Hi Reddit, I'm Warren Chan of the University of Toronto. Ask me anything about applying nanotechnology to treating cancer and infectious diseases. AMA!

AmerChemSocietyAMA [1] and r/Science AMAs[1]

[1]Affiliation not available

April 17, 2023

Abstract

ACS AMA Hello Reddit! My name is Warren Chan, and I am currently Distinguished Professor of Biomedical Engineering at The University of Toronto. I also serve as Associate Editor of ACS Nano. I am very much looking forward to my first time participating in Reddit. I obtained my B.S. from University of Illinois in 1996 and a PhD from Indiana University in 2001, both in Chemistry. Then I did my post-doctoral work at the University of California-San Diego in Biomedical Engineering and I joined the faculty at the University of Toronto in 2002 at the Institute of Biomaterials and Biomedical Engineering. I am interested in developing nanotechnology for diagnosing and treating cancer and infectious diseases. As a chemist, I learned how to make and design nanomaterials and as I started my independent career, I wanted to focus on applying these materials to the medical field. My interest can span two domains: (a) outside of the body, I am interested in developing handheld nanotechnology devices that can identify biomarkers and link them to diseases. These devices can also measure these biomarkers with a single drop of blood. (b) inside the body, I am interested in figuring out how to deliver nanoparticles to the diseased site. I think the biggest challenge of using nanotechnology is to be able to deliver enough of the medical agent to the site of action. I work with engineers, chemists, biologists, and clinicians to solve these problems. I would like forward to our discussion. Ask me anything about bionanotechnology! I'll be back at 11am EDT (8am PDT, 3pm UTC) to start answering your questions. It has been awesome chatting with everybody on nanotechnology! I am signing off! Have an awesome day!

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REDDIT

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AMERCHEMSOCIETYAMA R/SCIENCE

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CORRESPONDENCE:

DATE RECEIVED:
October 11, 2017

DOI:
10.15200/winn.150764.43491

ARCHIVED:
October 10, 2017

CITATION:
AmerChemSocietyAMA , r/Science , Hi Reddit, I'm Warren Chan of the University of Toronto. Ask me anything about applying nanotechnology to treating cancer and infectious diseases. AMA!, *The Winnower* 4:e150764.43491 , 2017 , DOI: 10.15200/winn.150764.43491

Single-drop blood analysis was the great dream of Theranos, which ended up being a spectacular failure. As someone working in that general area, what were your observations when all of that was going on? Were their claims a bit unbelievable to people in the field?

While this company didn't work out, do you think the basic idea can be made to work with some technological progress?

nate

I think the single-drop blood is an amazing idea. One of the problems in this research area is that people make claims without understanding what needs to be done to get the technology to work. It takes time to get the small stuff working (but these things are not sexy!).. For us, it has taken up 15 years to get our devices to point for clinical testing - and it will take another 5-8 years (at a minimum to figure a way to organize the components of the diagnostic test into a single unit system. Of course if we had a lot of money ($10 million), this could be done a lot of faster (but then it is more of organization challenge).

What's the coolest thing you've discovered or learned about nanotechnology?

nsfw0821

Nanotechnology continues to amaze me! It is such a fascinating topic and right now there are so many unknowns. I still find the different colours of quantum dots to be one of the most beautiful things I have seen. I also learned that nanotechnology is a really hard area of research, especially for when they are applied to applications inside the human body. The body is a like a crazy labyrinth and the size, shape, and chemistry of the nanoparticles somehow dictate how they move within this labyrinth. I think if we can figure this out, we can really engineer nanomachines to fix diseases. More exciting research and discoveries will come out in the next 10 years on this topic. I am pretty excited to see the results.

Do you see a future for DNA origami being used *in vivo* for drug/gene delivery, or do you think it will remain a "cool toy" for the forseeable future?

iorgfeflkd

I see tons of potential for DNA origami for in vivo applications. The most important aspects of origami is that fact that you can design a lot of different shapes and sizes. The problem is that we don't really know what is the best shapes and sizes for targeting and delivery. I think researchers in this area should continue to understand how to engineer these structures and eventually, when we figure out the appropriate design for a specific disease, I think the two areas will form a beautiful marriage.

What is the obstacle in delivering the nano-tech? is it difficult to get them in there and stay or how many nanoparticles are needed?

bowtoboot

This is a really an excellent question! This is what we are trying to figure out. Once you know the barriers, then I think you can develop solutions. Right now, we have to really figure what those barriers are. It is clear that the liver, spleen, and lymph node are involved with sequestering nanoparticles. Solid tumours also have barriers. It will take some time to figure this area! Your question is very loaded and will take years to really figure out! But this is critical to designing nanoparticles for tumour delivery.

I'm curious about the practical application of nanotech. What does it actually look like? What tools do you actually use to create nanomachines? Like, if you were going to build some nanomachines in your garage, what would be the first 10 things you'd buy. - asking for a friend

dillonmarkey

The inorganic ones just look like structures (spheres, rods, tetrapods). You can probably "google" nanoparticle and microscopic image and you will see beautiful images.

For nanomachines, we are still figuring out how to glue the parts together. We use DNA, proteins, polymers and other organic components.

Depends on what you want the nanotechnology to do.

One of the emerging methods for cancer treatment is immunotherapy. Can you talk about any possible synergy between using both nanoparticles and the immune system to treat cancer?

Lord_Fuzzy

There are a lot of synergy between immunotherapy and nanoparticles. Immune cells love to take up nanoparticles. If you can use the nanoparticles to control the function of the immune cells, that would be amazing. Imagine if you program the immune cells to attack when needed or to stay put when it is not needed. That would be incredible! Not there yet but a lot of very exciting work between nano and immune.

How do you see nanotechnology being used by emergency physicians and/or paramedics in the future?

AntigonishIGuess

The handheld diagnostic technology could be very useful for ER physicians and/or paramedics. Instant answer to the problem!

So, how do you replace the cancerous tissue?

poyrazogluyigit

I don't think you can replace it. I think you have to destroy them.

Despite a lot of money and time being spent on pre-clinical development of nanoparticle therapies why do you think so few are in clinical use?

derptrollington

I just think they are not being delivered to the tumour sites. The results of many studies are more show-and-tell type studies and it does not really teach how to design nanoparticles. It is not that hard to kill tumours in a mouse. To address this problem, we have to directly measure the delivery process and to focus the studies more on the mechanistic aspect of nanoparticle therapies. But these studies tend to not make "headlines".

What happens to nanomachines once they have done their job?

the-real-apelord

I am not sure. I think most people want to figure a way to clear them from the body once they have done their job.

What materials are used to develop these nanotechnology? Are they fully organic as to not react with the body? Or are they fully inorganic for the same reasons?

How soon can we see this being used in common hospitals and what impact would it have (adversely) on the body?

Where could we get more reliable information on this research?

739RedRose

There are metal, semiconductor, and organic nanotechnologies.

Nanotechnology diagnostic systems are being used in some hospitals (e.g., verigene system). There are also a few liposome formulations used for cancer treatment.

The adverse effect of nanoparticles on the body is not clear. I think it is likely related to dosing. Too many of anything can be harmful!

There are a lot of good review articles on the topic. Just google "Nanomedicine" Review articles. A number of review articles should pop up.

Is it ever going to be a mainstream thing in our lifetime

RUBI44

Nanotechnology is already starting to become mainstream. The name keeps on showing up in movies and tv shows nowadays. The general public knows the term "nano". In terms of clinical products, if you have used a pregnancy test, you have seen nanotechnology at work. The "red colour" is due to the gold nanoparticles that are embedded in the test strip.

How quickly can this kill individual cancer cells?

How quickly do cancer cells replicate?

Are there any particular types of cancer or diseases that you see posing a greater resistance to this treatment?

Darty96

Can be over hours!

Replication rate is dependent on the aggressiveness of the cancer cell (can be hours to days).

Not clear yet. Cancer becomes resistant to many drugs!

Is graphene useful in your line of work? If so what general graphene length and thickness scales would be most effective/useful, if at all?

I'm researching the volume/controlled liquid phase exfoliation of graphene and other 2D nanomaterials.

soujasimon

We haven't played around with graphenes yet. Graphene is slowly moving towards biological research but for us, the graphene has to have more solubility and stability for them to be useful for biological applications.

Aside from reactionary medical treatment, do you think there is potential for nano-delivery of nutrients for day-to-day health, or for people with special dietary needs?

I'm sure plenty of people have considered better ways to deliver insulin, but I wonder about effective delivery and tracking of protein, fiber, vitamins, etc. Do you think the delivery/tracking of nutrients is a realistic and worthy outlet for this sort of work.

And thanks for doing an AMA!

SeanyDay

I think this is a great area of research. I think it would be great to package nutrition into a nanoparticle to enhance delivery. I think many companies are starting to work in this area (e.g., UniLever). Nano can help enhance the solubility and stability of many nutritional component. Tracking is a little bit harder.

Sadly, I am not that smart. But I do have a question. Can we replicate certain types of cancer cells and healthy cells in the lab and fire treatments at them yet?

StarbuckPirate

Great question! We can grow cancer and healthy cells outside of the body but it is difficult to replicate the cancer environment. The environment is critical to the survival of the cancer.

As someone with Afib/Congestive Heart Failure. Thank you for your work, I hope your field extends my lifespan.

What do you see as the future of heart care with nanotechnology?

jimmyolsenblues

Thank you for you kind words. I think there will be new nano medicines that will target heart disease with lower side effects. I think there will be new nanotechnology diagnostic devices to detect strokes and other heart diseases quicker.

I'm a doctoral student researching engagement and the effects of burnout. Do you think nano-biomedical technology could help manage other chronic diseases such as obesity, inflammation, and heart disease, as all of these have high correlations to chronic exhaustion?

holzer06004

Yes, I think nanotechnology can be applied to these diseases. Nanoparticles are useful for carrying drugs and diagnosing diseases. However, there are not a lot of nanotechnology researchers working in these areas. But they are important diseases to start to apply nanotechnology concepts.

1) Do you think nanotechnology can be applied to pregnancy complications such as developmental disorders or immune system activation through the placenta?

2) What role do you think nanotechnology can play in studying neuroscience and treating neurological disorders?

crustystuch

I think nanotechnology can be applied to these clinical problems. There is a nice synergy between nanoparticles and immune systems. Immune cells love to take up the nanoparticles. Imagine if you can design a nanoparticle to program the immune cells. That would be so cool! For neuroscience, similarly, nanoparticles can be used to trigger electrical signal which can potentially alter brain function. There are researchers studying this. A lot one can do with nanotechnology.

Do you ever foresee nanotechnology being used for nerve repair? Or nerve substitution?

yukonwanderer

Yup, I can see metal and semiconductor nanoparticles controlling electrical signal when it is embedded in the nerve. This can lead to nerve repair. As a nerve substitution, I am not sure!

Do you think we will have working nanobots by 2020?

Exo123321

Nope if you consider a nanobot like a machine. For that, I think 2120 or 2222!

Please comment on treating the elderly (<70)

TeacherGift

Nano is being developed for cancer treatment and for simplify the detection of diseases. For example, if the nanotechnology can diagnose the disease with a single drop of blood with high enough sensitivity, it can really make life easier for elderly.

You said "*bio*-nanotechnology," most people imagine tiny computers floating around in the blood stream but it seems that's not what you're talking about, so would you mind explaining what you are talking about? what exactly does a bionanite consist of? is it a modified version of a biological (i.e. a bacteria changed to produce a vital drug, where you can place that bacteria in the host in order to supply a constant stream of the material, or a super-powered white blood cell, which has been modified to detect cancer cells as dangerous)?

You mentioned somewhere else in this thread that pregnancy tests were commercialized usage of nanotechnology, specifically the gold in the test strip. How does that differ from a simple chemical reaction? Would the handheld device for testing a single drop of blood and identifying biomarkers function as basically an expanded version of a pregnancy test then? If that test relies on the color change generated by the reaction, would a general disease detection system require the use of a light spectrometer, to distinguish the various positive results?

sswanlake

When we think about nanotechnology (as a researcher), we don't think about a nanomachine. A nanotechnology is a technology that involves structures or materials that are on the size scale of nanometer (10-9 m). At this size range, the nanoparticles have unique electrical, magnetic, and optical properties. We can engineer metal and semiconductor structures at this size range in a reaction flask. We use them to target cancer (i.e., we coat them with a protein that can recognize sick cells). The nanoparticle (if storing drugs) can release its content and kill the cell.

When you see gold jewelry, it looks yellowish; however a gold nanoparticle (a nanoparticle consists of many gold atoms stuck together), they appear red (in solution). There is no colour change in the pregnancy test. The gold nanoparticles produce an intense red signal and when they are in the pregnancy test, they are bound to the surface through the pregnancy hormone. That is why you see a red line - many gold nanoparticles stuck on the test line.