DNA Origami Box

Student Sheet

- *Materials Needed:* Scissors, DNA Origami Box Sheet (Optional: Hole Punch, Extra Pipe Cleaners left over from Staple and Scaffold Activity)
- The outside of each side of the box has a DNA double helix design. Once it was discovered that these DNA nano structures could be assembled into lattices (which are basically woven support frames), these then can be used as "frames" with "sticky ends" to create 3d structures. [2]

- The design of this particular box models the one from the first source listed. This box folds up, side by side, just like the DNA cube in the model. [1]

- Each side of the cube is also scaled up from the 36 nm x 36 nm x 42 nm size of the box in the article. [1]

- This box would be really small if it were actually made of DNA! By comparison:
    - A single strand of DNA is 2.5nm in diameter
    - A virus is about 60-120 nm
    - A human red blood cell is on average, 7,000 nm wide
    - A strand of human hair is on average 50,000-100,000 nm wide
    - A sheet of copy paper is about 75,000 nm thick

- ***Challenge Question:*** If laid side by side, how many strands of DNA would make up one 36nm side of the box?
    - *Answer*: 14-15 strands. (36 / 2.5 = 14.4)

- After the boxes are constructed, if there are extra pipe cleaners left over from the Scaffold and Staple Strand activity, starting on side 1, each hole would have 2 pipe cleaners with one going to another side of the box. However, if I look at the corner of sides 1, 2 and 5, the holes adjacent to side 1 only have 1 "link" each.

- One potential application of these boxes could be as a medicine delivery system. [1]

- ***Challenge Question:*** Let's brainstorm! How might this DNA Origami Box be used as a medicine delivery system?'
    - *Think of the DNA Origami Box as being "locked". How could a particular "key" could open the box?*
    - *Answer:* Researchers are able to code this box to open when two or more external signals (such as a protein marker) are present, which would then release any medicine contained within the box at a specific location. One way that researchers

can confirm that the medicine was successfully delivered to the correct spot would be that these boxes can be coded to fluoresce upon opening.

- ***Challenge Question***: Why might a medicine delivery system be a good idea?
  - *Have you ever taken medicine for something (ex: Aspirin for a headache). How did you take that aspirin? How long did it take to work? Why do you think that aspirin took time to work?*
  - *Answer:* A direct medicine delivery system could ensure that medicine goes only where it is needed, and not throughout the entire body. This means that medicines would be more efficient and likely more effective!

This activity was designed from information and ideas shared by Dr. Rebecca Taylor, CMU Mechanical Engineering Faculty and from the published articles:

1. "Self-Assembly of a Nanoscale DNA Box with a Controllable Lid." Ebbe S. Andersen, Mingdong Dong, Morten M. Nielsen, Kasper Jahn, Ramesh Subramani, Wael Mamdouh, Monika M. Golas, Bjoern Sander, Holger Stark, Cristiano L. P. Oliveira, Jan Skov Pedersen, Victoria Birkedal, Flemming Besenbacher, Kurt V. Gothelf & Jørgen Kjems. https://www.nature.com/articles/nature07971, 2009.

2. "Structural DNA Nanotechnology: From Design to Applications." Zadegan, R. & Norton M. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3397516/, 2012.