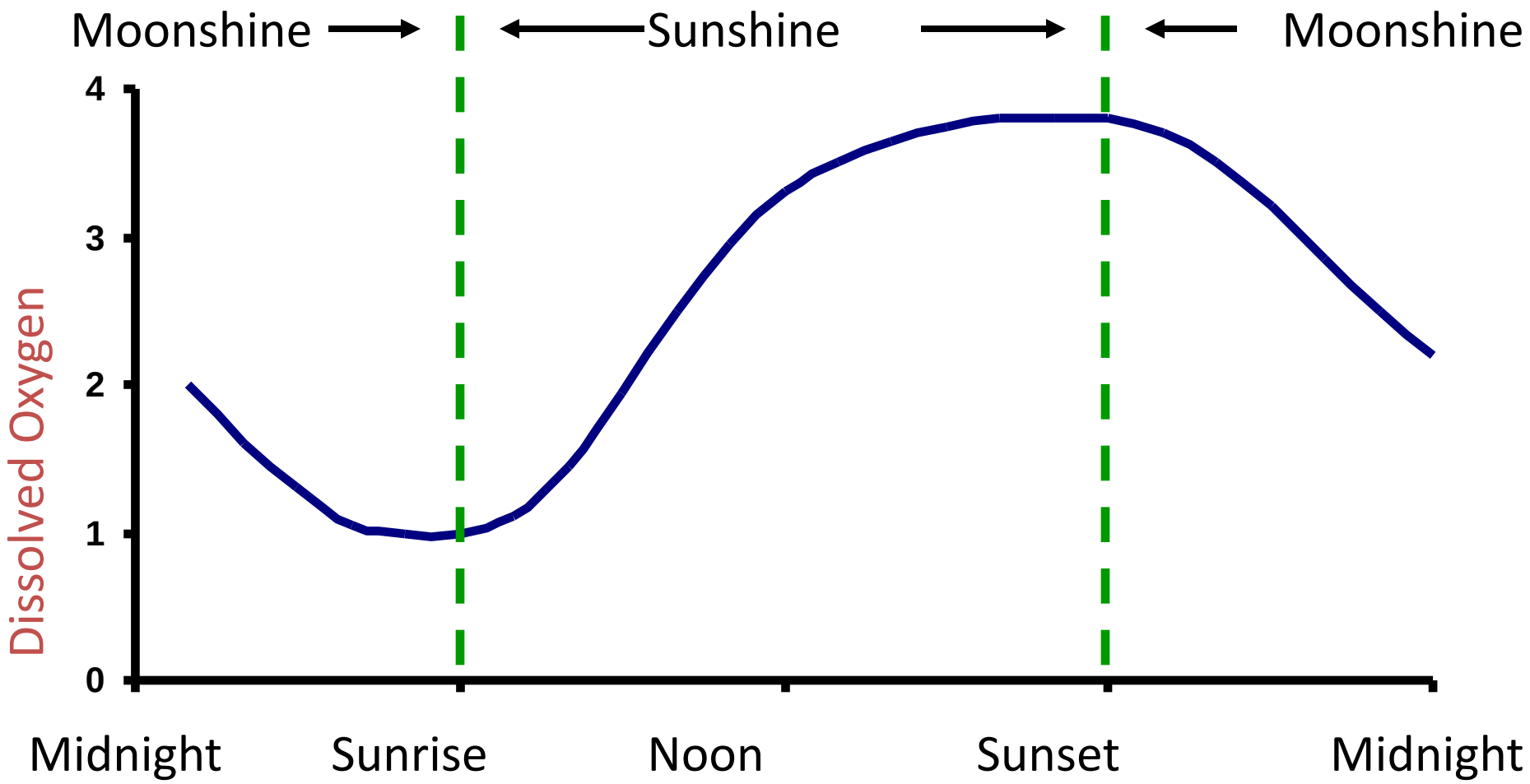


Most fish need oxygen levels > 2.0 mg/L

Biological Production and Consumption of Oxygen

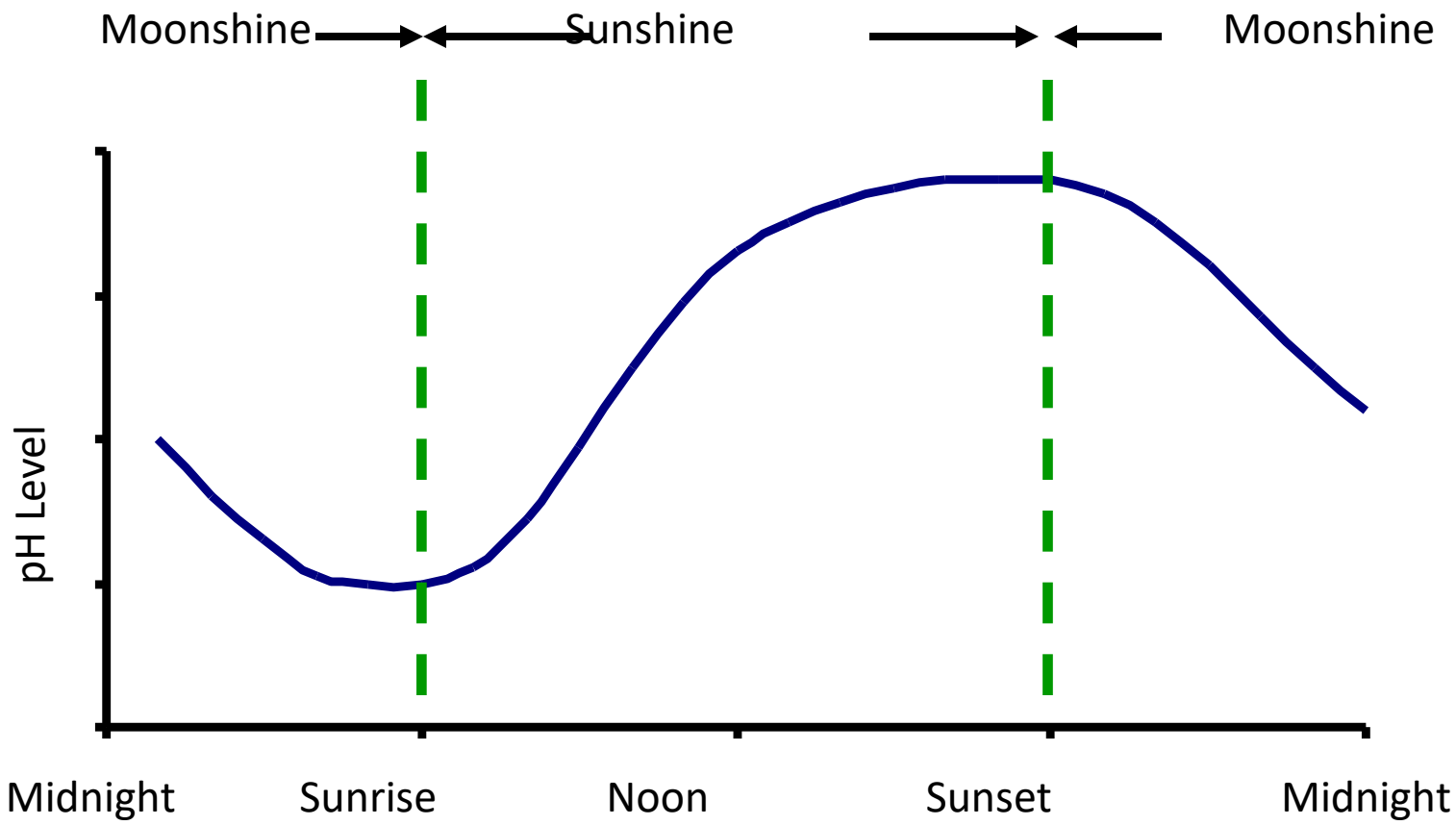


Daily Aquatic Oxygen Cycle



$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^- \leftrightarrow 2H^+ + CO_3^-$

An increase in CO_2 causes an increase in H^+ → pH ↓



Decomposition – *Not* good for DO

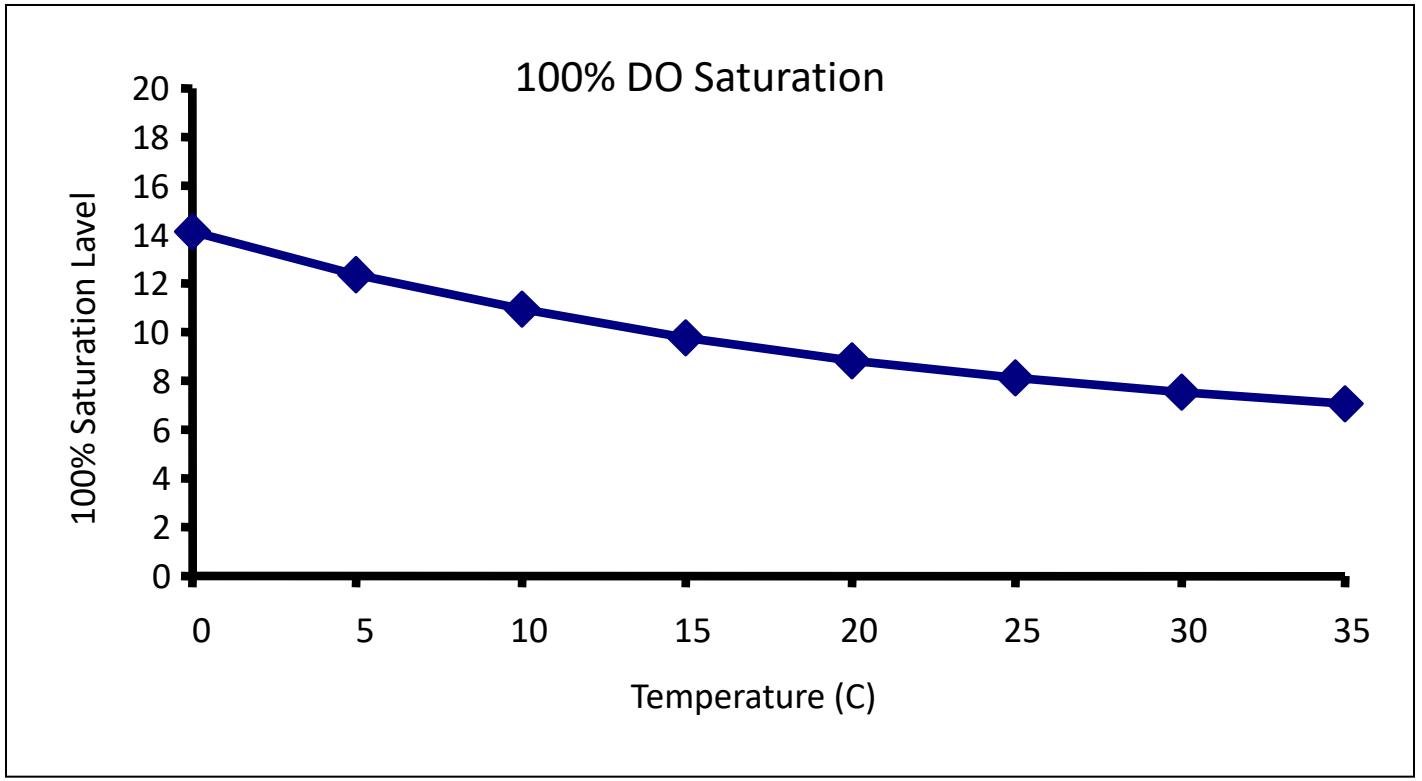
- Decomposer organisms (mainly bacteria) consume oxygen
  - Sometimes consume oxygen faster than plants can produce it, even during the middle of the day!
- A sudden increase in organic matter (*think leaf litter*) can create a spike in decomposition activity – especially if it is hot
  - Hurricanes not only add organic matter to our waterways, but also stir up the sediment.
  - Can cause fish death!!

Abiotic Factors That Affect DO Concentration

- Temperature
- Water Clarity
- Current Velocity (Flow)
- Salinity
- Wind
- Cloud Cover

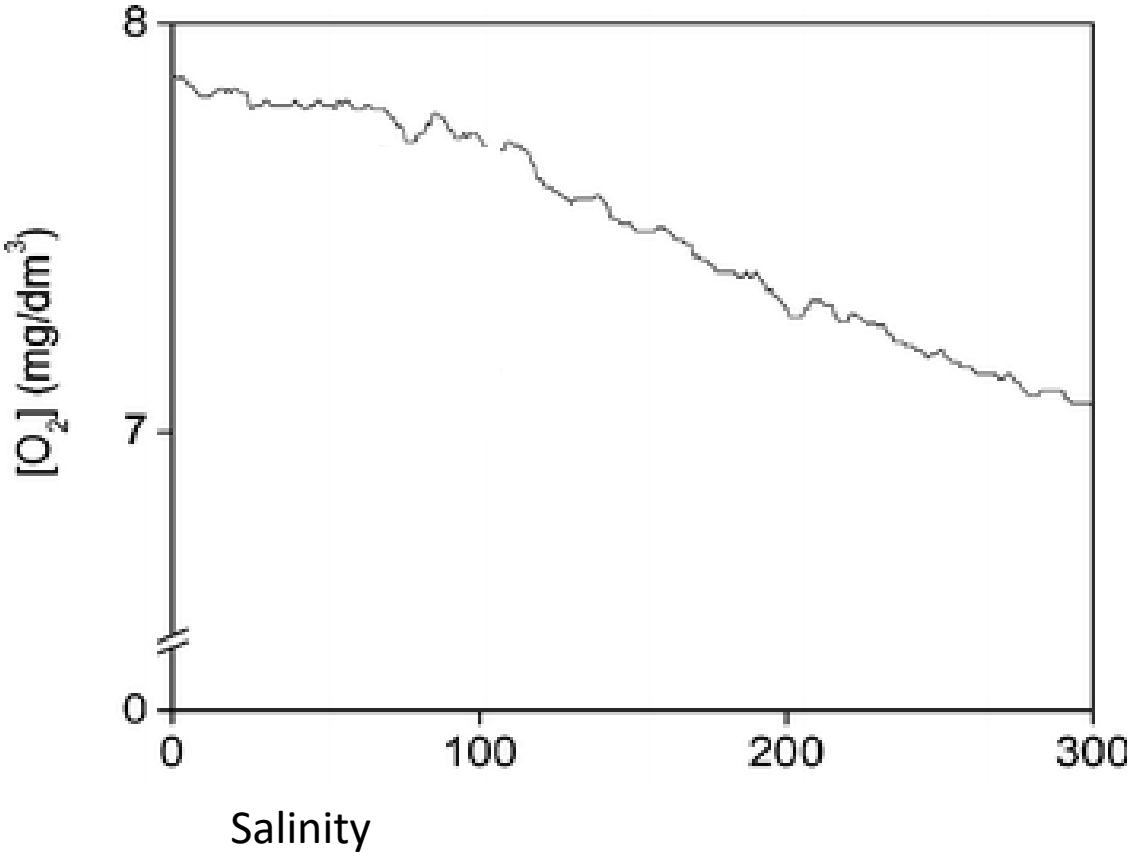
Temperature

- The warmer water is, the less DO it can hold

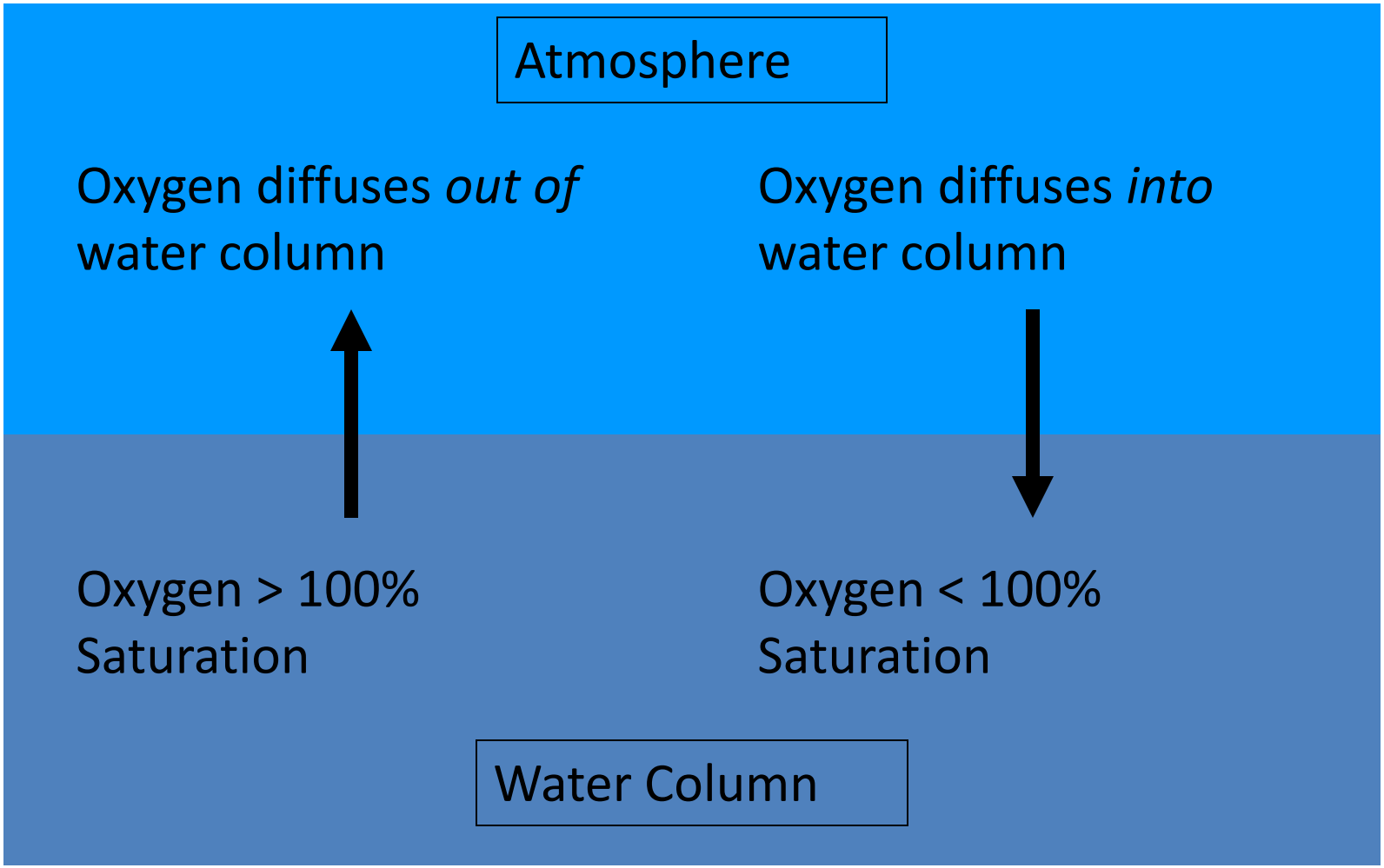


Salinity

- Increase in salinity, decrease the DO in water



Oxygen Can Diffuse *Out of* or *Into* the Water Column



Passive diffusion

Wind

Stirs in atmospheric oxygen

Current Velocity

- The faster water flows, the more atmospheric oxygen is mixed into the water.

Cloud Cover

- Clouds decrease the amount of sunlight reaching aquatic plants, thus oxygen production is reduced.