QUANTUM DOTS

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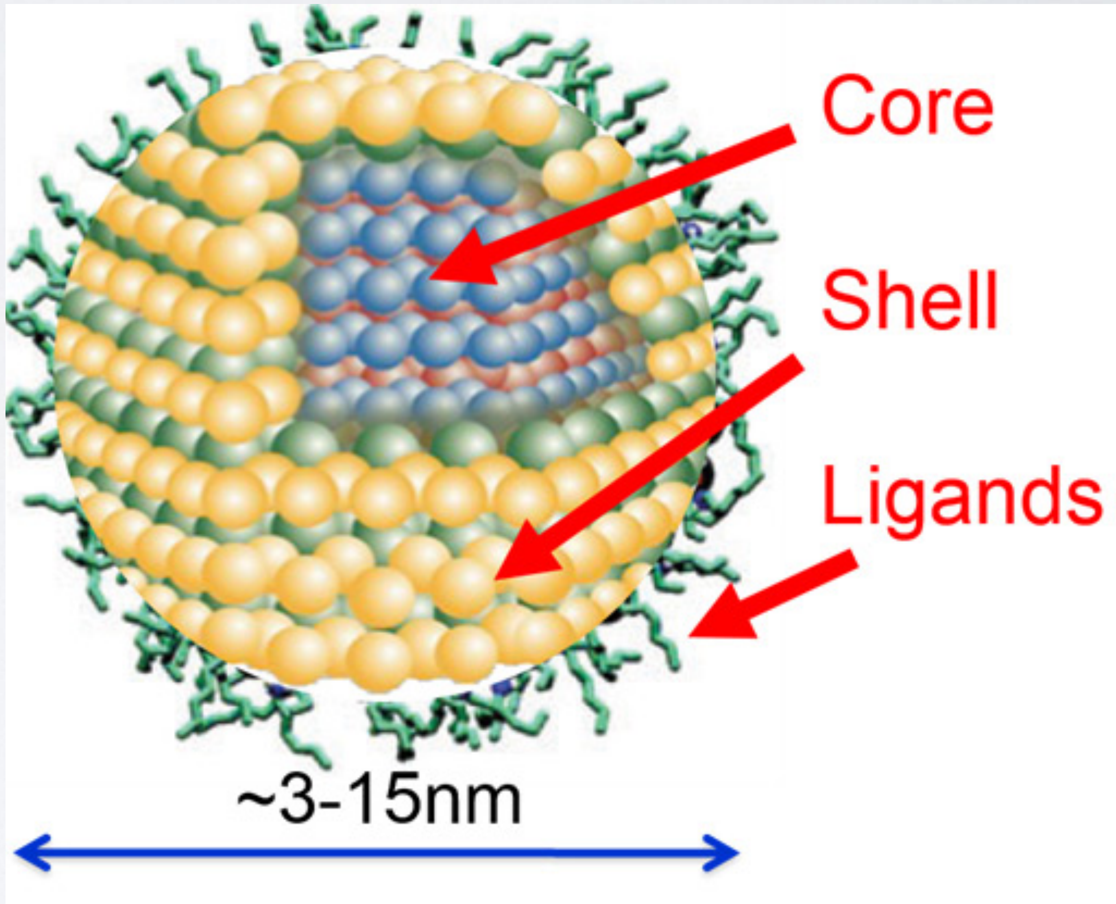
OUTLINE

- Introduction
- Quantum Confinement
- Quantum Dots
- How Quantum Dots are Made
- Applications
- Conclusion/Questions

WHAT ARE QUANTUM DOTS?

- Quantum dots are nanoparticles that exhibit a 3D **quantum confinement**, which in result leads into unique optical and transport properties.
- In other words, they are tiny semiconductor crystals.



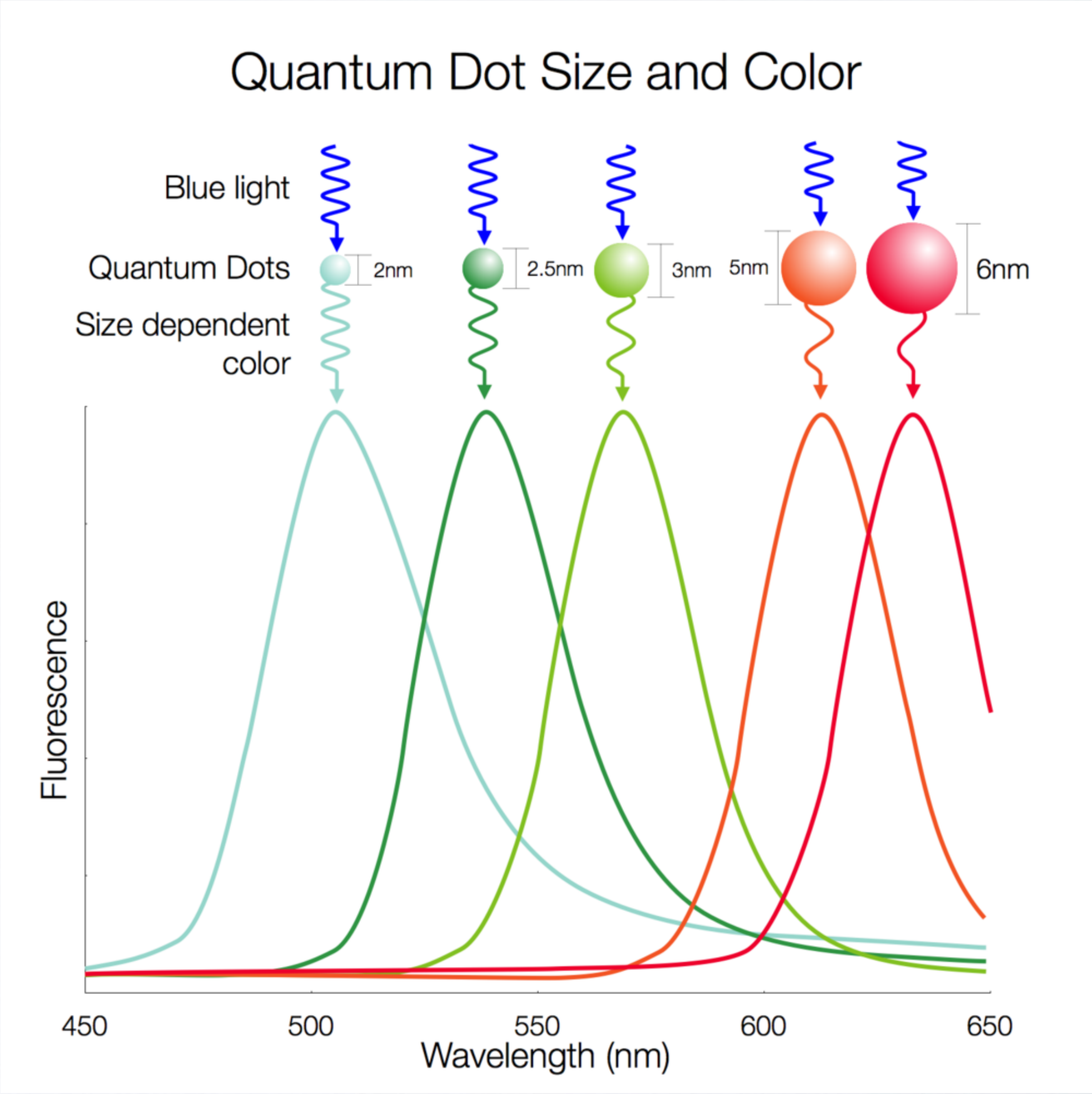
QUANTUM CONFINEMENT

- Quantum confinement is the spatial confinement of excitons (electron-hole pairs) in one or more dimensions within a material.
  - 1D Confinement
  - 2D Confinement
  - 3D Confinement

- Excitons become spatially confined when the diameter of the particle approaches the de Broglie wavelength of electrons.
- This means that the energy difference between energy bands increases as the particle size decreases.

QUANTUM DOTS

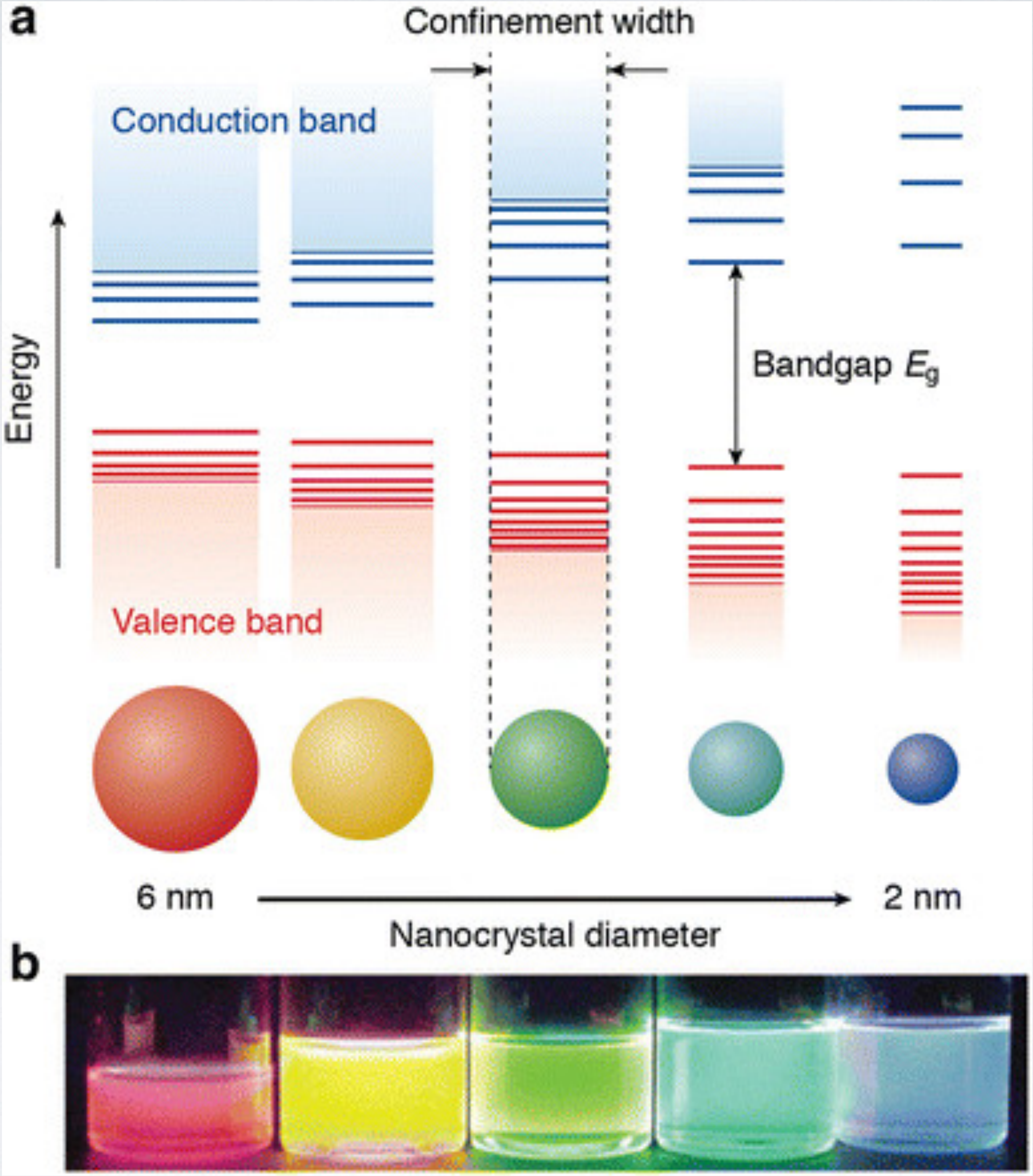
- Quantum dots emit color based off their crystal size not the material they are made out of.
- The bigger the quantum dot the larger the wavelength and the smaller frequency it will emit.
- Therefore, the largest quantum dots will emit red light and the shortest blue light.



- The color changing phenomena in quantum dots is the result of different **band gaps** between different size quantum dots.

- The **band gap** of a semiconductor is the energy required for its electrons to enter an excited state.

- Smaller quantum dots have larger band gaps so they need a larger amount of energy to enter an excited state. This high energy input results in a high energy frequency which results in smaller wavelengths.

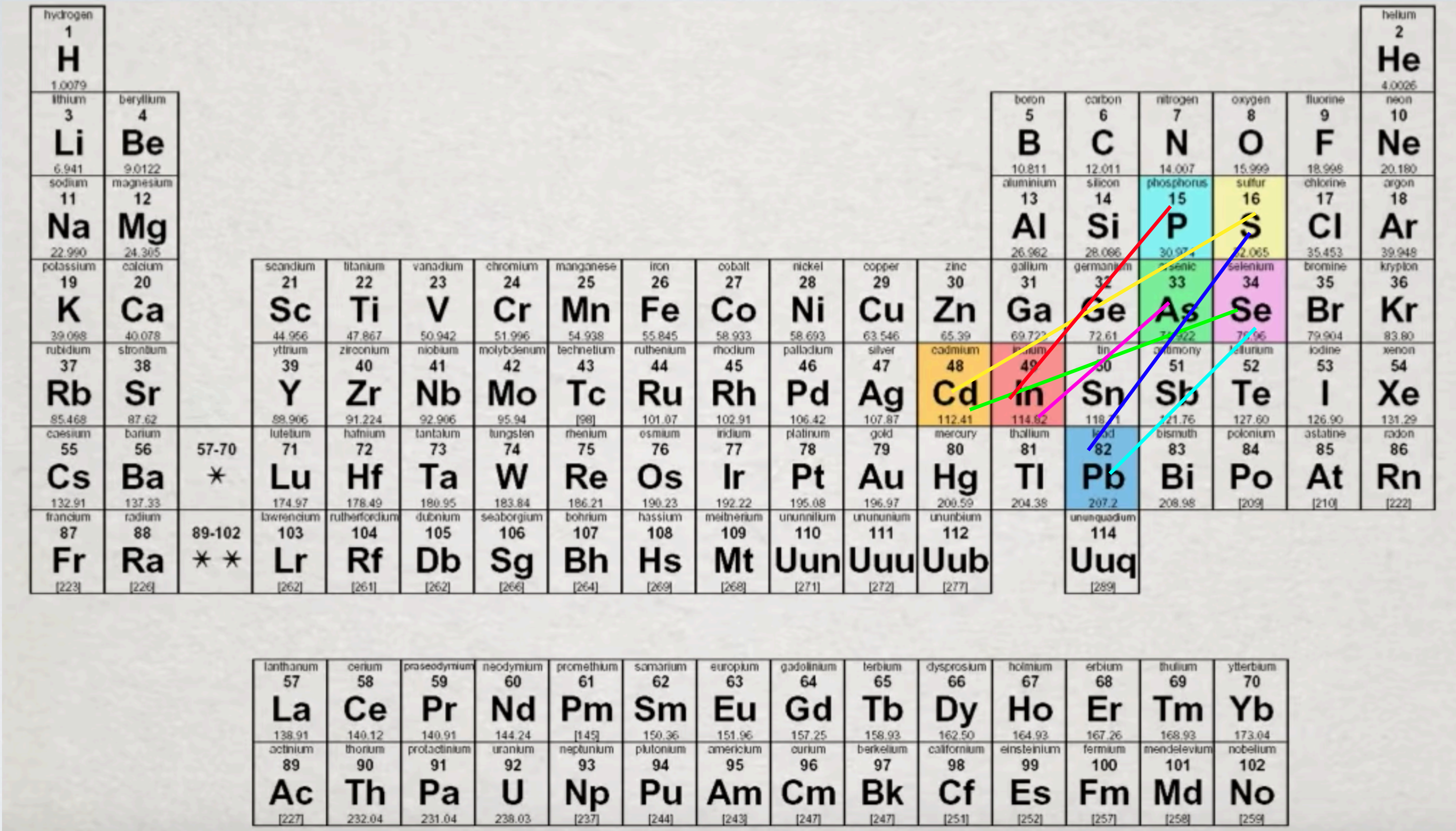

a
Confinement width
Conduction band
Energy
Bandgap E_g
Valence band
6 nm
2 nm
Nanocrystal diameter
b

HOW QUANTUM DOTS ARE MADE

- They are generally made in a chemical reaction in a solution resulting in solid nano crystals.

- Chemicals are combined over heat and start to react around 255 °C.

- Once the heat is removed the crystals retain their size and color.



ELEMENTS USED

- Many semiconductor materials can be used.

APPLICATIONS

- Since quantum dots are **band gap tunable** by size it means its optical and electrical properties can be engineered into applications.
- Medical Imaging
- Energy Efficient Lighting in Displays
- Photovoltaic Cells (Solar Panels)

DISPLAYS

- Operate at lower energy costs which reduces power conception.
- Productions costs are lower than OLED screens.
- Are able to create a purer white than the standard LCD displays.

WORK'S CITED

- Techquickie. "Quantum Dots as Fast As Possible." YouTube. March 29, 2015. Accessed November 20, 2017. https://www.youtube.com/watch?v=EeMws32VfJc&t=44s.
- Caplin, Tony. "Quantum Dots." YouTube. December 01, 2014. Accessed November 20, 2017. https://www.youtube.com/watch?v=cXNzfR1qaHU.
- Nack Network. *Materials in Nanotechnology* . PPT. The Pennsylvania State University, 2013.
- Dias, Luis. Lectures: Condensed Matter II. PDF. UT/ORNL.

QUESTIONS

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