



Introduction to Photocatalysis

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Environmental Pollutions

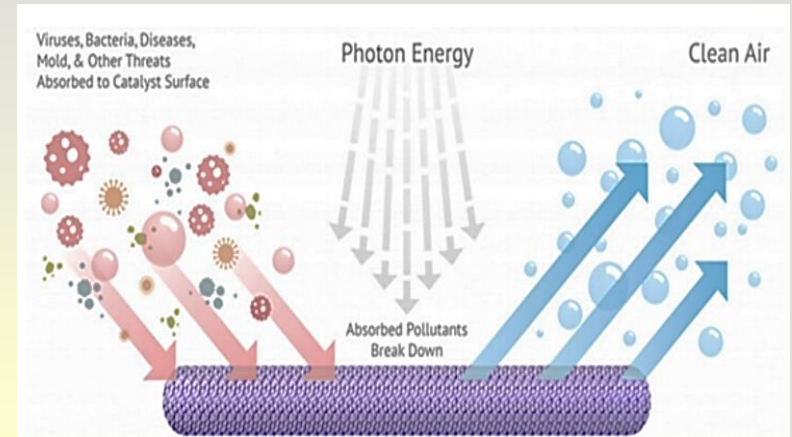
➤ Atmosphere pollution

- ❖ Green house effect (CO_2)
- ❖ Acid rain

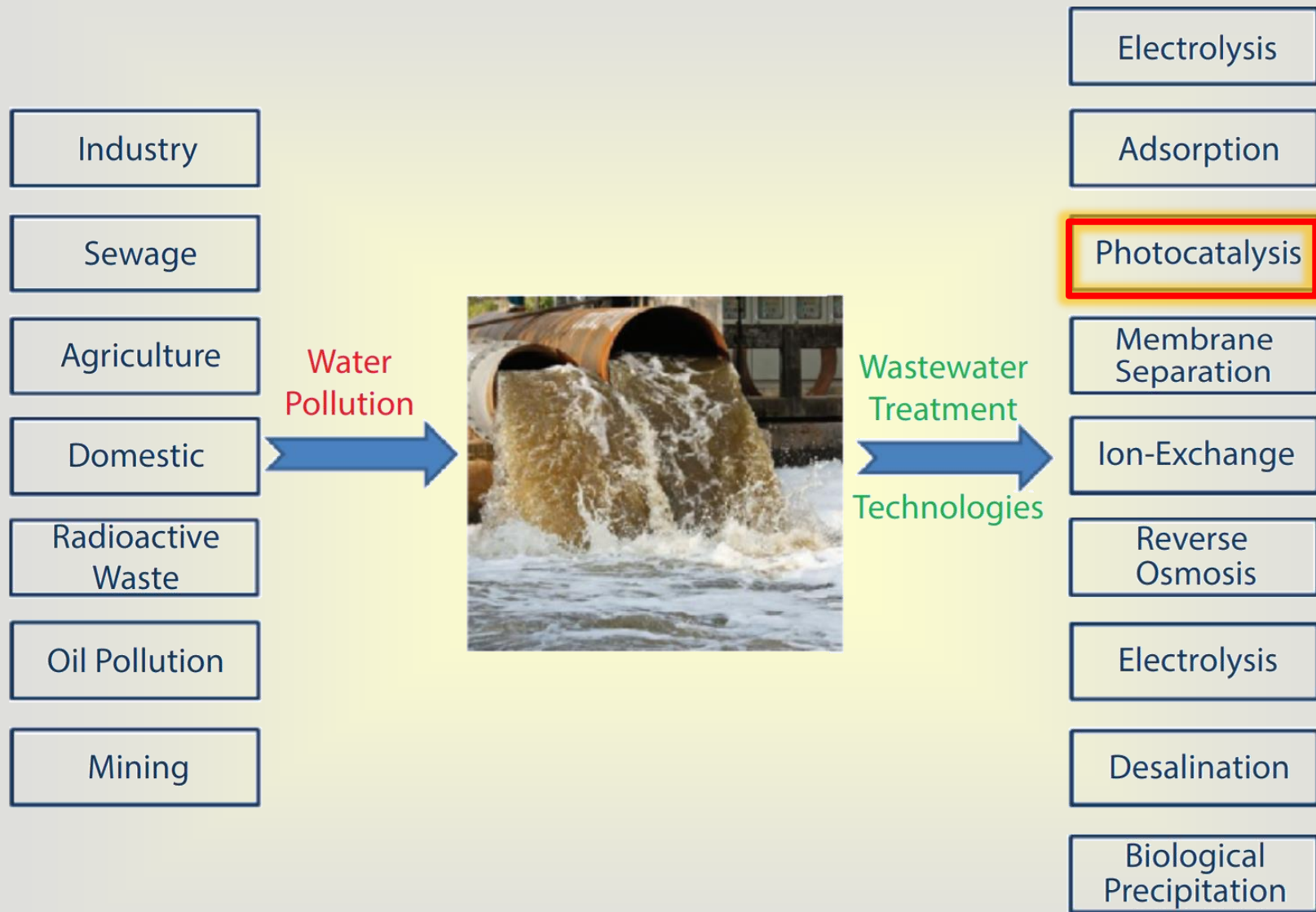
➤ Water pollution

➤ Soil pollution

➤ Burning fossil fuels

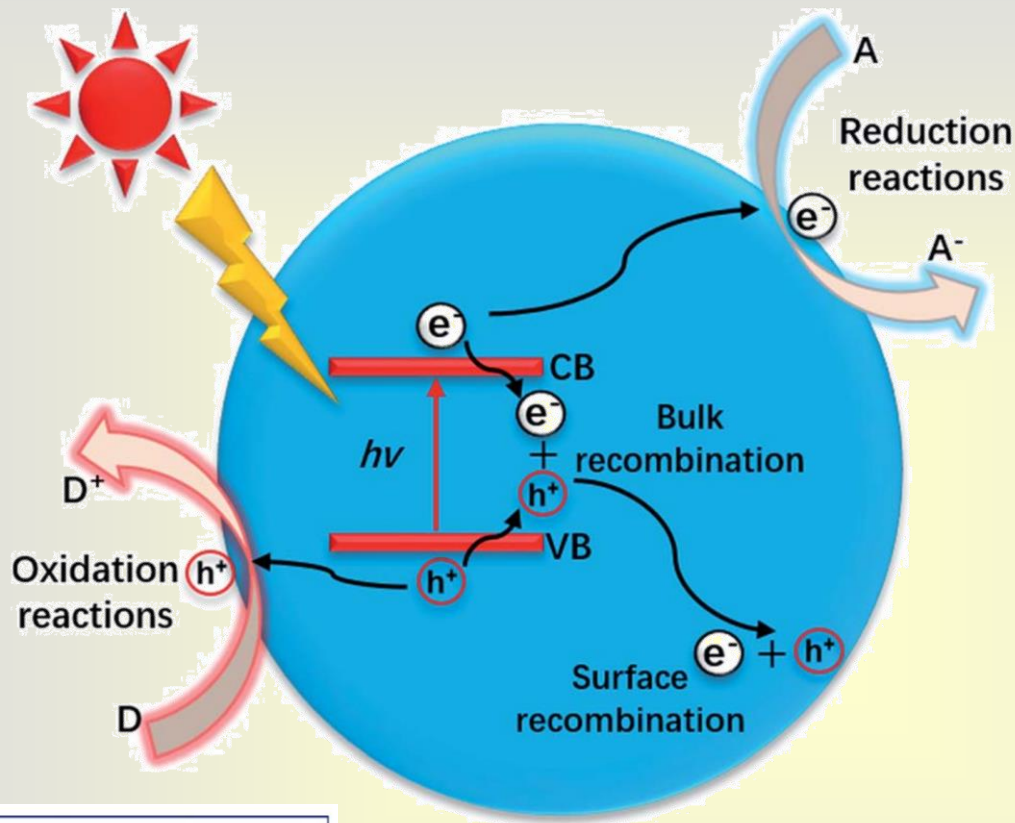


Water Pollution

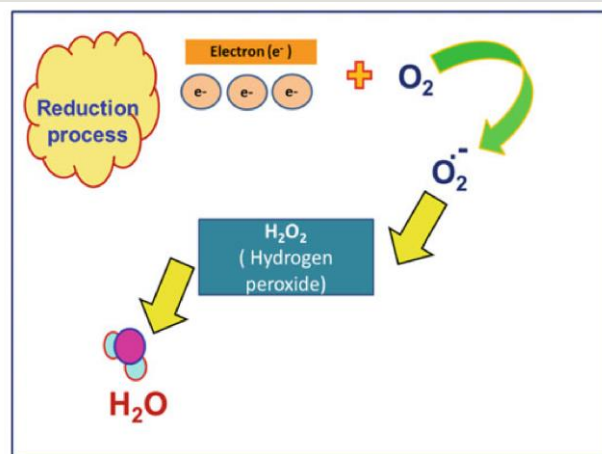


Various sources of water pollution along with different technologies to clean the wastewater.

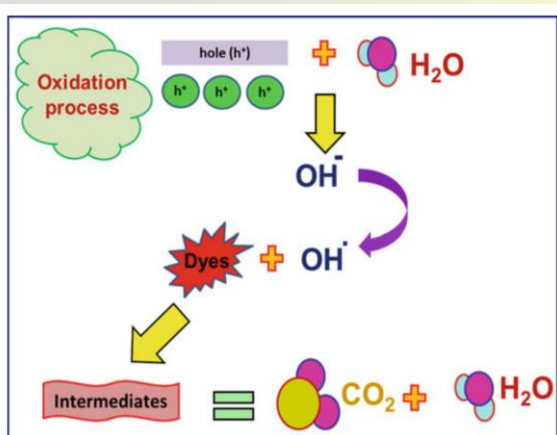
What is Photocatalysis?



Photocatalyst



Schematic representation of reduction mechanism



Schematic representation of oxidation mechanism

Photo: Light

Catalysis: using a **catalyst**

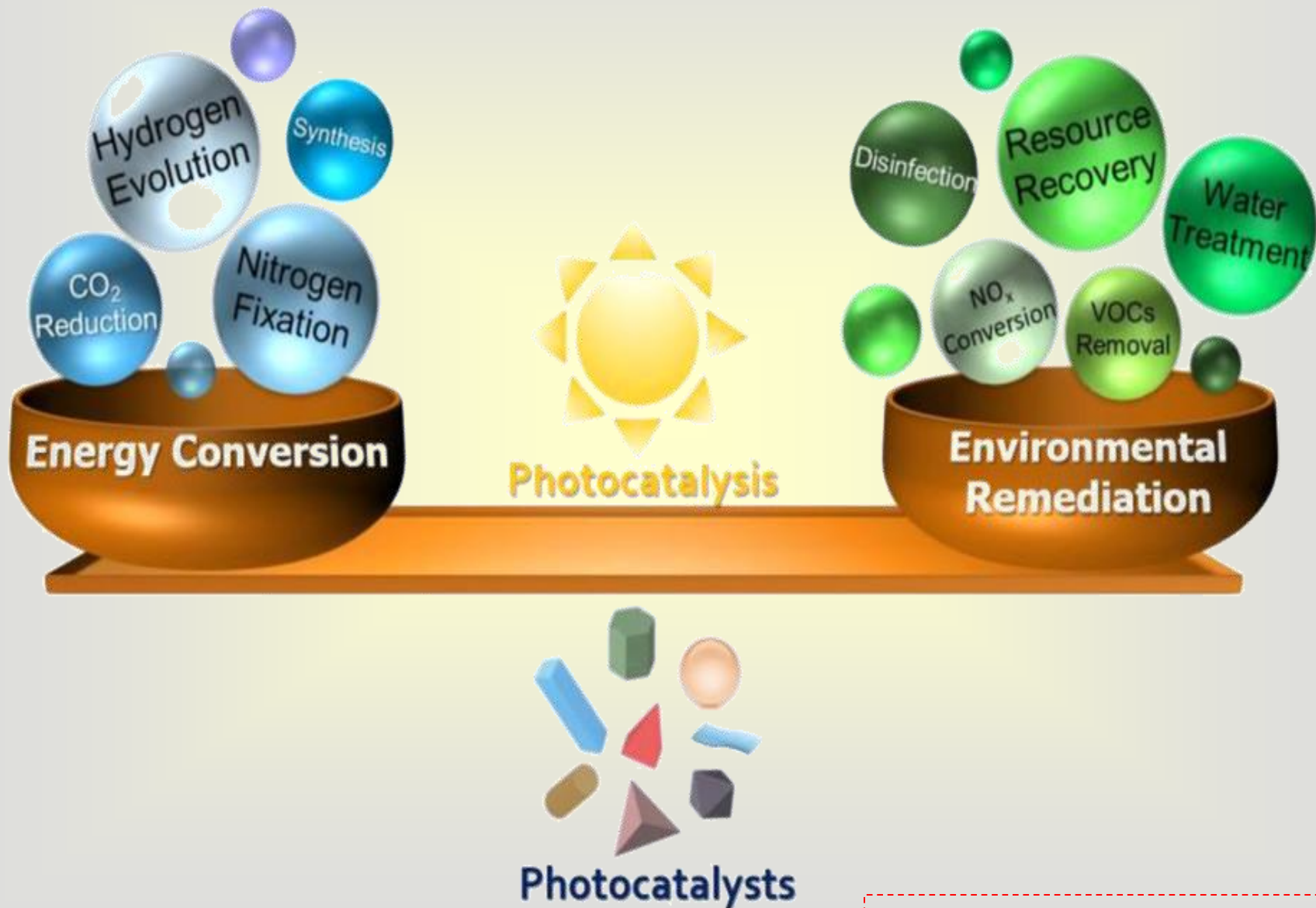
Catalyst: Decreases activation energy to speed up a reaction

Photocatalysis: Speed up reactions using a light source and a catalyst

J. Mater. Chem. A, 9, 2021, 17143–17172.

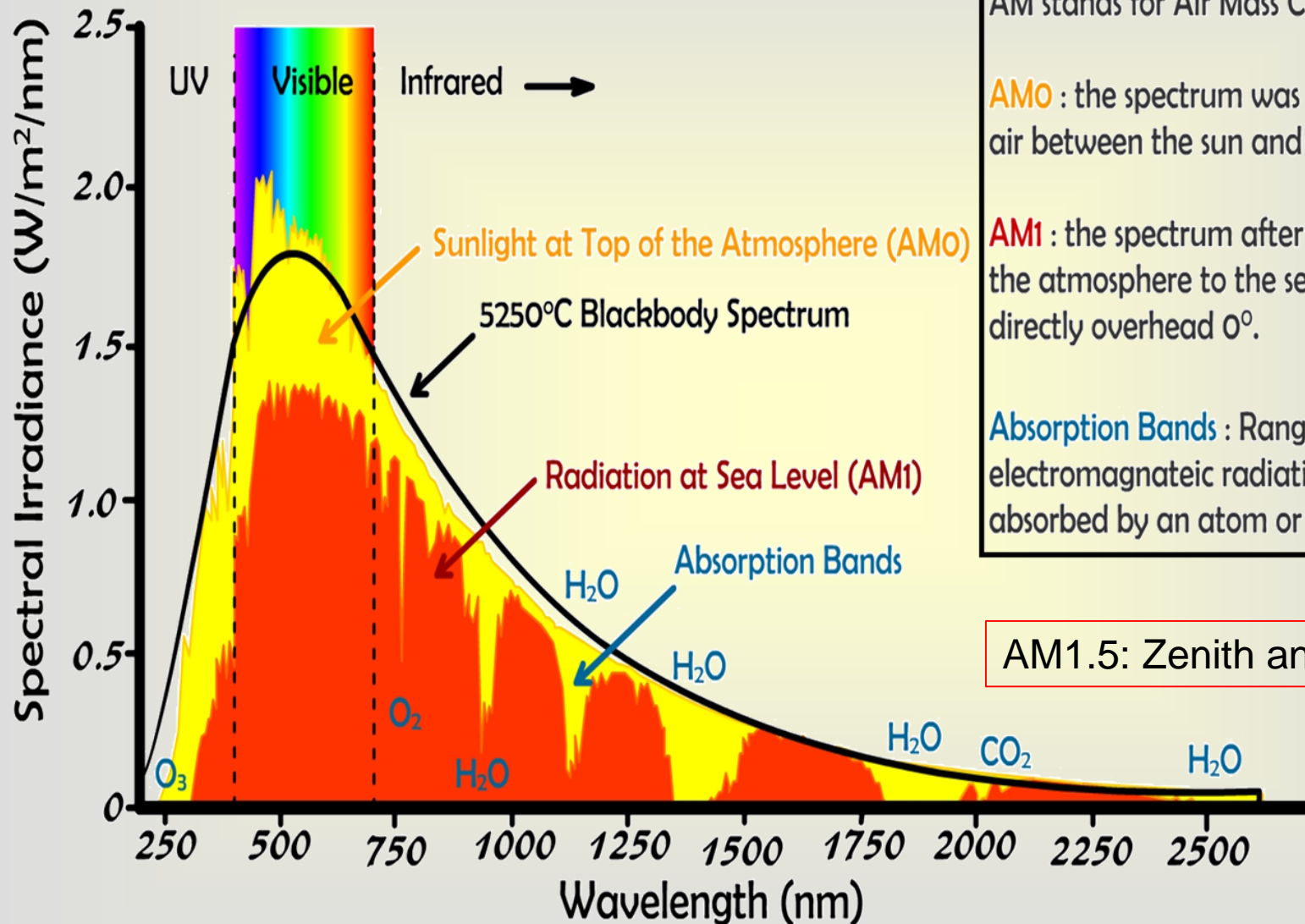
Nanocomposites for Visible Light-induced Photocatalysis, Chapter 2, 2017

Balance on Photocatalysis





Solar Radiation Spectrum



AM stands for Air Mass Coefficient

AM0 : the spectrum was measured with no air between the sun and the receiver.

AM1 : the spectrum after travelling through the atmosphere to the sea level with sun directly overhead 0° .

Absorption Bands : Range of electromagnetic radiation that had been absorbed by an atom or molecule

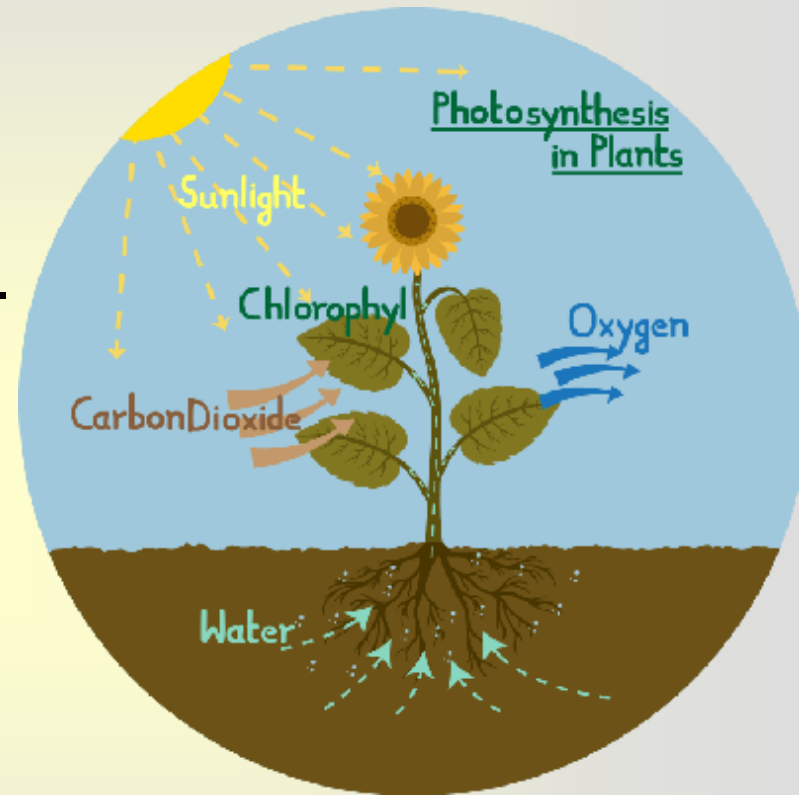
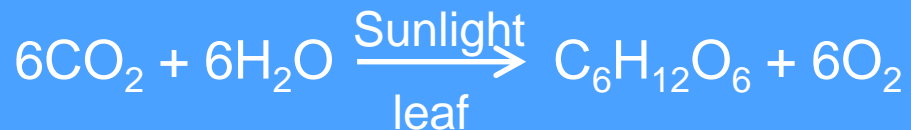
AM1.5: Zenith angle $\sim 48.2^\circ$

Photosynthesis vs Photocatalysis

How to Utilize Solar Energy

Photosynthesis

- Green plant is the best example.
- Photosynthesis fuels life on earth.
- Two main reactions:
 1. Water splitting into oxygen
 2. Carbon dioxide into glucose



Source: google image

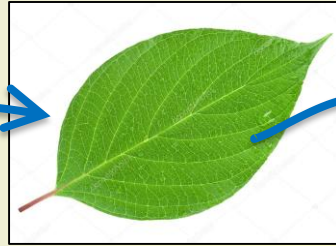
- Green plants convert solar energy into chemically stored energy.

How Does Photosynthesis Take Place ?

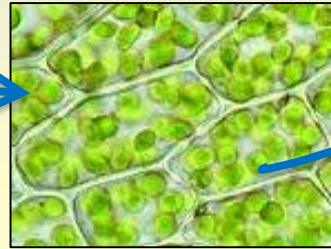
The photosynthesis process is a two-stage, multi-step process.



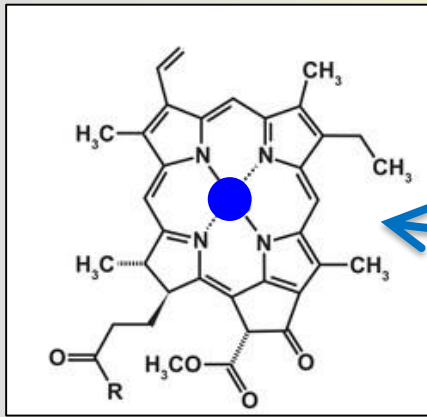
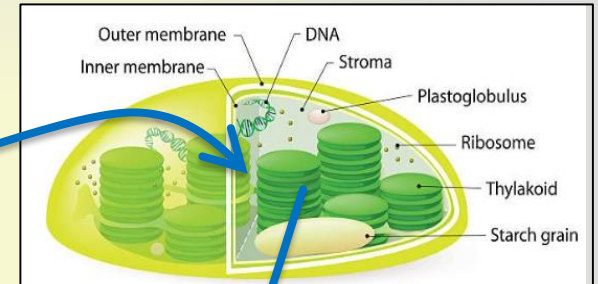
tree



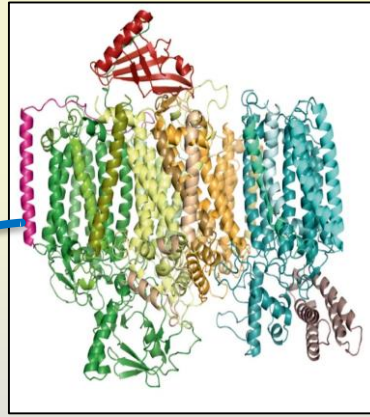
leaf



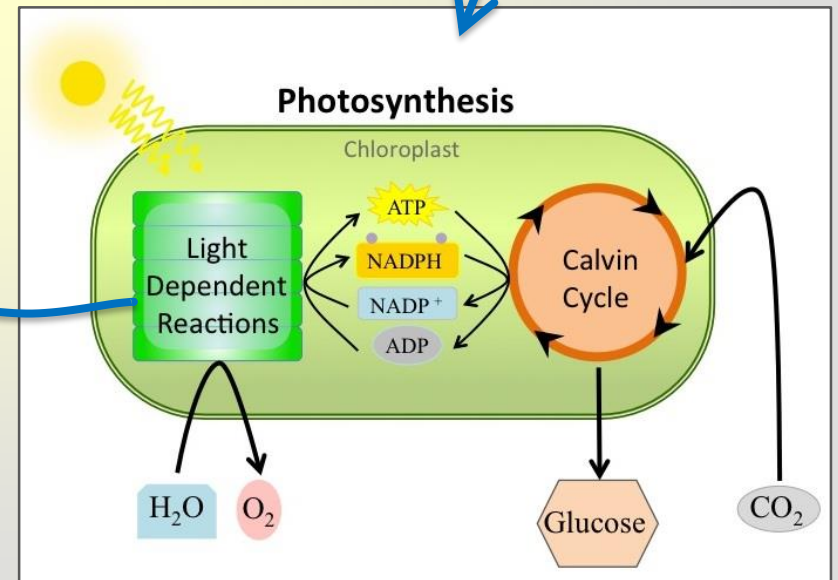
chloroplast



light absorber

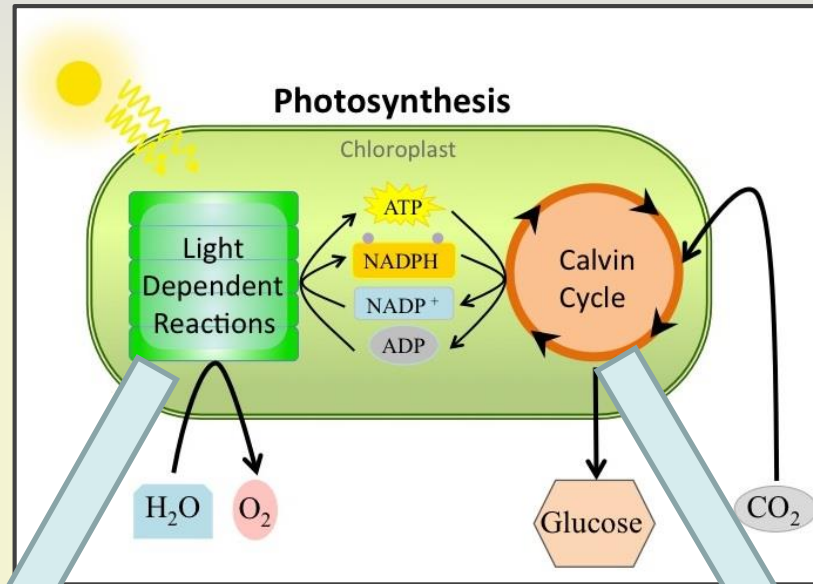


molecular machine



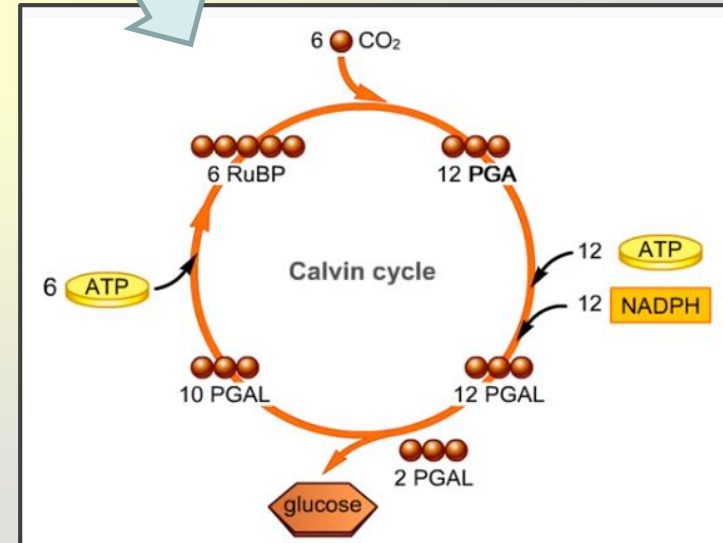
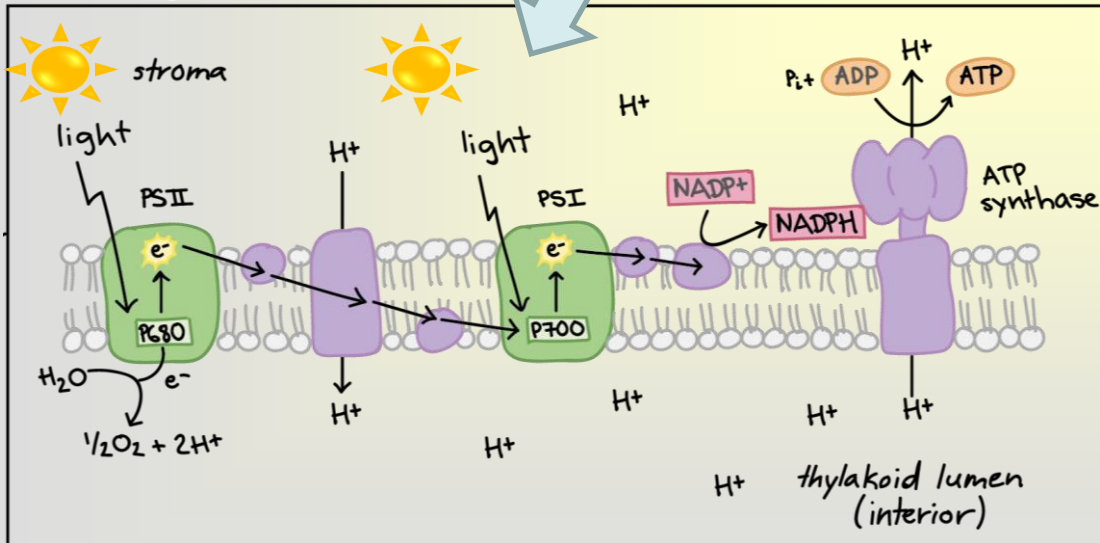
Understanding Photosynthesis

The photosynthesis process is a two-stage, multi-step process.



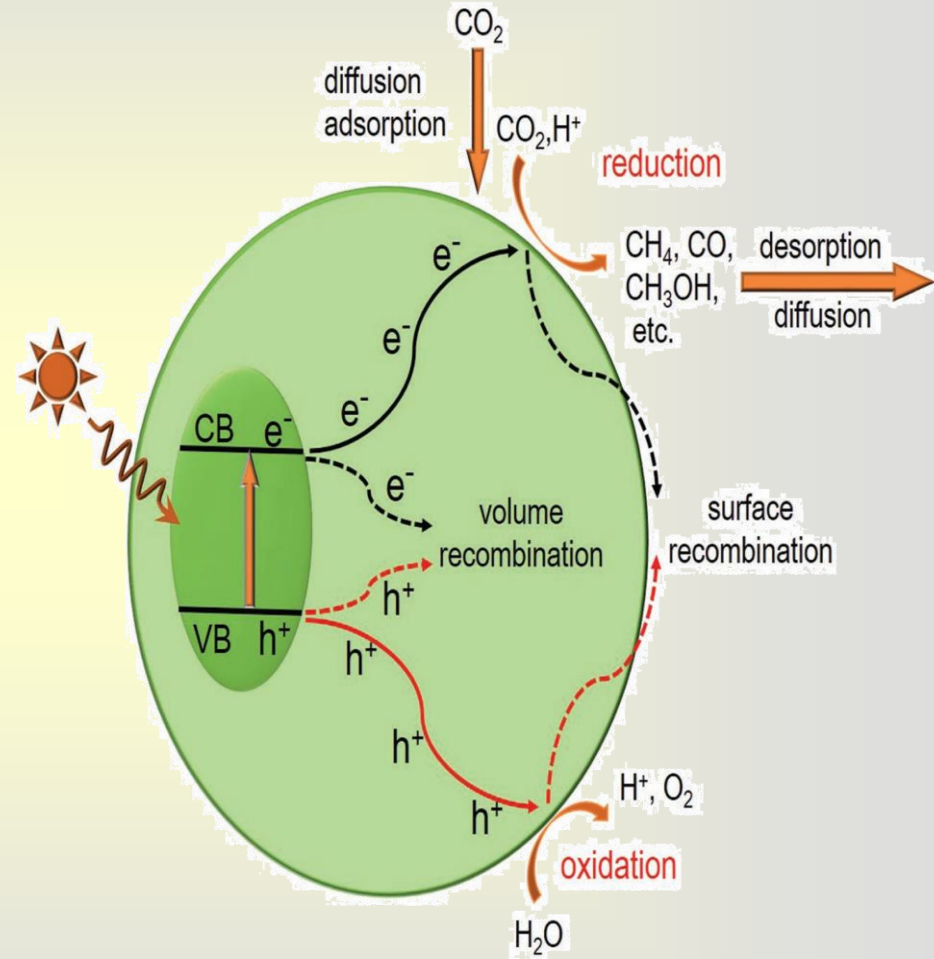
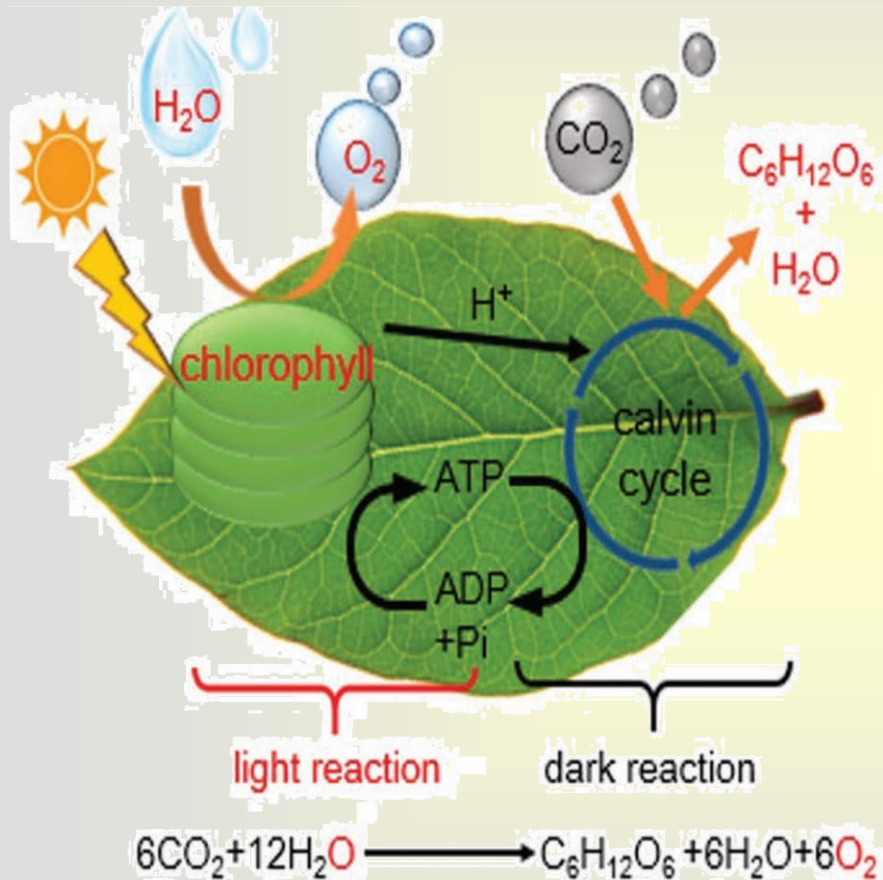
Light dependent

dark



Source: google image

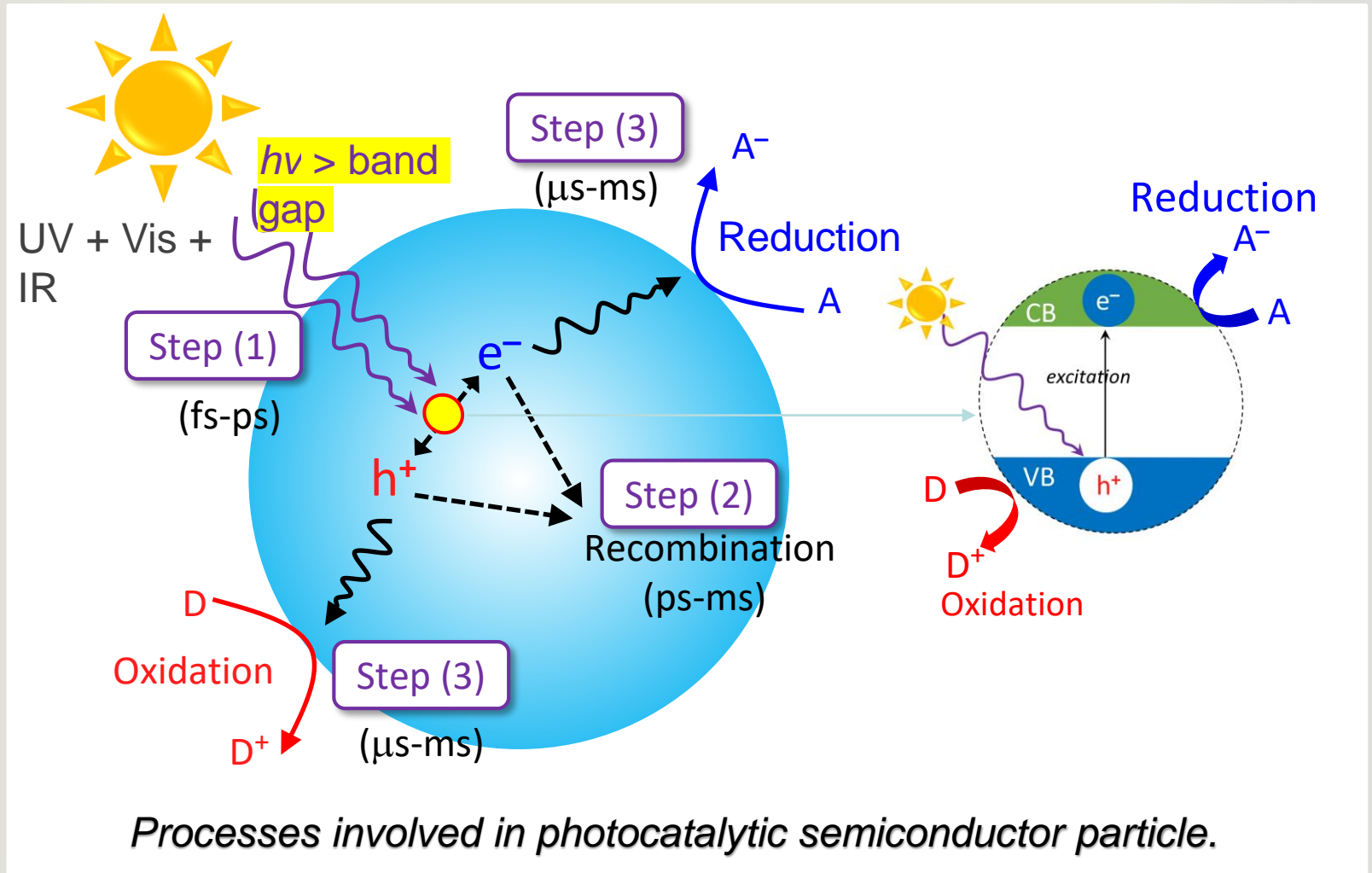
Natural Photosynthesis vs Artificial Photocatalysis



Photocatalysis: Artificial Photosynthesis

How a Photocatalyst Works ?

Fundamental Principles for Efficient Photocatalysis Systems



Better charge transfer and lower recombination are good for catalysis reaction.

Four Steps of Photocatalysis

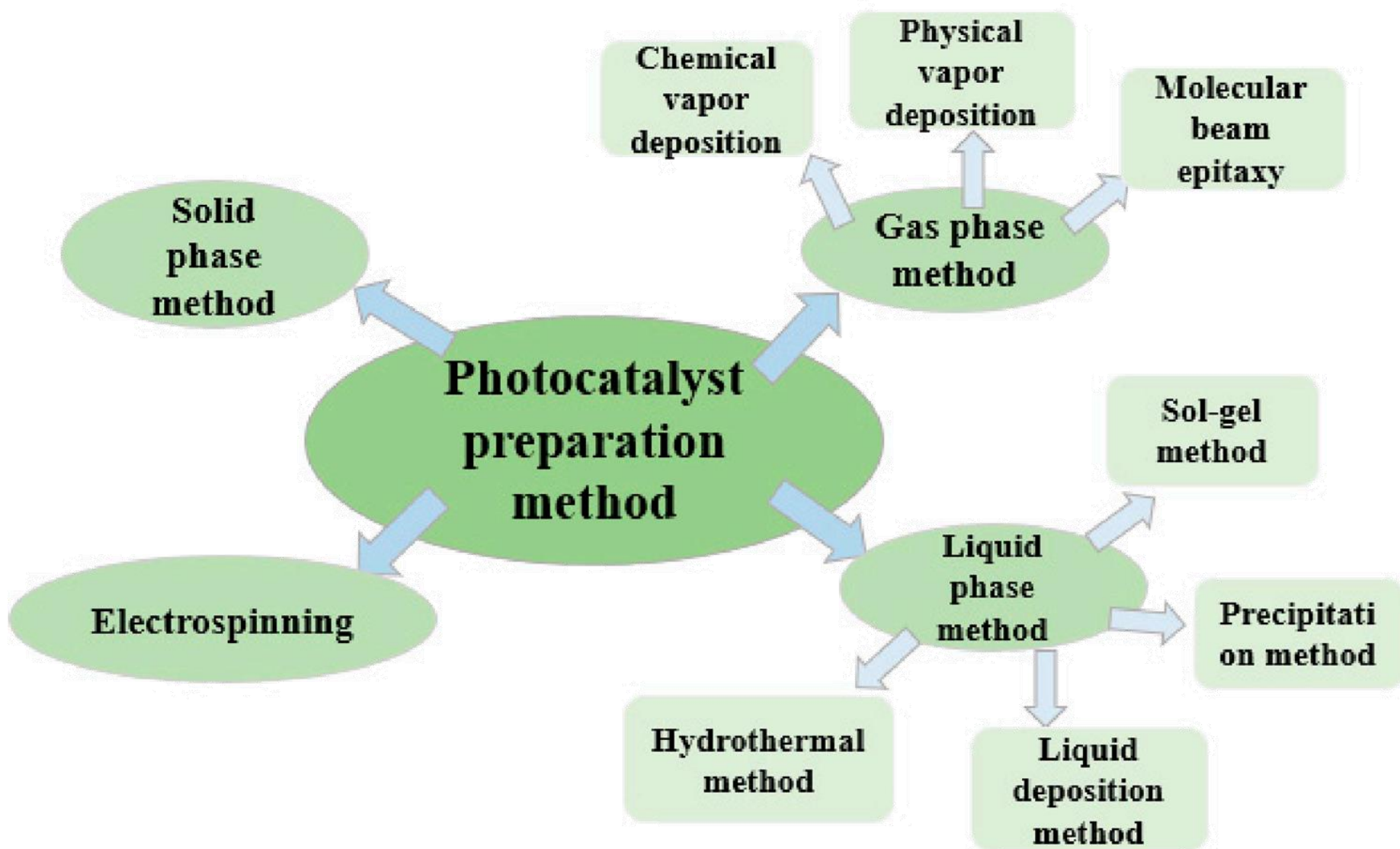
- **First Step:** Absorption of photons to generate electron-hole pairs.
 - Ideal band gap is 1.8-2.0 eV
- **Second Step:** Special separation of photogenerated electrons and holes.
 - Longer carrier lifetime and reduced charge recombination.
- **Third Step:** Pollutant adsorption (e.g., for CO₂ reduction).
 - Larger surface areas with more active sites for CO₂ adsorption.
- **Fourth Step:** Surface redox reaction.
 - Determined by external quantum efficiency (EQE) and solar-to-fuel conversion efficiency (SFE).

Types of Photocatalysts

Examples:

- Metal oxides (TiO_2 , ZnO , BiVO_4 , Fe_2O_3 , CeO_2)
- Metal sulfides (CdS , SnS_2 , MoS_2)
- Inorganic perovskite oxides (CaTiO_3 , SrTiO_3 , BiWO_6)
- Inorganic perovskite halides (MAPbI_3 , CsPbI_3 , Cs_2SnI_6 , $\text{Cs}_3\text{Bi}_2\text{I}_9$)
- Metal-free 2D materials ($\text{g-C}_3\text{N}_4$, GO/rGO , Mxene , Black phosphorus)
- Metal-organic frameworks (MOFs)
- Covalent-organic frameworks (COFs)

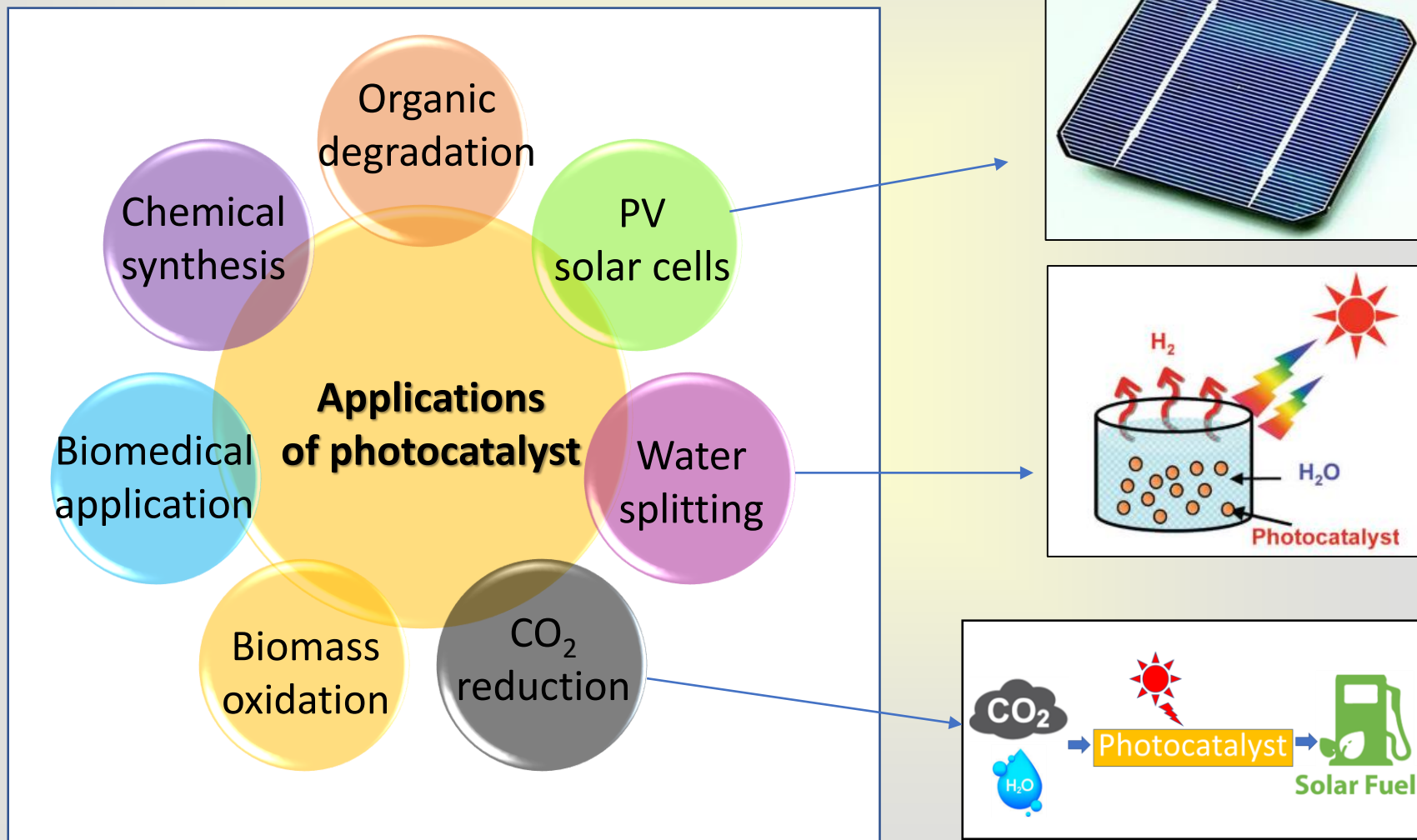
Photocatalyst Preparation Methods



Applications for Photocatalysts

Applications of Photocatalysts

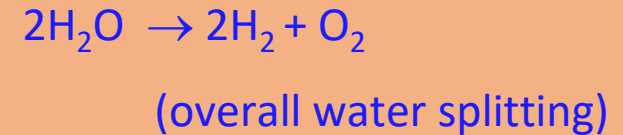
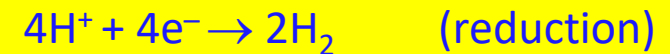
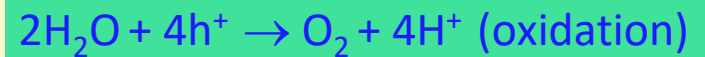
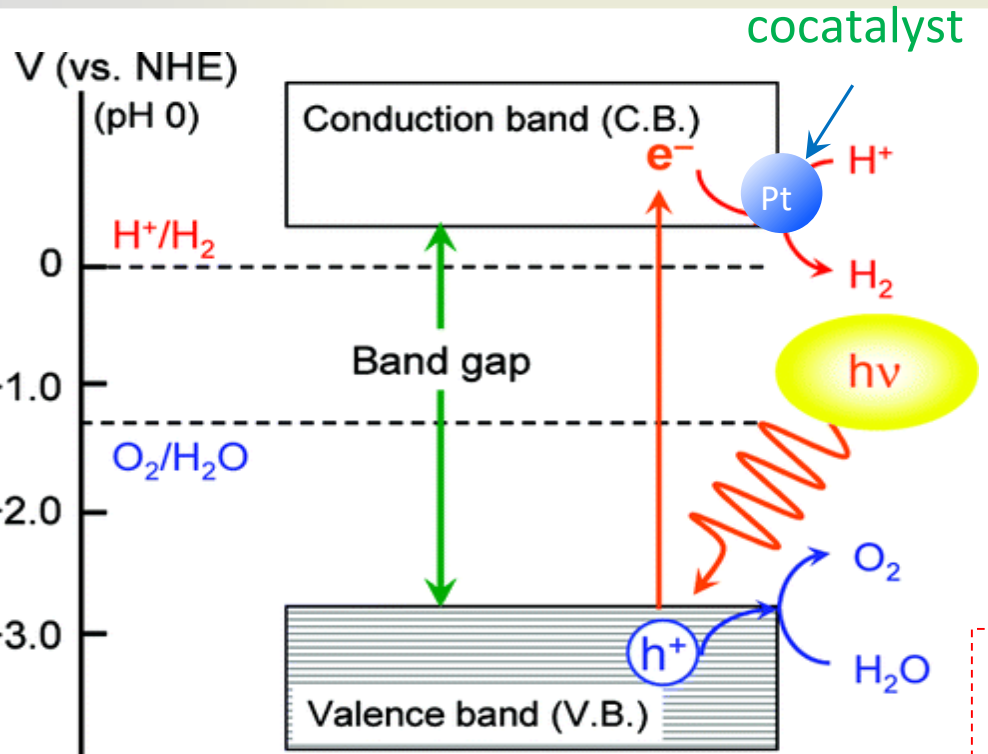
Photocatalysts have several potential applications.



Source: google image

Photocatalytic Water Splitting for H₂ Evolution

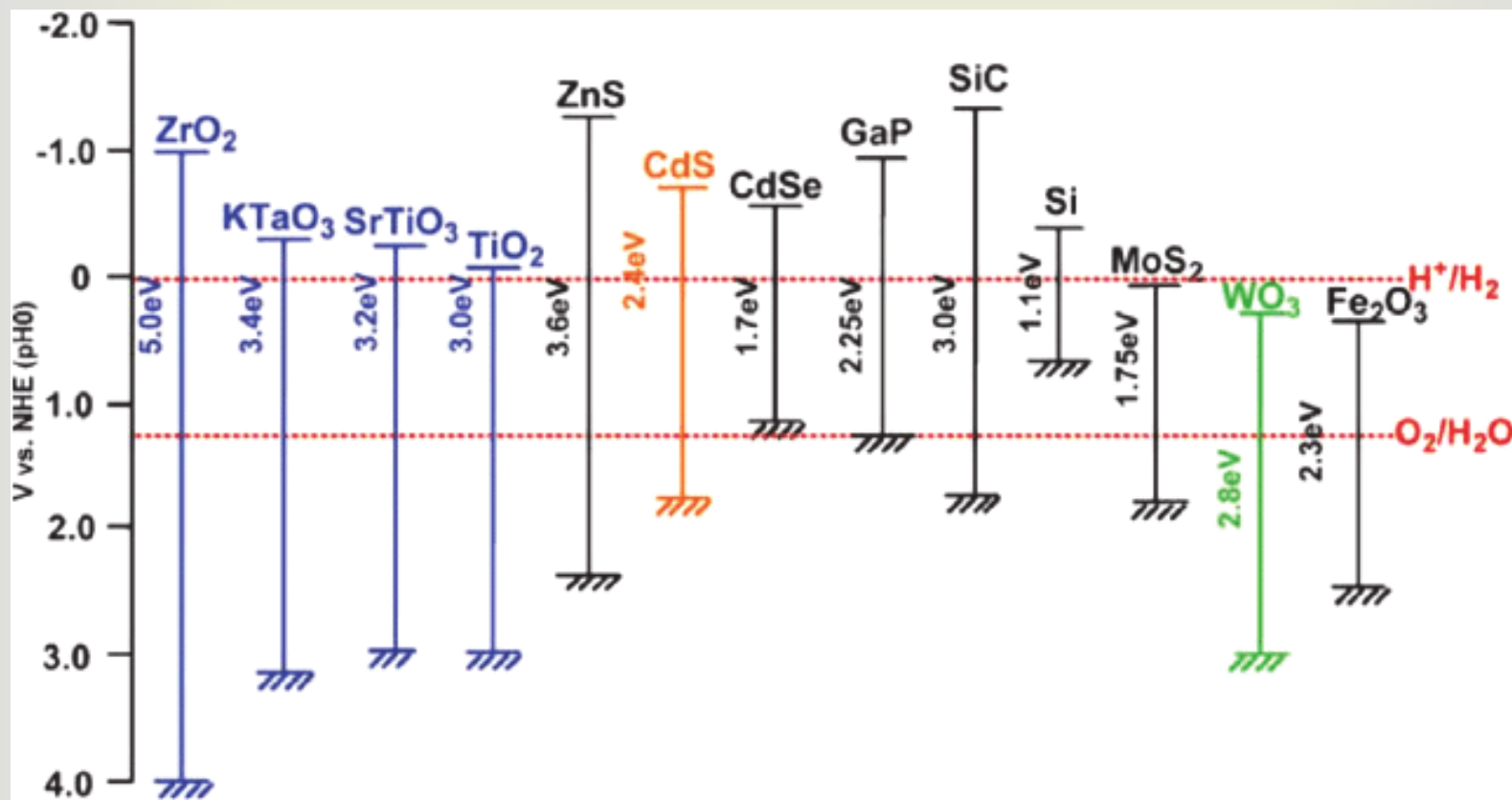
Basic principle of overall water splitting on a photocatalyst.



Hole scavenger:
TEOA, methanol, Na₂SO₃, Biomass,...

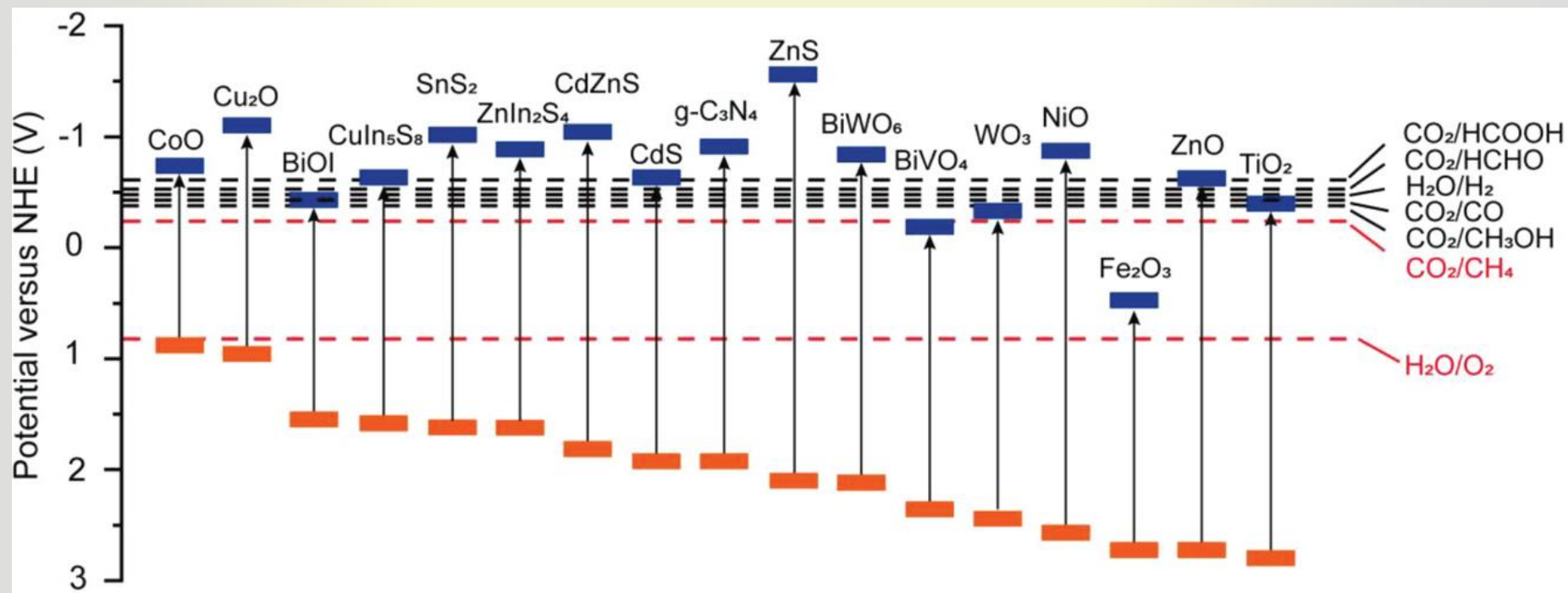
1. Recombination of photogenerated electrons and holes
2. The back reactions of the products
3. **Bottleneck of water oxidation**

Band Structures of Photocatalysts for Water Splitting



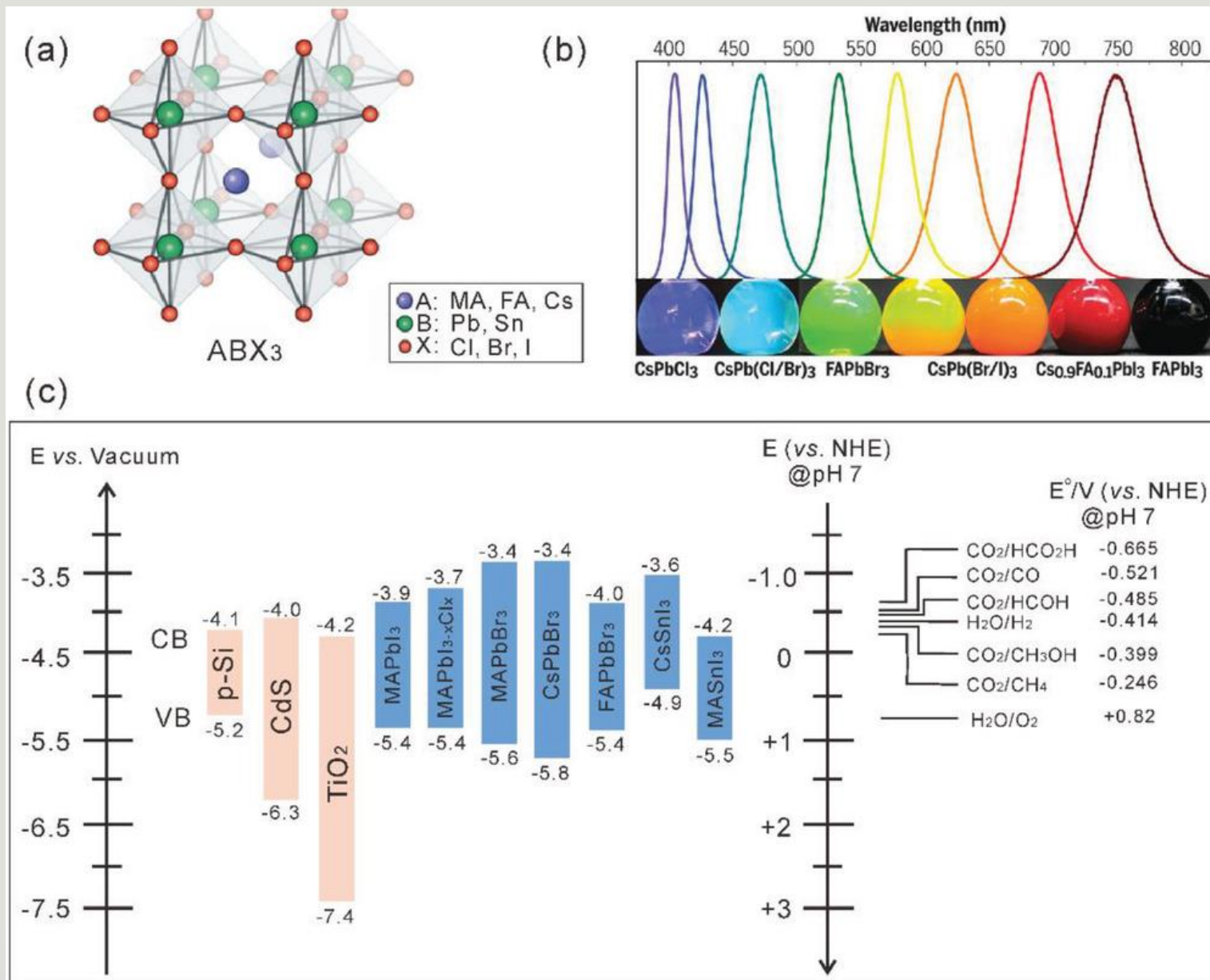
Relationship between band structures of semiconductors and redox potentials for water splitting.

Band Structures of Photocatalysts for CO_2 Reduction



Relationship between band structures of semiconductors and redox potentials for CO_2 reduction.

Halide Perovskites for CO₂ Reduction



(C)fuul



Thanks