

Quantum Dots

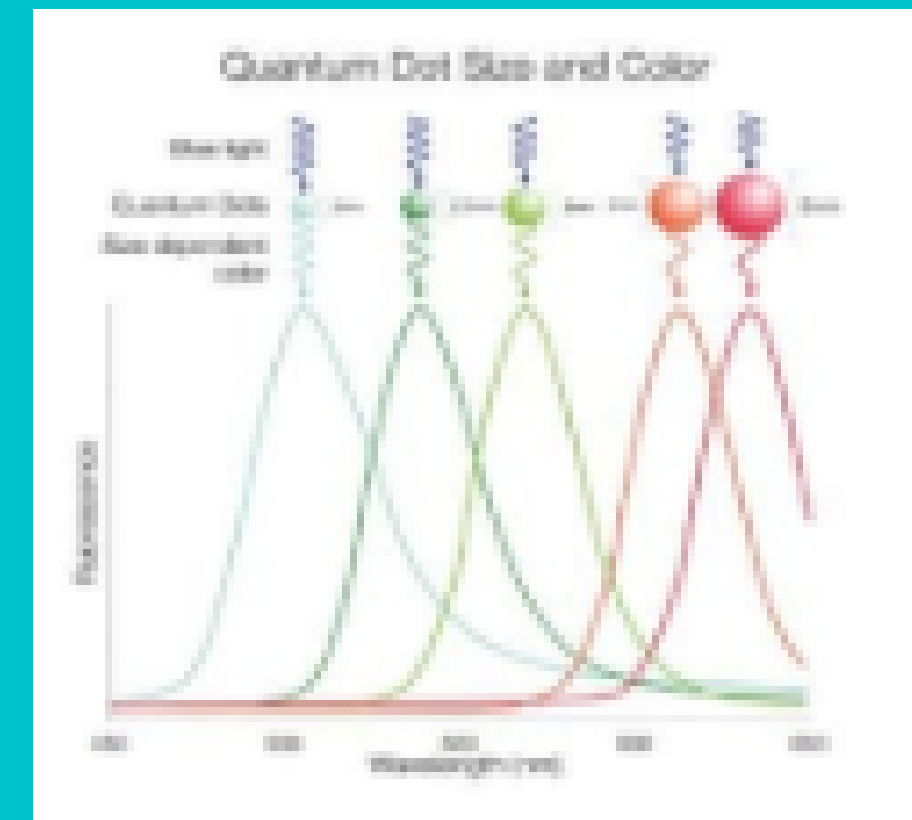
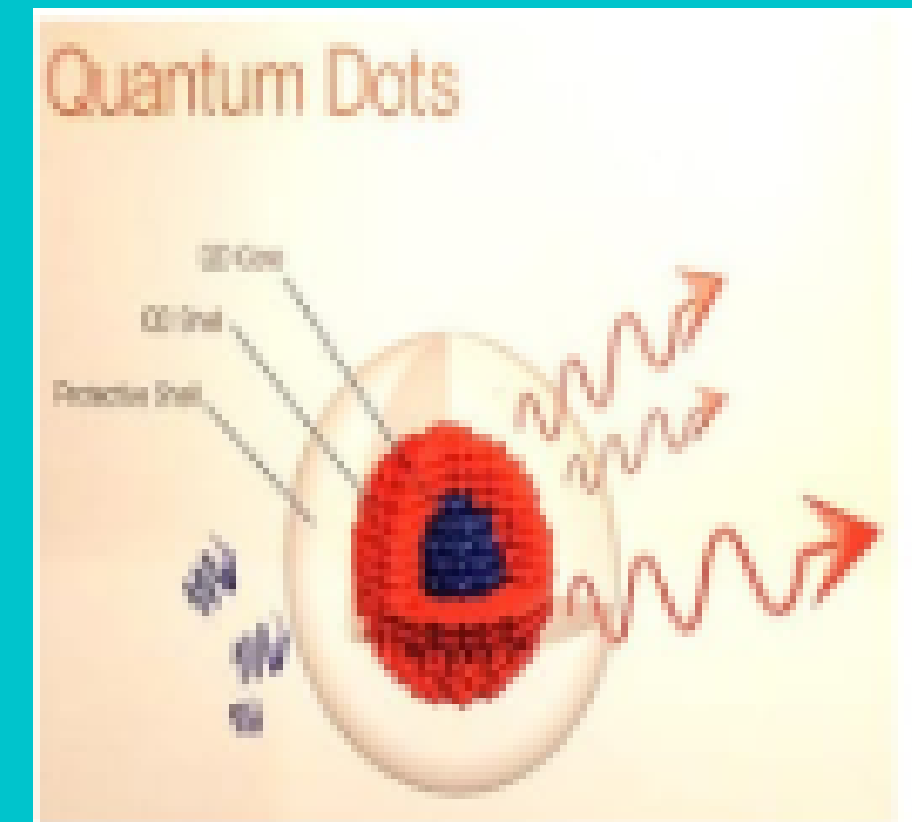
Introduction to QDs:

- Quantum dots (QDs) are semiconductor particles having size in the range of 2 to 10 nanometers with optical and electronic properties that differ from those of larger particles.
- These "artificial atoms" emit different colors of light depending on their size, with smaller dots emitting high energy blue light and larger dots emitting lower energy red light.

Smaller QDs (e.g., radius of 2~3 nm) emit shorter wavelengths generating colors such as violet, blue or green. While bigger QDs (e.g., radius of 5~6 nm) emit longer wavelengths generating colors like yellow, orange or red.

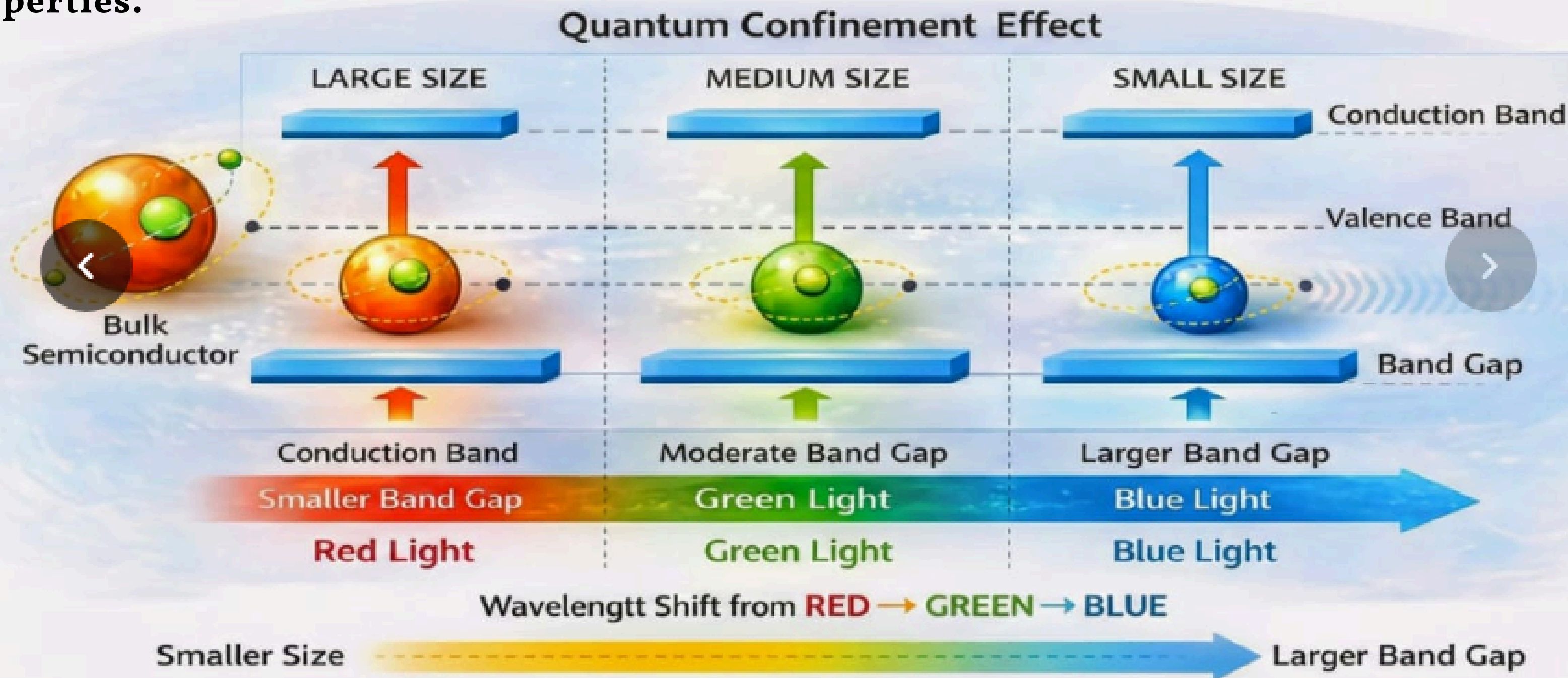
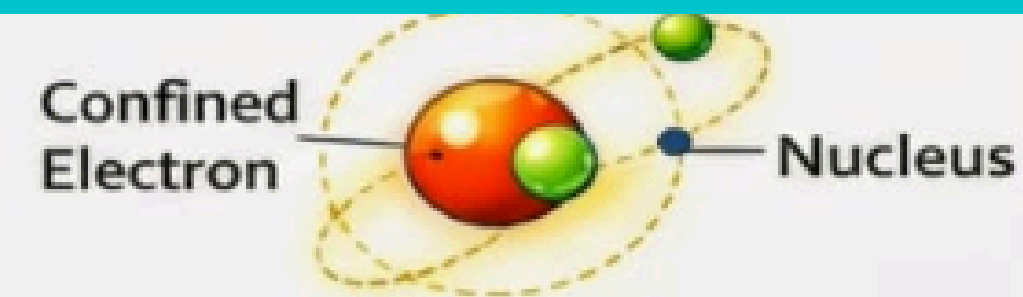
Applications of CdSe Quantum Dots (QDs):

1. Optoelectronics
2. Energy / Photovoltaics
3. Biomedical/ Healthcare
4. Displays and Lighting
5. Fluorescence tagging



Quantum Confinement Effect

Electrons are confined in extremely small semiconductor particles (quantum dots), leading to size-dependent energy levels and tunable optical properties.



Characteristic Properties of Quantum Dots

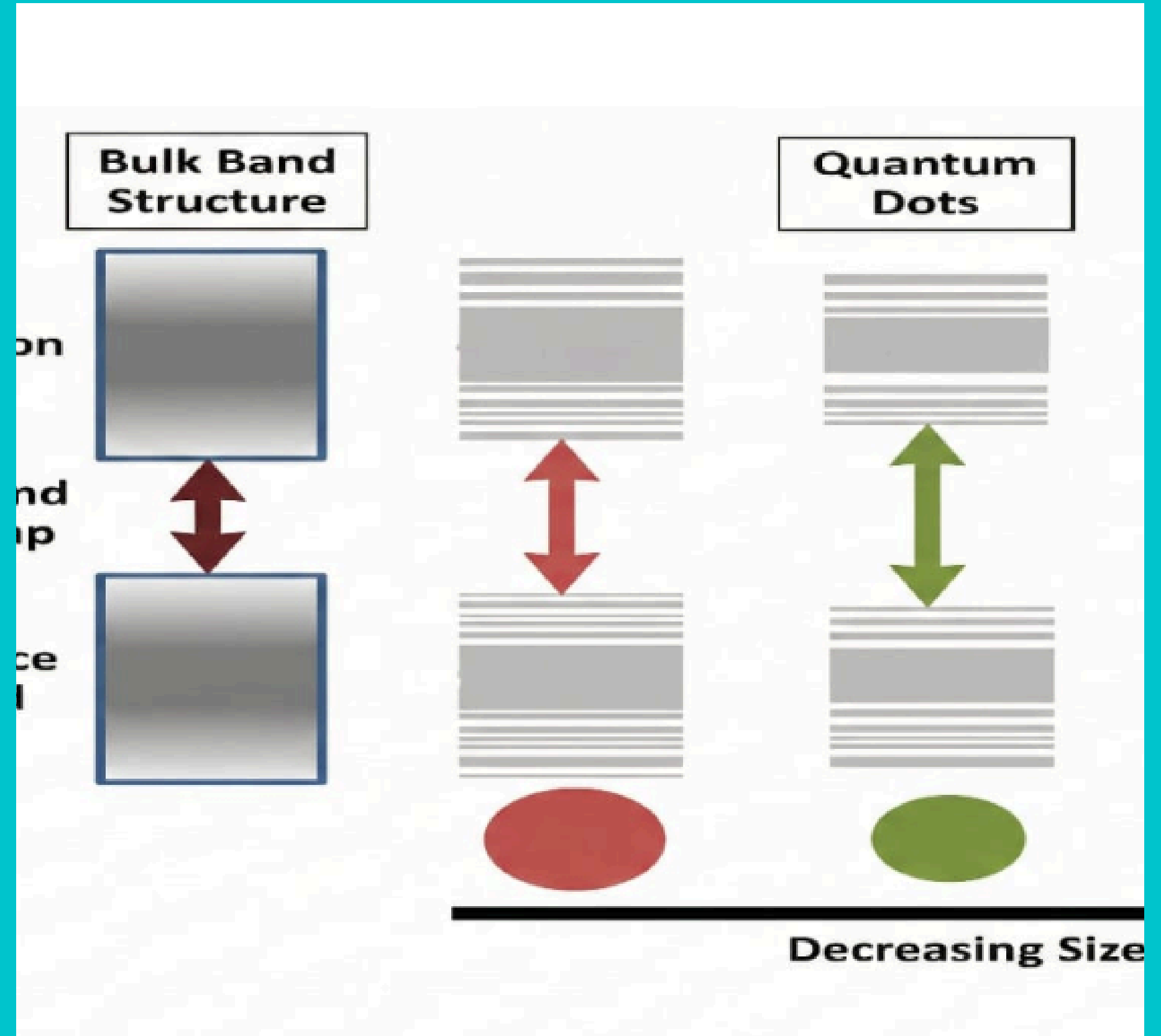
1. Band Gap Energy

- **Bulk Semiconductor:** Continuous band structure with fixed band gap.
- **Quantum Dot:** Band gap increases as size decreases.
- **Small QD** → strong confinement → higher energy transitions → blue-shifted emission.
- **Large QD** → weaker confinement → lower energy transitions → red-shifted emission. Example: CdSe QDs ~2 nm → emit blue, ~4 nm → emit green. ~6 nm → emit red

2. Surface-to-Volume Ratio

Smaller QDs: Large fraction of atoms at the surface → more surface defects and higher reactivity.

Larger QDs: Closer to bulk, fewer surface effects.



3. Optical Properties Absorption:

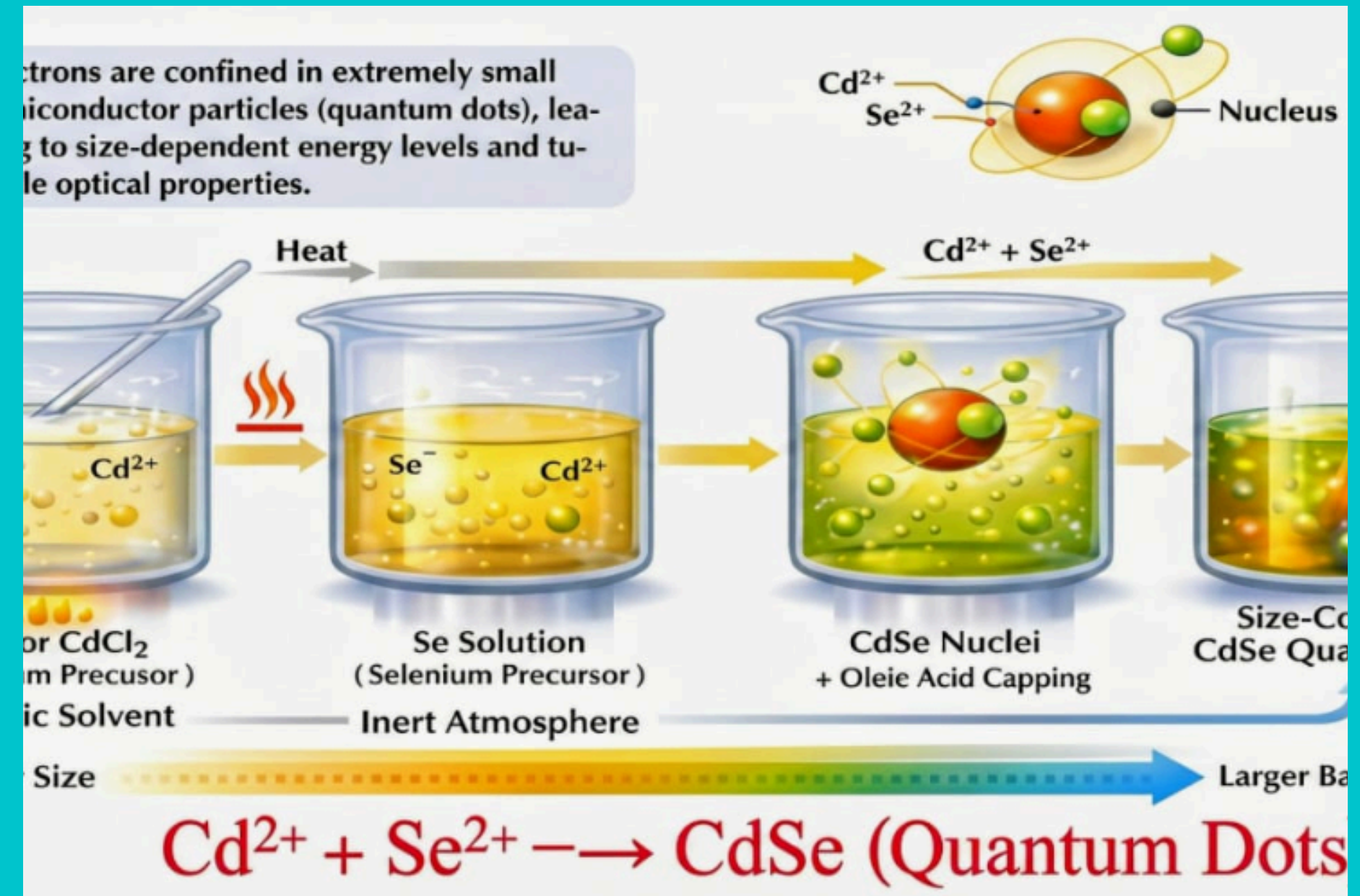
Smaller dots absorb at higher energies

(**blueshift**). **Emission:** Color is tunable (blue → green → yellow → red) by varying size. Sharp/narrow emission peaks → pure, bright colors (useful in displays, LEDs).



Synthesis of Cd-Se Quantum dots by wet chemical method

First, a cadmium precursor (CdO or CdCl₂) is dissolved in an organic solvent with a capping agent (oleic acid). Separately, selenium powder is dissolved to form a selenium precursor solution. The cadmium solution is heated under an inert atmosphere. The selenium solution is then quickly injected into the hot cadmium solution. Cadmium and selenium ions react to form CdSe nuclei. Controlled heating allows particle growth, determining size. Finally, the solution is cooled, and the quantum dots are purified by centrifugation and washing.



applications of quantum dot sensitized solar cells

1. Low-cost photovoltaic devices
2. Flexible and lightweight solar panels
3. Indoor and low-light energy harvesting
4. Wearable and portable electronics
5. Used in solar cells

Thank you...!