

## The Physical Environment

- I. Light
- II. Thermal Environment
- III. Water
- IV. Elemental Nutrients

## A view of the Earth - Day & Night



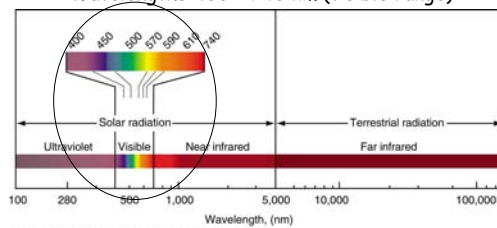
Satellite data provided by [The Living Earth](#)® Inc./Earth Imaging  
© 1996, All Rights Reserved.

## I. Light

- A. Nature of Light
- B. The fate of Light
- C. Leaf Area Index and Extinction Coefficient

## I. Light

- A. Nature of Light
  - Components of light:
    - Wavelengths 400 - 740 nm (visible range)



Copyright © Benjamin Cummings, an imprint of Addison Wesley Longman

## I. Light

- A. Nature of Light
  - Components of light:
    - Wavelengths 400 - 740 nm (visible range)
    - **Photosynthetically Active Radiation (PAR)**
    - Wavelengths used in photosynthesis
  - Qualities:
    - Intensity, duration, directionality

## I. Light

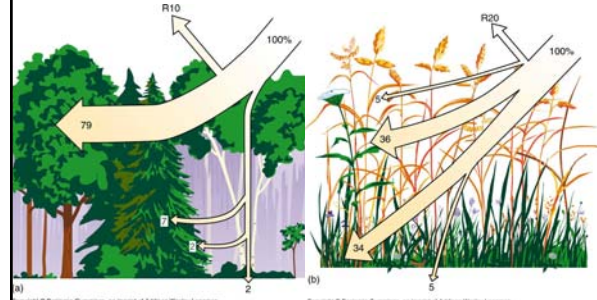
- A. Nature of Light
  - Qualities:
    - Intensity = varies daily and seasonally
      - (depends on angle of incidence)
    - Duration = also seasonal
      - (function of latitude and season)
    - Directionality = shifts daily and seasonal
      - (depends on sun altitude and angle - i.e., North- and South-Facing Slopes)

## I. Light

### B. Fate of Light

- Absorption, Reflection, and Transmission (in plants)
  - Most (70%) infrared WL reflected, only 6-12% of PAR reflected (varies with leaf type)
  - Most visible radiation (PAR) is absorbed (~70% used for photosynthesis)
  - A remaining fraction is transmitted through the leaf (depending on thickness and structure)

## Attenuation of radiation



## I. Light

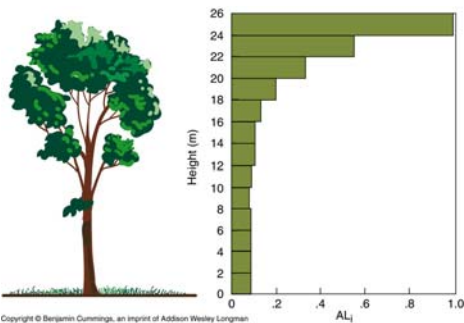
### C. Leaf Area Index and Extinction Coefficient

- **Photons**: transport light (in bundles)
- The amount or availability of light depends on the amount of canopy cover (i.e., vegetation cover)
- Canopy cover is a function of leaf quantity or foliage density
- **Leaf Area Index (LAI)**: quantify the changes in light environment with increasing foliage density
  - Area of leaves per unit of ground area
  - $LAI = m^2 \text{ leaf area} / m^2 \text{ ground area}$
  - $\uparrow LAI = \downarrow$  light availability (Beer's Law)

## I. Light

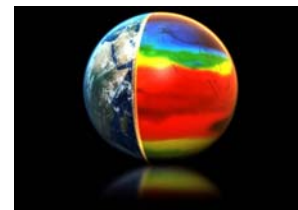
### C. Leaf Area Index and Extinction Coefficient

- Beer's Law:  $AL_i = e^{-LAI_i(k)}$
- **Light Extinction Coefficient (k)**: measures the degree to which leaves absorb and reflect light



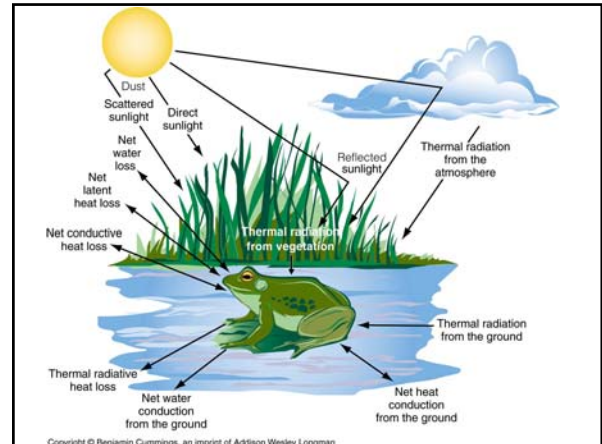
## II. Thermal Environment

- A. Temperature
- B. Thermal Energy Exchange



## II. Thermal Environment

- A. Temperature
  - **Heat**: form of energy possessed by all substances that results from the random motion of molecules
  - **Temperature**: average kinetic energy possessed by individual molecules of a substance
    - Influenced by solar radiation
  - **Eurytherms**: organisms capable of withstanding wide temperature ranges
  - **Stenotherms**: organisms restricted to a more narrow temperature range



## III. Water

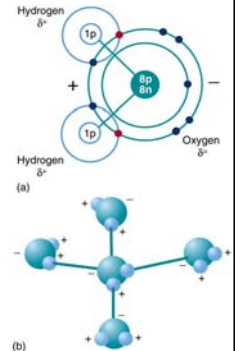
- A. The Structure of Water
- B. Physical Properties
- C. The Water Cycle
- D. The Local Water Cycle



## III. Water

### A. The Structure of Water

- $H_2O$
- Polar molecule
  - "Sticky" electrostatic bonds
  - Water is adhesive & cohesive
- Lattice-like arrangement most highly organized when frozen



## III. Water

- A. The Structure of Water
- B. Physical Properties
- C. The Water Cycle
- D. The Local Water Cycle



## III. Water

- A. The Structure of Water
- B. Physical Properties
  - High **specific heat** → water can store large quantities of heat; only exceeded by few other liquids (i.e., ammonia)
  - High heat of fusion & evaporation (θ 100°C)
  - Approx. 80 calories for  $H_2O$  to go from ice to liquid (@ 0°C) & ~536 calories to go from liquid to vapor (@ 100°C)

### III. Water

- A. The Structure of Water
- B. Physical Properties
  - **Cohesion**: the holding together of like substances (hydrogen bonds)
  - **Adhesion**: the holding together of unlike substances (polarity of molecule)
  - **Capillarity**: ability to move through pores (infiltration)
  - Water molecules are repelled by nonpolar molecules (i.e., oil)

### III. Water

- A. The Structure of Water
- B. Physical Properties
  - **Surface tension**: due to molecular cohesion (can form a barrier/support → elastic membrane)



- Creates an entire system
- Neuston = Organisms that live in the surface tension (waterfilm)

### III. Water

- A. The Structure of Water
- B. Physical Properties
  - High **Viscosity**: property of a fluid that resists the force within the fluid that causes to flow (source of frictional resistance to objects moving through water)
  - "thickness"

### III. Water

- A. The Structure of Water
- B. Physical Properties
- C. The Water Cycle
- D. The Local Water Cycle



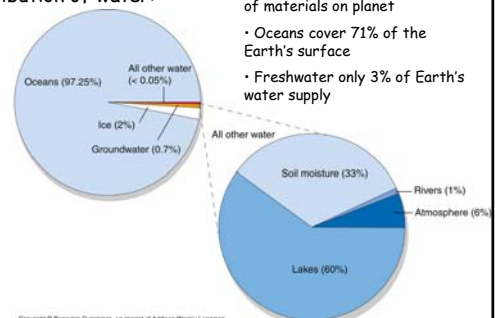
### III. Water

- A. The Structure of Water
- B. Physical Properties
- C. The Water Cycle
  - Distribution of water:
    - Vapor
    - Fresh surface water (streams and lakes)
    - Groundwater
    - Snow and ice
    - Salt water (oceans)
    - Water inside the bodies of organisms

### III. Water

#### C. The Water Cycle

#### Distribution of water:



### III. Water



- A. The Structure of Water
- B. Physical Properties
- C. The Water Cycle
- D. The Local Water Cycle



### III. Water

- A. The Structure of Water
- B. Physical Properties
- C. The Water Cycle
- D. The Local Water Cycle
  - Precipitation → driving force of the water cycle (begins as water vapor in the atmosphere)
  - Interception → retention of rain before reaching the ground → loss via evaporation

### III. Water

- A. The Structure of Water
- B. Physical Properties
- C. The Water Cycle
- D. The Local Water Cycle
  - **Throughfall**: portion of rain intercepted by vegetation that falls to the ground
  - **Stemflow**: portion of rain intercepted by trees that flows down their trunks

### III. Water

- A. The Structure of Water
- B. Physical Properties
- C. The Water Cycle
- D. The Local Water Cycle
  - Rain that reaches the soil moves into the ground by **infiltration** (influenced by soil type, vegetation type, and rain intensity)
  - When soil exceed its infiltration capacity excess water becomes **overland flow**

### IV. Elemental Nutrients

- Chemical elements needed for growth, development, and metabolism
- A. Macronutrients
  - Needed in large amounts
  - C, O, H, N, Ca, P, Mg, K, S, Na, Cl
- B. Micronutrients
  - Needed in much smaller quantities
  - Fe, Mn, B, Co, Cu, Mo, Zn, I, Se
  - essential to all organisms

### IV. Elemental Nutrients

- Sources?
- **Terrestrial**: weathering mineral soils, decomposition of organic matter, N fixation, atmospheric gases, atmospheric deposition, precipitation, ocean salt spray
- **Aquatic**: terrestrial inputs, organic matter, sediment, precipitation