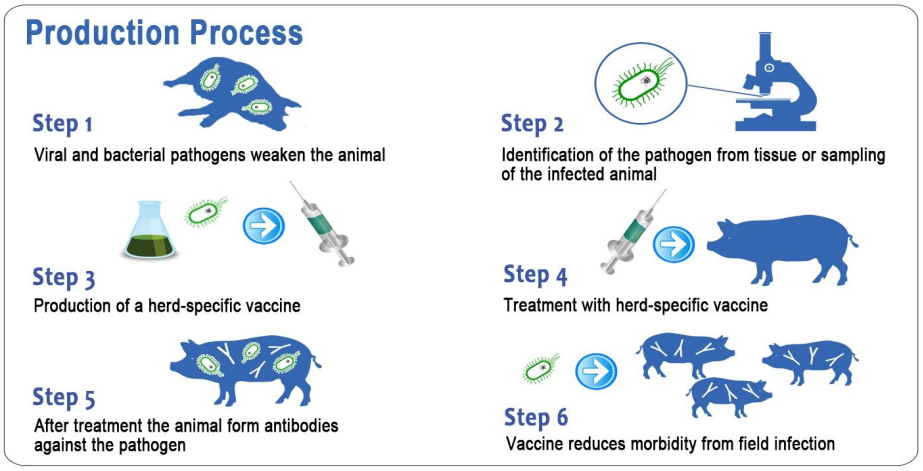
Nick Anderson
Assigned Field: Applications

Biotech Design Research and Writing Challenge

Everybody must answer this question for basic context of this year's theme:

1. Define what a vaccine is and where it originated from. If needed, expand more on vaccine knowledge.

- A vaccine is a man-made substance that stimulates the growth, development, and production of antibodies, which are then used to combat one or more present or future diseases and hopefully provide immunity to these diseases. In simpler terms, the vaccine is injected into an organism with the very thing that is harming, or could harm the organism, causing immunization and allowing the organism to be protected from the disease. Below we can see the 6-step process, simplified above, that scientists follow when forming a new vaccine



- Vaccines are very effective to date. Childhood vaccines provide immunity over 90% of the times they are applied. An example of a disease that has been completely wiped-out from the development of vaccines is the measles virus. Since 1960, the number of measles cases has decreased by nearly 100%, simply because of the development of the measles vaccine. This disease along with many others have been greatly diminished by the introduction and development of vaccines. By clicking on the following link, we can see the incredible effect of vaccines on deadly diseases, ranging from Hepatitis A to Measles.

https://www.google.com/imgres?imgurl=https://ourworldindata.org/wp-content/uploads/2013/05/Vaccine-Reduction-of-Cases-and-Deaths.png&imgrefurl=https://ourworldindata.org/vaccination/&h=4297&w=3160&tbnid=EEcutVCrCOVnvM:&vet=1&tbnh=160&tbnw=117&docid=i1IzQYWUIMkcTM&usg=__ZGXtafr3YEVSs5nPNGN_bLJK2JE=&sa=X&ved=0ahUKEwiZ2cDl7JzQAhVW9mMKHRRCDe8Q9QEIHzAA

- Vaccines originated through the insight and intelligence of French scientist Louis Pasteur. In 1877, Louis developed and produced The Germ Theory of Disease - the

simple thought that diseases are caused by microorganisms who can spread and invade organisms quickly. Shortly after, Louis introduced the first live attenuated viral vaccine (rabies). He then opened the Pasteur Institute, a center for research on infectious diseases and training. Since this historical landmark, around 1900, we have seen the continuous development of different types of vaccines, specifically in Europe, and eventually in the United States.

- Vaccines do obviously have their negatives. Many vaccines have side-effects, however minor they may be, although some side-effects can be deadly. A more global and modern vaccination issue is the fact that diseases can evolve to work around or even become immune to vaccines through natural selection. This creates a major problem for scientists, one that has simply not been solved to date.

Research and Investigation - Application:

1. Research the potential scope of carbon nanotube technology beyond vaccines.
   - Carbon nanotubes can be used for many things beyond vaccines (including the Engineering Design event). A few of the many instances where they can be applied is shown in the list below.
     - Municipal water facilities
     - Medical facilities
     - Laboratories
     - Distilleries
     - Desalination plants
     - Industrial facilities
     - Wastewater treatment facilities
     - Consumer markets
     - Thermal Conductivity
     - Energy Storage
     - Fibers and Fabrics
     - Military

   - Carbon nanotubes are already rather prevalent and revolutionary in the medical industry today. This just goes to show that since they are so structurally effective in such an intense and knit-picky industry such as the medical field, they can certainly be applied to larger and more prominent industries such as infrastructure and water and energy industries, which don't require such precision and reliability.

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   - An advantage that carbon nanotubes have over other strong materials is their flexibility. Because of their thin circuit-like walls, CNTs can bend, even though they are stronger than steel. Due to this, they can be incorporated in many, many different things such as those listed above.

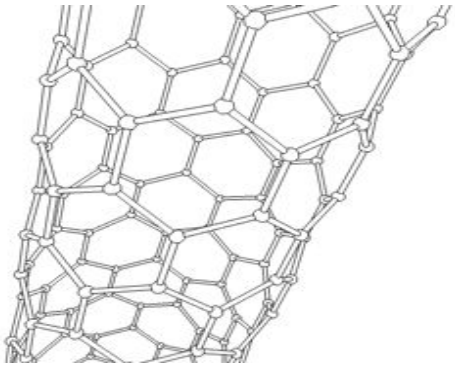
   - Fun fact, one recent experiment has been conducted testing the strength of carbon nanotubes when put up against a bullet. Because of its incredible strength, when shot with a bullet a carbon nanotube body armor actual caused the bullet to deflect/bounce

off of the plate on impact. Yes that was stated correctly, IT BOUNCED OFF. In relation to the application side of CNTs, the military could obviously use CNT body armor and plates to act as protection against oncoming enemy fire.

2. Understand the structure of carbon nanotubes and why they would be preferred over regular vaccines.

- The basic structure of carbon nanotubes is as follows: a form of carbon, similar to the graphite in pencils, in the shape of a cylindrical tube that is 10,000 times smaller than human hair, but stronger than a piece of steel. It is also incredibly flexible for its powerful strength allowing it to bend under intense pressure instead of snapping or breaking. It forms an outside layer through simple geometric shaping as shown in the GIF below, which allows it to stay connected and limit pressure points throughout the tube.

- Carbon nanotubes have a large volume and surface area when taking into account their actual nanometric dimensions, and and a result of this is that they are able to immobilize biomolecules, meaning that they can easily deliver drugs or antigens to targeted cells and provoke a faster and more effective immune response.



- This type of structure is preferred over a regular vaccine because CNTs are a better form of antigen delivery. CNTs activate a faster innate immune response from T-cells than regular vaccines do, and it doesn't poison the cells either as it is generally non-toxic towards humans. CNTs can also be used as a potential vaccine adjuvant.

Writing Challenge:

1. Depending on your field of research, summarize what you learned in addition to the first question. Analyze the significance of the research in your field in relation to vaccines in 1-2 paragraphs.

- In summary, vaccines are crucial towards the survival of our species and the elimination of deadly viruses affected human life every day. Vaccines have greatly eliminated the danger and prevalence of many deadly and large-scale viruses and diseases. However, the common vaccine is very unreliable and has a massive amount of room for improvement. Although imperfect, the best solution for these vaccines, or the most

influential and potential-filled form of vaccine, is the carbon nanotube. Because of its immense strength, flexibility, and potential, carbon nanotubes should be considered as a novel vaccine platform for both infectious diseases and cancers. Because of their nanometric dimensions, CNTs can easily be taken in by cells, and because of their ability to allow biomolecules to be immobilized on their outer surface, these CNTs serve as the epitome of the future of drug and antigen delivery.

- In relation to vaccines, my applicational research is obviously significant. The varied and widespread application of carbon nanotubes shows how we can incorporate a rather common yet useful component as a part of an incredible product. CNTs themselves are the future of not only vaccines but of the entire medical industry, and therefore, every piece of information we can gather and every idea or concept we can grasp regarding CNTs is a step in the right direction. The future of vaccines is an open door left for the taking, and the analyzation and use of CNTs is the very thing that could help us cross that threshold hopefully toward a revolutionary finding and a state and national championship.

Sources:

- http://www.vaccines.gov/basics/
- http://www.immunize.org/timeline/
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3846653/
- http://www.nature.com/nnano/journal/v6/n3/full/nnano.2011.1.html
- http://pubs.acs.org/doi/abs/10.1021/acs.nanolett.5b04773
- https://www.cdc.gov/vaccines/index.html
- https://www.vaccines.gov/diseases/index.html