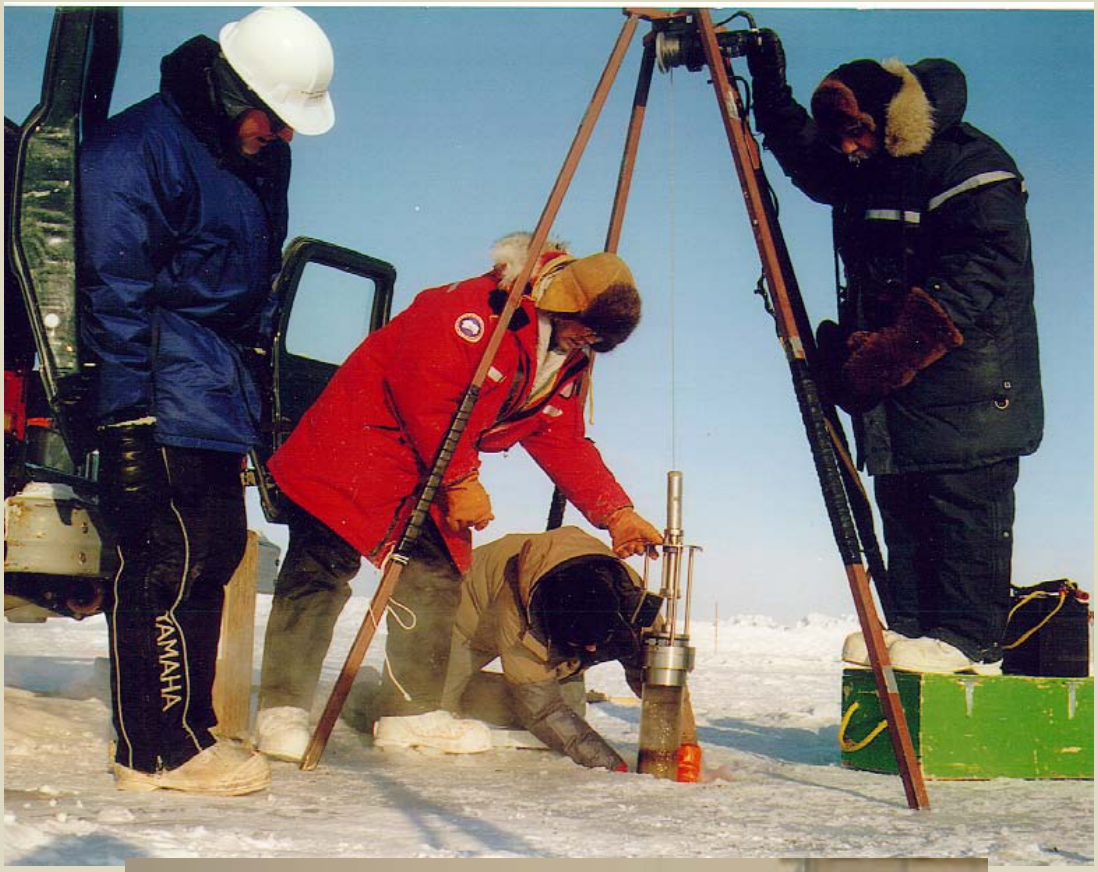
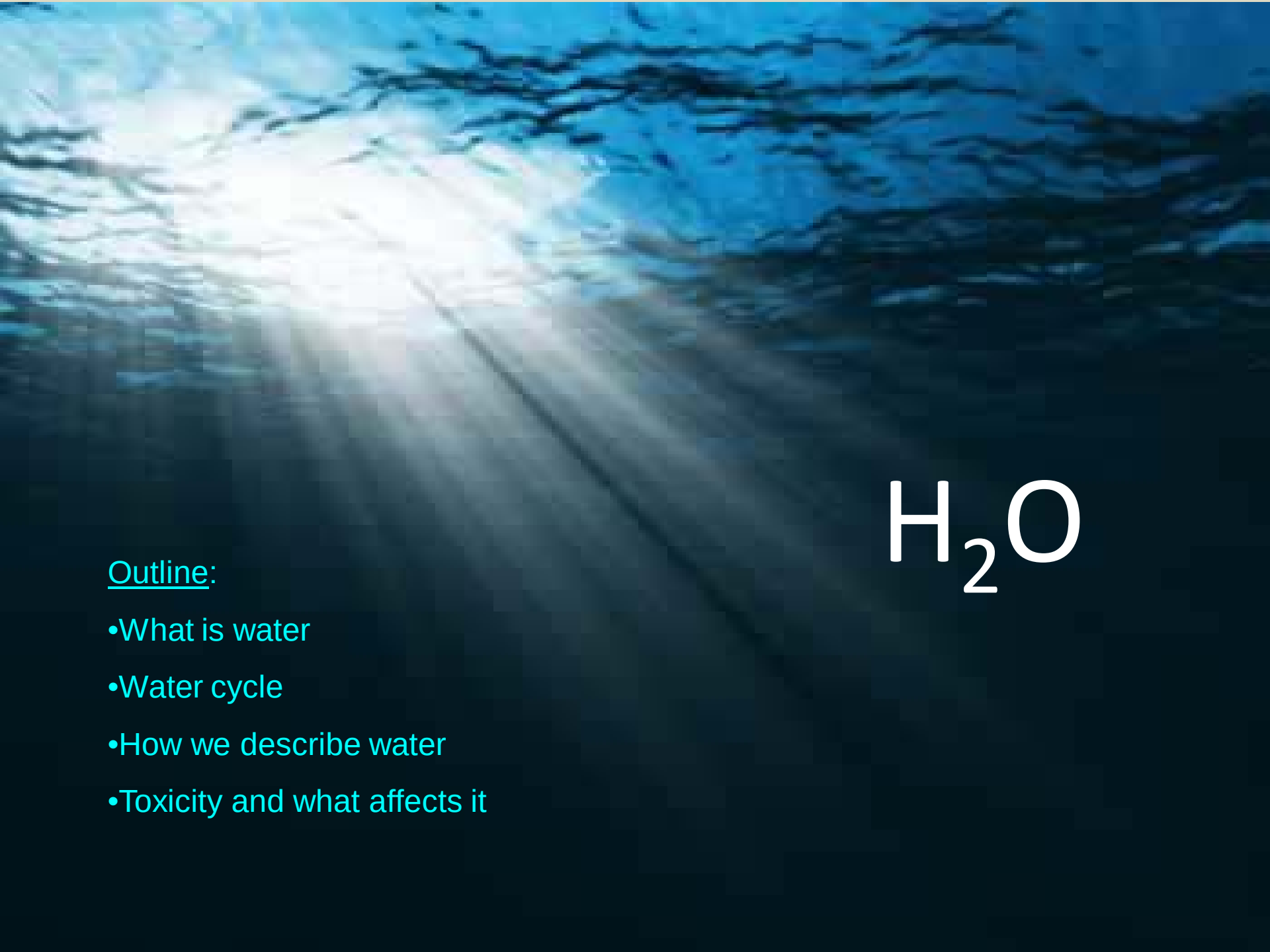
Anne Wilson





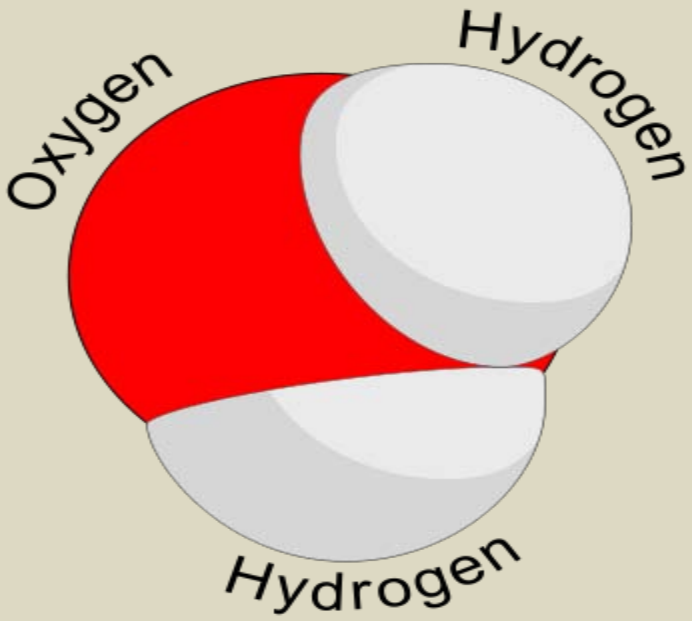
H_2O

Outline:

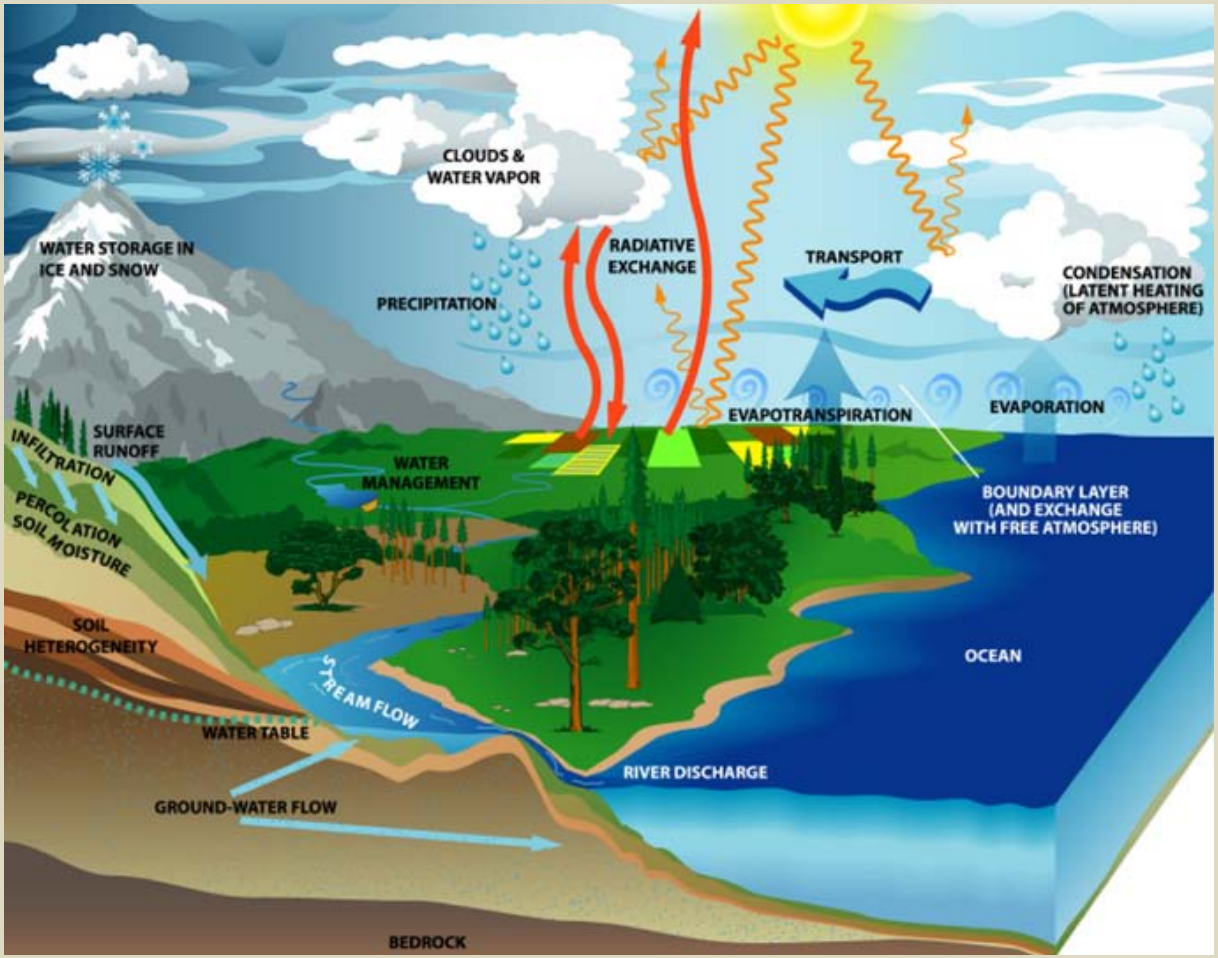
- What is water
- Water cycle
- How we describe water
- Toxicity and what affects it

What is Water?

- Oceans
- Lakes
- Rivers
- Streams
- Groundwater
- Rain, Snow, Hail



Water Cycle


CLOUDS &
WATER VAPOR
WATER STORAGE IN
ICE AND SNOW
PRECIPITATION
RADIATIVE
EXCHANGE
TRANSPORT
CONDENSATION
(LATENT HEATING
OF ATMOSPHERE)
EVAPOTRANSPIRATION
EVAPORATION
SURFACE
RUNOFF
INFILTRATION
WATER
MANAGEMENT
PERCOLATION
SOIL MOISTURE
BOUNDARY LAYER
(AND EXCHANGE
WITH FREE ATMOSPHERE)
SOIL
HETEROGENEITY
OCEAN
STREAM FLOW
WATER TABLE
RIVER DISCHARGE
GROUND-WATER FLOW
BEDROCK

Talking About Water Quality

- Conductivity
- Turbidity
- TSS
- pH
- Hardness
- Dissolved oxygen
- Temperature

Conductivity

- Conductivity is a measure of electrical resistance
- This can tell us how many ions are in the water, but not which ones. Conductivity can be affected by the level of metals as well as salts and other charged particles
- Conductivity can be measured in the field using a meter, and is useful for tracing effluents or spills

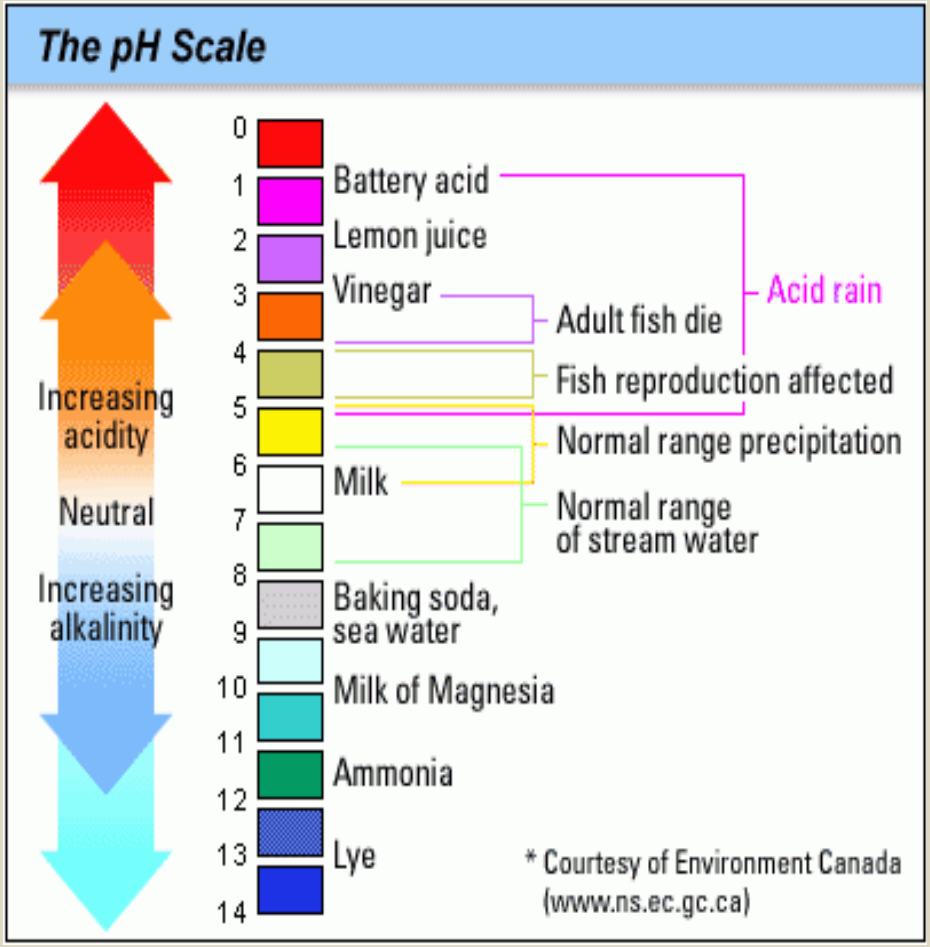
Turbidity

Total Suspended Solids

- TSS includes all particles in the water column that don’t pass through a 0.45 micron filter
- This can include silt, clay, fine particles of organic and inorganic matter, bacteria, algae, and zooplankton
- TSS causes harm by clogging and abrasion of gills, behavioural effects, habitat changes, burial of eggs and benthic organisms, and reduced feeding
- Primary productivity can be reduced by high TSS

Water Quality and pH

- Average pH in northern water ranges from 6.8 to 8.1
- Groundwater and rain are naturally more acidic than natural surface water
- pH is measured in the field and verified in the laboratory



Hardness

- Hard waters contain concentrations of dissolved alkaline earths such as calcium and magnesium (>150 mg/L) measured as $CaCO_3$

Dissolved Oxygen

- Dissolved oxygen analysis measures the amount of gaseous oxygen (O_2) dissolved in water
- Oxygen gets into water by diffusion from the surrounding air, by aeration, and as a waste product of photosynthesis
- Arctic lakes frequently have areas of low oxygen due to long ice cover and low light getting through, so algae don't release O_2

The Importance of Water Temperature

- Water temperature has an effect on:
  - Chemical and physical parameters
    - Affects the rate of chemical reactions and solubility of gases such as oxygen, nitrogen, and carbon dioxide
    - Influences conductivity, pH, salinity, and DO
  - Biological activities
    - Photosynthesis and respiration rates, spawning, uptake of toxic substances
  - Circulation in lakes by influencing water density

Toxicity

- We measure toxicity using standard tests, so that we know the response by the test animals is due to the solution being tested.
- There are two ways to test:
  - Acute – tests short-term exposure, with mortality as the endpoint
  - Chronic – tests longer-term exposure, and the responses measured include various endpoints such as reproduction, growth, mortality

What Factors Affect the Toxicity of Substances (eg. Metals) in the Aquatic Environment?

BIOAVAILABILITY

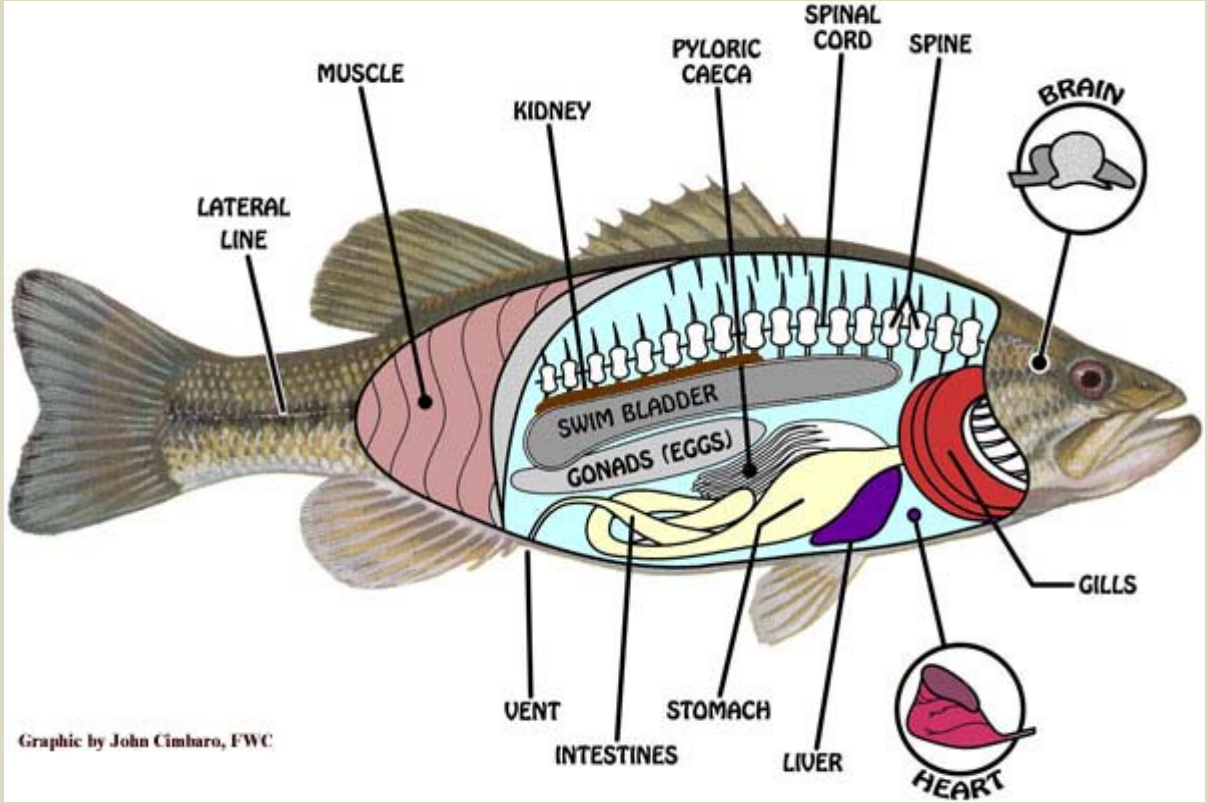
The ease with which a substance can be incorporated into an organism

As(III) vs As(V)

An effect will not be produced unless the substance can interact with the surface or interior of an organism's cells

Toxicity: How Does it Happen?

Toxicants normally have to penetrate through at least one layer of cells to affect organisms



Factors Affecting Toxicity

Biotic

- Age
- Size
- Health
- Taxonomic Group

Abiotic

- Temperature
- pH/Alkalinity
- Salinity
- Hardness
- Chemical Mixtures
- Organics
- Particulates

Biotic - Age, Size, Health

- Life stage and body size: larval fish = more sensitive than adult fish; eggs = most resistant
- Small animals: larger surface area = faster chemical uptake per unit weight
- Age: smaller + less developed immune systems or detoxifying systems + unhealthy or old organisms
- Young and small species: higher metabolic rates = increase in toxicant intake

Biotic - Taxonomic Group

- In general, metal contaminant sensitivity:

arthropods > fish > larval amphibians > algae and macrophytes

- daphnids are usually among the most sensitive crustaceans
- salmonids are usually the most sensitive fish

Abiotic - Temperature

- Metabolism ↑ twofold every 10°C
- Increase in respiratory rates, chemical absorption, detoxification, and excretory rates
- Increased temperatures can lead to increased membrane permeability at the cellular level and effects on enzyme activity, i.e. increased toxicity

Abiotic - pH/Alkalinity

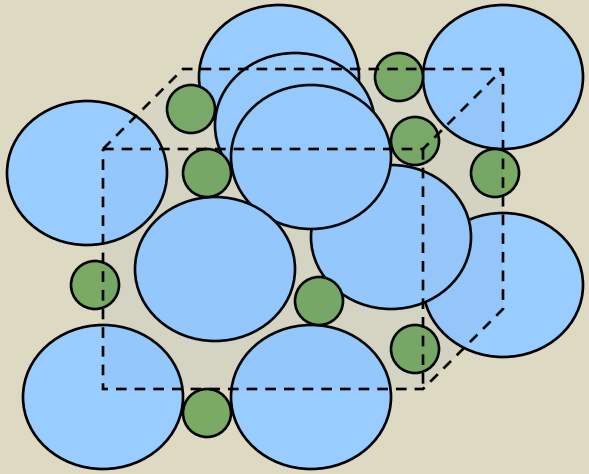
↑ in H+ ions (low pH) =

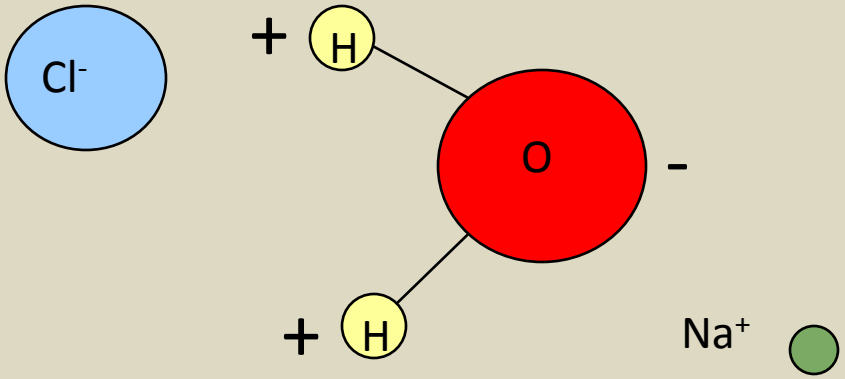
- ↑permeability of an organism's membrane
- affects the speciation of metals
- ↑ metals in solution (from metal leaching)

- Buffering Capacity/Alkalinity
  ability to counter the acidity

} In NWT - high or low?

Abiotic - Salinity





- ↑in salinity generally =↓ in toxicity
- More toxic or bioavailable chemical species is favoured in freshwater (eg. cadmium, copper, silver, and zinc)
- Salts will act with some metals to form complexes that are less bioavailable

Abiotic - Hardness

- Soft = 0-75 mg/L $CaCO_3$ equivalents
- Hard = >150 mg/L $CaCO_3$ equivalents

- Generally = more toxic effects in soft waters than hard waters
- Chemical complexes or dilution effect when competing for access across organism membranes

Abiotic - Chemical Mixtures

- Additive
  the effect of A + effect of B = A + B
- Synergistic
  the effect of A + the effect of B > A + B
- Antagonistic
  the effect of A + the effect of B < A + B

- Both substances may act on the same receptor, or they may compete for the same receptor
- One chemical/group may affect the speciation of another
- One chemical/group may alter the membrane permeability

Abiotic - Organics/Particulates

- Dissolved organic carbon can reduce toxicity of some metals
  - Other factors may alter behaviour and affect toxicity
- Metals may either react with or sorb onto the surface of DOC particulates
- If organisms aren't ingesting the particulates, this may reduce bioavailability

Summary

- Water is never just dihydrogen oxide – it is affected by a range of modifying factors
- Toxicity of single and mixtures of parameters is complex, and we use bioassay tests as one measure of overall potential to cause harm
- To protect Northern waters, we must keep improving on our understanding of the natural systems, and of the site-specific conditions that affect how contaminants behave

Any questions?