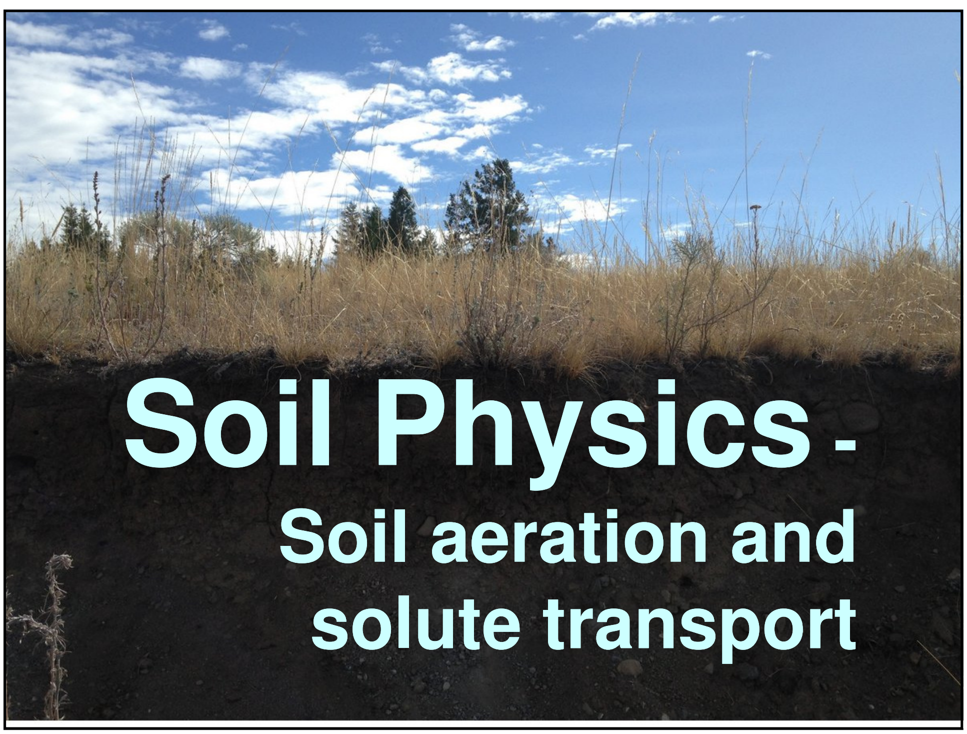

APBI 200
SOIL COMPONENTS


Soil Physics -
Soil aeration and
solute transport

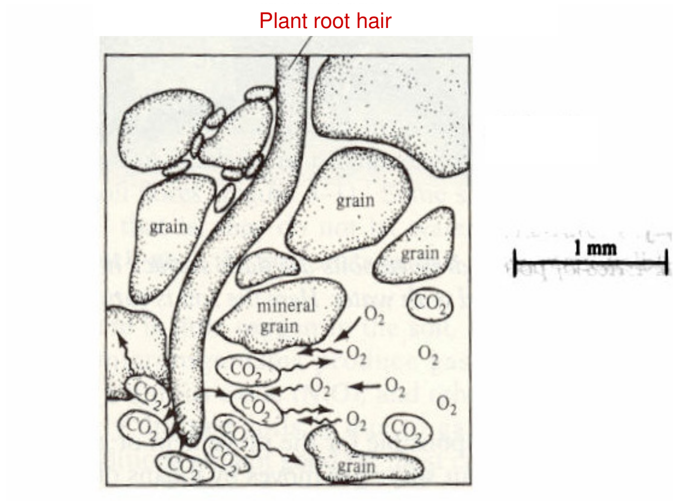
Lecture outline

A. Soil aeration

- A.1. Nature of soil aeration
- A.2. Diffusion

B. Solute transportation processes

CO_2 and O_2 movement in soil



Oxygen availability depends on

- Soil macropores
- Soil water content
- O_2 consumption by respiring soil organisms

- **Atmospheric air contains:**

  0.035% CO_2

  21% O_2

  78% N_2

- **Soil air contains:**

  0.35% CO_2

  ~20% O_2 near soil surface

  ~ 5% O_2 in lower horizons of poorly drained soils

  78% N_2

Poor soil aeration

when >80-90% of the soil pores are filled with water

Gas exchange between atmosphere and soil air is due to

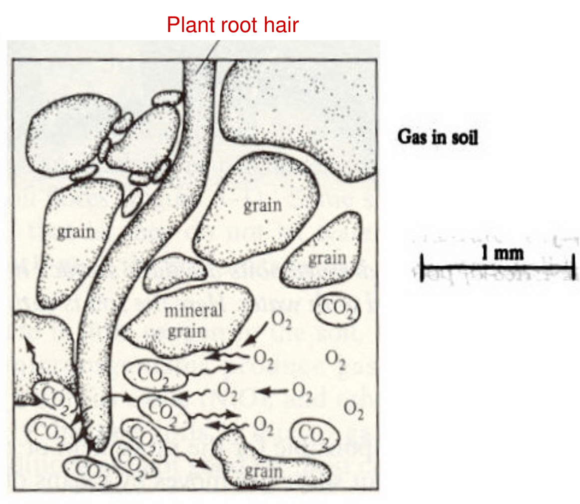
- Mass flow (convection) of air
- Diffusion

Mass flow (convection) of air results in the entire mass of air streaming from a zone of **higher** pressure to one with *lower* pressure.

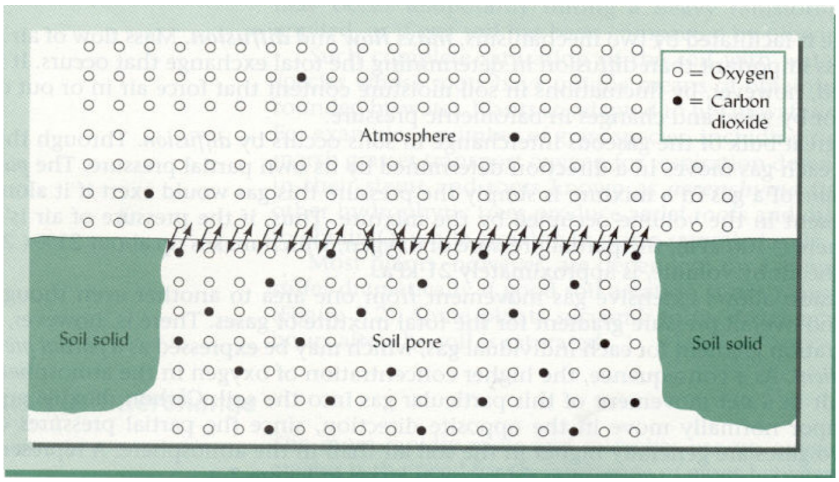
Moving force → gradient of total gas pressure

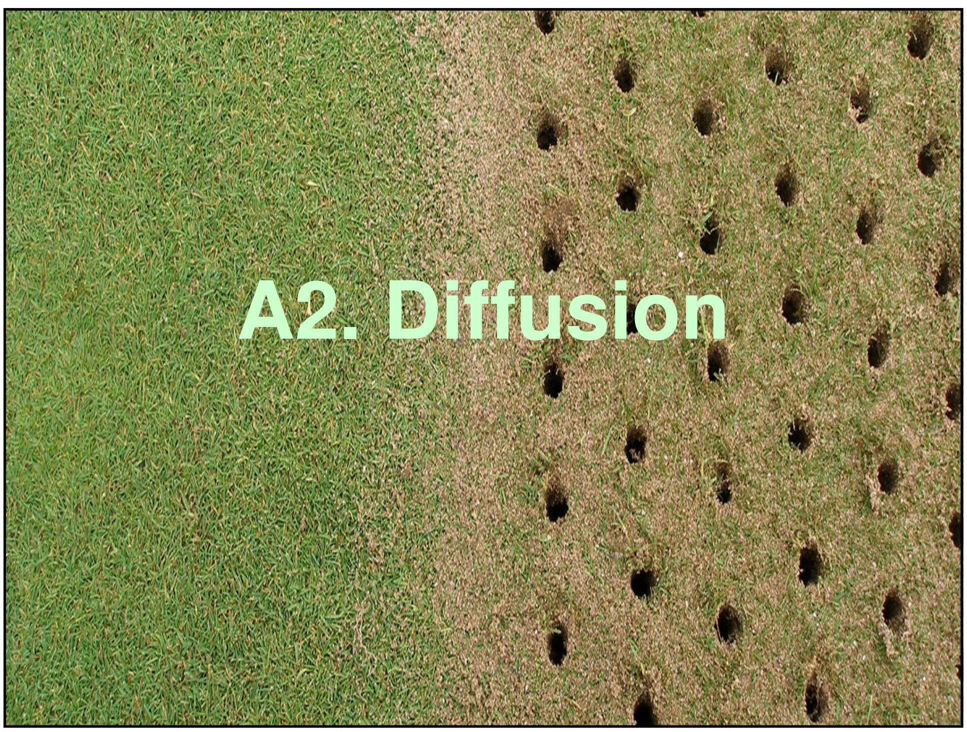
Diffusion – each gas moves in a direction determined by its own partial pressure.

Moving force → gradient of partial pressure of any constituent member of air



CO_2 and O_2 **diffusion** between atmosphere and soil air





Fick's Law of Diffusion

$$J = -D\frac{dC}{dx}$$

J = diffusive flux density of a gas [mg/m^{2}s]
D = diffusion coefficient [m^2/s]
dC/dx = gas concentration gradient [g/m^4]

- **Oxygen flux** is amount of O_2 which crosses a plane per unit time [g of O_2/s]
- **Oxygen flux density** is the O_2 flux per unit area of the plane per unit time [g of O_2/m^2 s]

- The axis of O_2 flow is perpendicular to the plane

Oxygen diffusion coefficient (*D*) for diffusion in air is about 10,000 times as large as the coefficient for diffusion in water.

D is strongly affected by soil water content

Solutes (substances dissolved in the solvent) in soil solution are translocated by:

- Mass flow
- Diffusion

Mass flow - due to solution concentration gradient the entire mass of soil solution moves from **higher** to *Lower* concentration zone

Diffusion of solutes means that each type of solutes moves in a direction determined by its own concentration gradient

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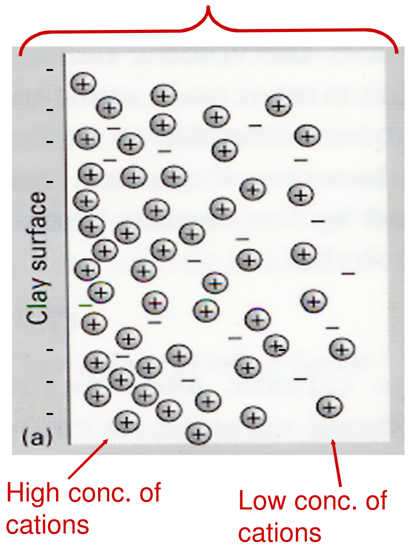
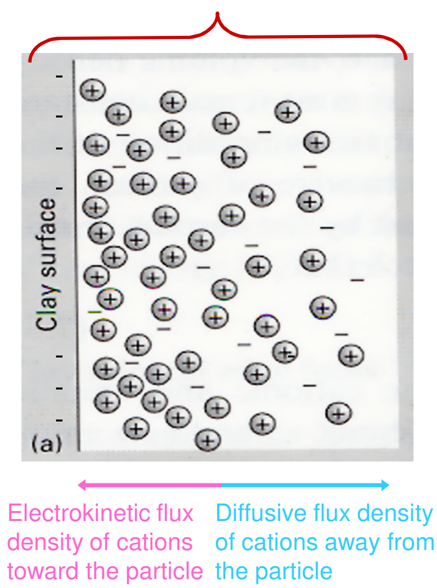
Diffuse double layer (DDL)



A third type of nutrient (solute) movement occurs near electrically charged surfaces of soil colloids (e.g. clay).

Solute movement is along the electrical potential gradients imposed by charged surfaces (and is caused by Coulombic forces).

Diffuse double layer (DDL)



The electrostatic (Coulombic) attraction of cations by the charged clay surface is counteracted by diffusion.

A steady state is reached when the electrokinetic flux density of cations toward the clay particle is balanced by the diffusive flux density of cations away from the particle.

Thickness of diffuse double layer (DDL) depends on:

- Concentration of soil solution
- Valence of attracted ions
- Cation size (hydration radius)

Particle with a **thick DDL** tends to stay **DISPERSED**

Particle with a **thin DDL** is susceptible to **FLOCCULATION**