# NanoScience – NanoTechnology / NST

## ID Student: Activity 3

### NST & Medicine

***Part A***: Real-world problem: conventional cancer therapy procedures and their various drawbacks.

1) Have you ever heard possible conventional cancer therapies drawbacks?

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***Part B***: Exploring Photodynamic cancer therapy

2) Have you ever heard of possible solutions to the aforementioned drawbacks through the implementation of novel technologies like NST?

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3) What are, in your opinion, the ideal characteristics of a future cancer therapy? Are those characteristics met in the aforementioned possible cancer therapies?

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4) Photodynamic cancer therapy (PCT) (Yang et al 2022) is a potential cancer therapy with appealing characteristics. Based on the picture below, please describe the fundamental principles of PCT:

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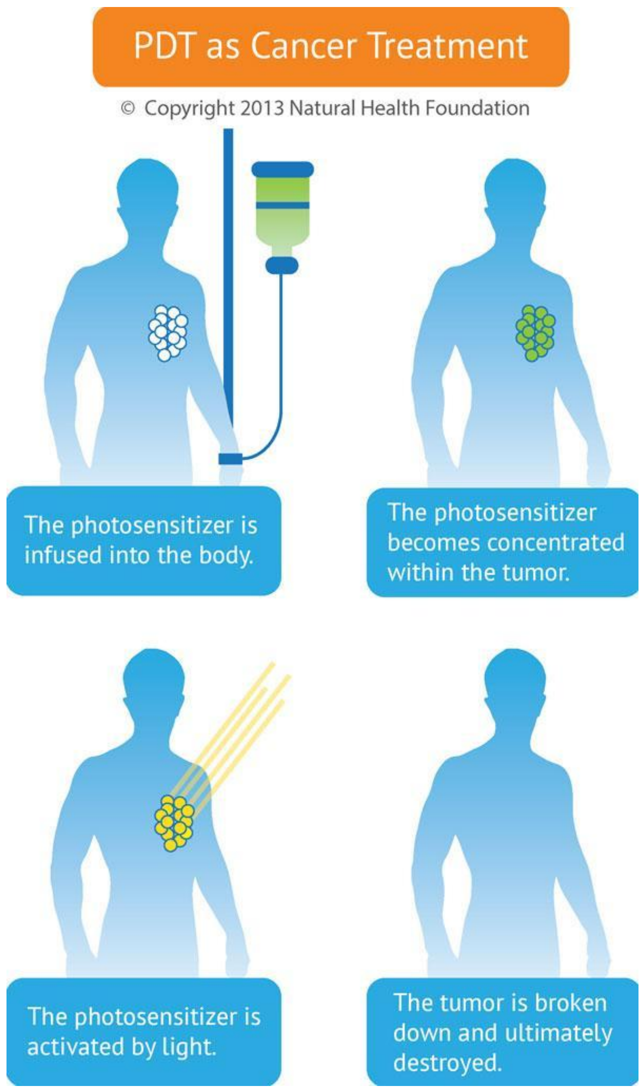


The fundamental principles of PCT. (As seen in http://photoimmune.org/photodynamic-therapy/#imageclose-418)

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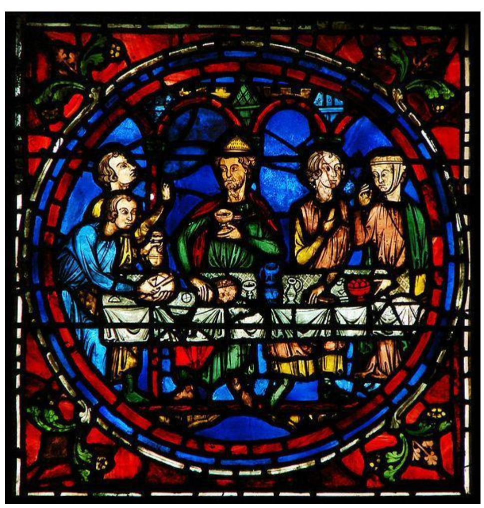
5) Could you brainstorm potential compounds for PCT?

6) What about metals?
Noble metals (e.g Ag or Au) are biocompatible, can absorb energy and expel it as heat, destroying the tumor's cells.
Thus, could Noble metals be used for PCT?

***Part C***: Exploring potential PCT compounds

It is known that some noble metals like gold has unique optical properties. For instance, in medieval stained glasses the distinct red hue is due to gold nanoparticles.



An example of a medieval stained glass
(as seen in https://commons.wikimedia.org/wiki/File:Vitrail_Chartres_210209_07.jpg).

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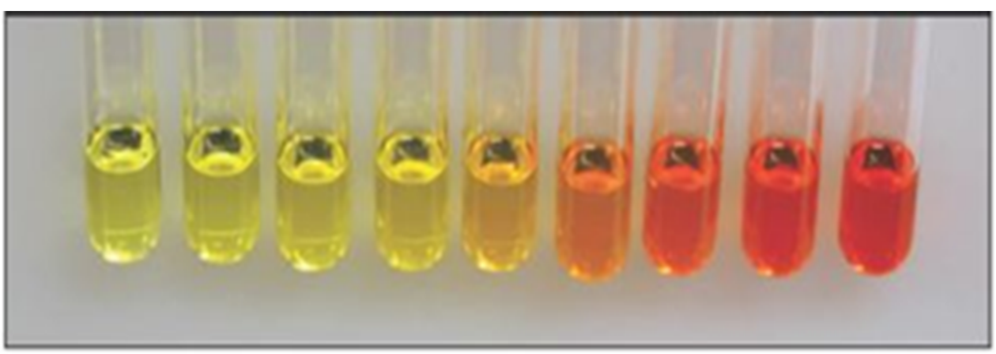
7) Is this gold's typical color?

8) Watch the following video about Cd/Se nanoparticles synthesis (NurdRage, 2012): https://www.youtube.com/watch?v=bNuoYm7Su4o&ab_channel=NurdRage (1:37 till 2.37) and then explain the color changes that you observed (as illustrated also in the figure below)



An example of CdSe nanoparticles (Reused from Nordell et al. 2005)

9) In your opinion, what are the structural differences between Cd/Se nanoparticles in each sample in the above figure?

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10) The number of nanoparticles is the same in all the samples. The reaction that is presented in the above video is the following:

$$Cd + Se \rightarrow (CdSe)_x$$

The reaction of Cd/Se nanoparticle synthesis. The x is the number of atoms in the nanoparticle and its value changes during the synthesis.

11) Based on these information, has anything changed in your opinion?

Let's examine the size as a parameter of color change.
Visit the link: http://ridiculousfish.com/wavefiz/
(Guidelines for the simulation are provided in Annex I)

12) How does a particle's size define its energy levels?

13) Please open the excel spreadsheet and pick sizes (values between 1 and 15) for materials in the three different scales. What do you observe?

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14) Why are these optical properties size - dependent only in the nanoscale?

***Part D***: Metallic Nanoparticles as PCT compounds

15) Based on the previous activities and the fact that in PCT usually IR or red radiation is used, would you propose gold nanoparticles as a potential PCT compound?

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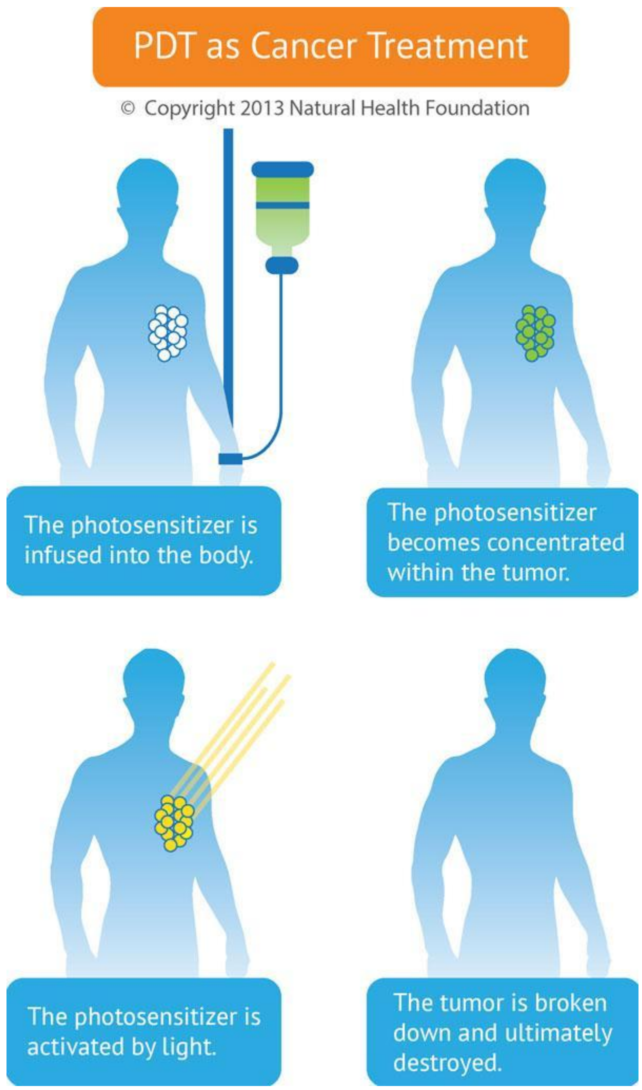


The fundamental principles of PCT. (As seen in http://photoimmune.org/photodynamic-therapy/#imageclose-418)

16) What other applicability could nanoparticles with different optical properties have?

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17) How could NST contribute to Medicine? What are the benefits from such an approach?

18) Compare your initial views on NST with the latter ones. What shifts, if any, do you recognize in using NST in Medicine?

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**References**

Nordell K. J.; Boatman, E. M. & Lisensky, G. C. (2005),A safer, easier, faster synthesis for CdSe quantum dot nanocrystals, *Journal of Chemical Education, 82* (11), 1697–1699

NurdRage (2012, May 7). *Make Quantum Dots (Cadmium Selinide Type)* [Video] YouTube. https://www.youtube.com/watch?v=bNuoYm7Su4o&ab_channel=NurdRage

Hao, Y., Chung, C. K., Yu, Z., Huis in 't Veld, R. V., Ossendorp, F. A., Ten Dijke, P., & Cruz, L. J. (2022). Combinatorial therapeutic approaches with nanomaterial-based photodynamic cancer therapy. *Pharmaceutics, 14*(1), 120.

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**Annex I**

- In Image 1 you can see the simulation environment.

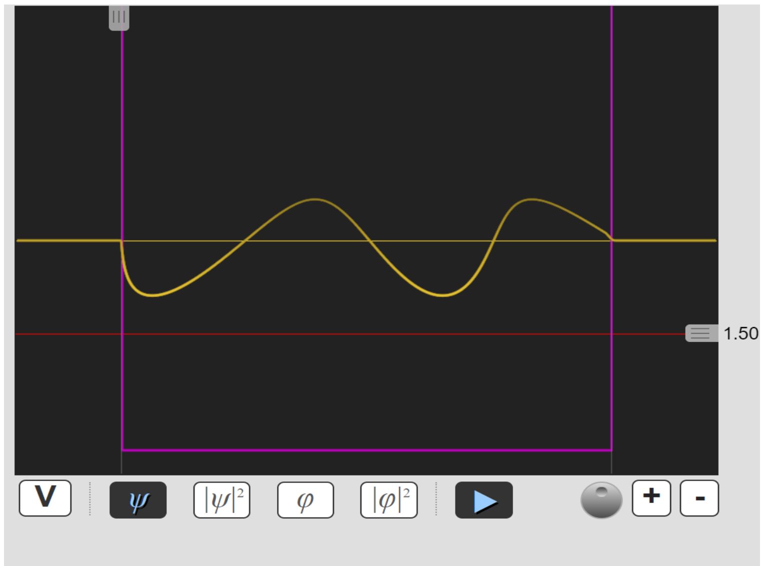


Image 1

- Press the “V” button  and choose Infinite Square Well (Image 2)



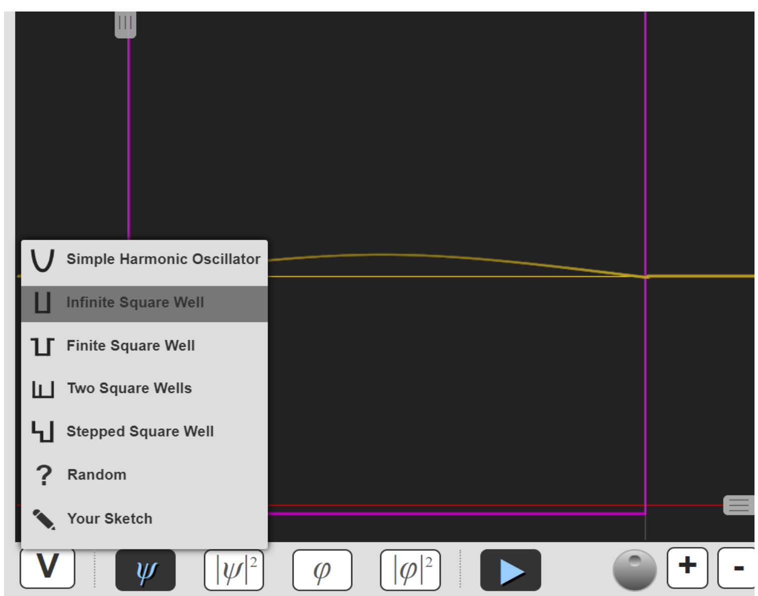


Image 2

Consider the purple box as a nanoparticle in which we study a trapped electron.

- Press the $\psi$ or $|\psi|^2$ button and consider the yellow wave as the trapped electron we study. We set as border conditions that the wave at the borders of the nanoparticle is equal to zero, since the electron cannot escape outside of the box.

- Move the Energy bar (red bar with the thin gray lines) up and down so as to find the first allowable energy level (Image 3) that responds to the border conditions. Then repeat the process for the second allowable energy level. Write down the energy values.

- The purple bar with the thin gray lines will help you to minimize or maximize the nanoparticle's size. Choose a small (in your opinion) nanoparticle and repeat the process so as to find the first allowable energy level and then the second one. Write down the energy values.

- Finally, use the purple bar to choose a large (in your opinion) nanoparticle and repeat the process like the two previous times. Write down the energy values.

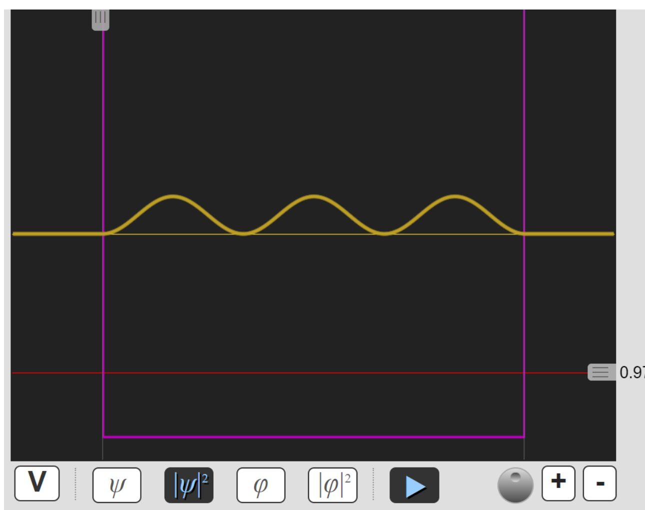


Image 3: Allowable energy level

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