

ACS Science Tuesday: I am Todd M. Przybycien, a Professor of Biomedical Engineering and Chemical Engineering at Carnegie Mellon University, AMA about Chemical and Biomedical Engineering

AmerChemSocietyAMA¹ and r/Science AMAs¹

¹Affiliation not available

April 17, 2023

Abstract

Greetings! I am Todd M. Przybycien, a Professor of Biomedical Engineering and Chemical Engineering at Carnegie Mellon University. I am the instructor for the short course “Chemical Engineering for Chemists” for the American Chemical Society. I’ve taught the course since 2007, delivering it 25+ times both as part of the ACS U.S. short course circuit and on-site at multiple companies across the country. I really enjoy teaching this course – it’s given me the opportunity to meet a large number of interesting people and I enjoy talking about chemical engineering. As background, I received undergraduate degrees in chemical engineering and in chemistry from Washington University in St. Louis and Masters and a PhD degree in chemical engineering with a minor in biology from Caltech. I started my professional career with Monsanto Agricultural Company in St. Louis in 1989. I then re-joined academia in 1991 as a faculty member in chemical engineering at Rensselaer Polytechnic Institute in Troy, NY. In 1998, I moved to Carnegie Mellon University in Pittsburgh, PA where I joined the chemical engineering faculty and later became the Founding Head of the Biomedical Engineering Department. I’ve taught a wide variety of courses at the university level including introductory courses in chemical engineering and biomedical engineering as well as advanced courses in thermodynamics, transport phenomena, kinetics and reactor design and biotechnology. I currently teach BioProcess Design and Biomedical Engineering Systems modeling and Analysis. My primary research interest is in the area of downstream process development for the production of biopharmaceuticals. Additional research interests include surfactant-enhanced pulmonary drug delivery and biosensor development for early detection of pressure ulcers (bedsores). Feel free to ask me about my short course, Chemical Engineering for Chemists, my teaching, my research, or the best runs off chair 23 at Mammoth Mountain or the front four at Stowe. . . . I’ll be back at 3 pm EST (12 pm PST, 8 pm UTC) to answer your questions! Wow - did an early check this morning (8 am PST) - lots of good questions and commentary already. I will pick my way down through these a bit before the live session and keep my ears on afterwards too. Ok, its a couple minutes ahead of 12 noon PST, I’ll have my ears on here live until 1 pm PST So, we’ve reached 1 pm PST and I’m going to return to my conference (we’re on lunch break). I will stop back to this site over the next coupla days to see if I can get a few more responses in. Thank you for participating in the AMA! If it’s of interest and as a thank you we’d like to extend a discount to you for any of my courses through ACS. Register between now and December 3, 2015 using the code ACSREDDIT20OFF to receive 20% off of your registration fee.

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ABSTRACT

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Feel free to ask me about my short course, Chemical Engineering for Chemists, my teaching, my research, or the best runs off chair 23 at Mammoth Mountain or the front four at Stowe...

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CORRESPONDENCE:

I am a physicist currently working in the biomedical engineering field and 90% of my staff are BME's. The feeling toward this discipline is that it is incomplete. Most of the people that I work with come from very prestigious colleges but seem very out of place in an engineering environment. Most engineers

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that I have worked do not leave college equipped with the practical knowledge that an engineer needs and need to pick this up as part of the job, but with BME's even the fundamentals had to be taught to them on the job. The more capable BME's have voiced regret over their choice in degree.

Clearly this discipline is very important, probably now more than ever, so what do you think can or should be done to bridge the gap between biomedical engineering and the more mainstream engineering disciplines?

[FoolsShip](#)

Great comment - and an issue that BME faculty agonize over around the country. As one of the responses below from a Carnegie Mellon BME alum notes, Carnegie Mellon tackled this problem by requiring BME majors to do a full dual major with one of the other "traditional" engineering disciplines so that BMEs would have broad applied life sciences training and deep engineering training. Our track system (bioimaging and biosignals, biomaterials, biomechanics and biotechnology) has tracks that have natural pairings with the traditional programs - e.g. biomaterials with materials science & engineering.

I also noted a Johns Hopkins alumnus in the response thread - JHU used to require (and perhaps still does) a minor in one of the traditional engineering degree programs to pair with BME - a similar approach to the same issue.

Thanks so much for doing this ama Dr. Przybycien. I'm a third year chemical engineering undergrad at Ohio State who has know idea what to do after graduation. From your experience, what are some really engaging and meaningful career paths for ChemE's to go into that are not typical industry or process engineering gigs? Related to that, what are some fields that you think would be a great place for a young ChemE to make a career in? Again, thanks so much for taking the time to do this ama!

[drazerclaw](#)

I'm very partial to the biotechnology industry - lots to do there for chemical engineers. And the product pipelines from biopharma companies are loaded with interesting new drug candidates that need new kinds of process development. This industry will be rich for years with new opportunities. Plenty of other high-tech industries where ChE background is key - energy storage, alternative energy, biofuels, electronics processing....

You might consider working with an engineering consulting company that services a broad range of industries - over the course of several assignments, you may come into contact with a number of exciting possibilities.

Think about looking in areas of the country with lots of company start-up activity - the hours may be long as these are typically all-hands-on-deck ventures - but (chemical) engineers end up involved in a broad range of technical and non-technical activities in these environments.

As a Chemical and biochemical engineer, thank you for doing this AMA. My question for you is the following: Where do you see the next major breakthroughs taking place where people that have a similar degree or skill sets will be needed? Thanks!

[GoldenTechy](#)

Biopharma, implantable medical microdevices, the human/bio-device interface e.g. neuro-device interface, 3D organ and tissue printing..... Lots of exciting possibilities.

Hello Dr. Przybycien

Thanks for doing this AMA!

I am a third year BME at NJIT and hope to have a career in developing prosthetic limbs. Unfortunately I am not really sure where to begin once I graduate. Right now I plan on working for Stryker or any other company that specializes in orthopedics and working my way from there. How would you suggest that one makes their way into that profession?

Also, what is your stance on the increasing use of 3D printing for bone grafts and the like? I have had aspirations of integrating the use of 3D printing with the fabrication of prosthetics in a way that allows patients to walk into an office and have replacement parts printed on the spot. Is this feasible?

[Floba](#)

My pleasure! If you're headed for an orthopedics specialty career, make sure core/elective work in biomechanics, biomaterials and the device-tissue interface and perhaps rehabilitation engineering are in your background.

Regarding 3D printed tissues and repairs, there are a number of research groups across the country, including at Carnegie Mellon University, that specialize in this area. You may wish to consider pursuing a Masters or PhD and doing research with one of these groups to build towards this career path.

What's your views on synthetic biology ?

Can it holds the promises it made ?

Most of the professionals told me that applications would see the light in about 10years, which seems very far for me, given the speed of scientific advances. What's your estimation for this ?

Thank you

[Mergendil](#)

My views of synthetic biology are focused on metabolic engineering. Here we see great promise in terms of modifying microorganisms to make new drugs, "green" fuels and "green" chemical intermediates. The drug applications are upon us. The fuels and intermediates applications are upon us as well, but glut of non-renewable carbon-based resources are really hammering the economics.

Hello, and thanks for doing this AMA! Since I'm a complete layman, I was wondering what some of the practical applications a chemical engineer adds to the field of medicine. Are they involved in developing pharmaceuticals, vaccines, and other type of medicines, or do they do something else entirely?

[what_what_7](#)

Good question. There is a large population of chemical engineers working in process research and development and in manufacturing of all types of drugs and vaccines - from small molecule drugs typically associated with the pharma sector, to recombinant proteins and biologics associated with the biopharma industry. It's mainly about developing and operating the processes that are used to make medicines. More broadly, with medical applications in mind, you have chemical engineers working on bioreactor systems to grow stem cells for therapies, to 3D print tissues....

My daughter is in a high school STEM program and loves science. On the one hand our society seems to be strongly promoting STEM programs for high schoolers. But as these individuals graduate from college/graduate/PhD programs, it appears that the pool of available career options for STEM focused individuals is rapidly diminishing. Do you have anything to say about this?

[Ispellman](#)

Thanks for your comment and question. I don't think the pool of options is diminishing - as evidence, I cite the large number of international technically oriented students we recruit and retain in the US to populate tech jobs every year. There are many opportunities, but it seems that US students, as an overall population, are decreasingly interested in tech jobs and the associated studies that are required to prepare for these jobs.

The US has been remarkable in terms of its ability to generate new high tech opportunities over time. If your daughter has interests in this dimension, I would encourage her.

How is the job market looking for soon to be Chemical Engineering graduates?

[MasakaVenom](#)

ChEs from my institution, Carnegie Mellon, seem to be having a good number of opportunities at the BS, MS and PhD levels - not as many opportunities, though, in the oil and gas industry at the present given the glut in the oil/gas market.

How does a chemical like DMSO pass through the skin and into deeper tissues as easily as it does, and are there other chemical compounds which do the same? (I'm thinking of drug delivery systems which could bypass the digestive tract and be delivered in smaller effective doses.) Oh, and by the way, I have skied Mammoth since it was a little hole in the wall with just a couple of lifts. It's my favorite escape!)

[GSnow](#)

Mammoth is my favorite in North America with Big Sky coming darn close....

As a strongly polar and water-miscible H-binding organic solvent, DMSO can cross the stratum corneum easily. It also can solvate a wide range of less and more polar species. That's why it's so dangerous - if you spill some on yourself, it will solvate trace compounds on your skin and transport them into the tissue directly. There are other polar, aprotic organic solvents like dimethyl formamide and tetrahydrofuran, but there are toxicity concerns....

In your own words what is chemical engineering? How is it so much different than chemistry? Why academia? What's your favorite thing about Pittsburgh?

[hi_im_jay](#)

The application of math, chemistry, physics and/or biology to make things. It's all about the process.

Chemistry is certainly an underpinning science. Chemistry will be involved in identifying useful reactions ('natch) and compositions; chemical engineering applies this knowledge, reducing it to practice to make things.

As a transplant to the 'Burgh, I'd have to say the people. Incredibly warm and friendly, help-your-neighbor types who are very proud of their city and southwestern PA. Have to give a shout out to the

Stiller's, the Pens and the Bucs too.

Thanks for the AMA. My question would be, how far is research into nano medicines that can deliver precision medicines so far ? How long will it take into production? It would deficiently prove for fewer after effects and surgeries.

[warlock1992](#)

This is an incredibly hot area for research - the NIH (through multiple study sections such as nanotechnology, biomaterial and biointerfaces, gene and drug delivery systems...) is a supporting a large amount of work on clever, targeted nano-particle-based delivery systems. These are coming - 5-10 years perhaps for the first of these new, smart nano-particle technologies to make their way through the FDA approval process and become commercialized.

I am a chemical engineer interested in going back to school and possibly becoming a professor.

How does being a professor compare to life in industry?

How much of your time is dedicated to teaching vs applying for grants vs research?

What do you enjoy most about your job?

[lauradactyl](#)

While I enjoyed my (short) time in industry (~2 years), I really enjoy being a professor. I get to meet talented people from around the world in my classes, in my research group and at conferences and in the companies with which I work.

Both academic and industrial careers involve dealing with limited resources (most, but not all companies... Google anyone?) and internal politics - these are challenging aspects for both. In industry, there can be tremendous time pressures, but great personal rewards in terms of seeing the results of your work being reduced to practice. In academia, the reward is in seeing students grow in their abilities and knowledge as a result of your efforts (the best moments are when students say after a meeting in my office or after class - "ooooh, now I get it!") and in seeing the efforts of your research group starting to have impact.

For me, it's about a third teaching, a third research and grant applications, and a third internal service to my university and external service to my profession.

The best part of my job is those a-ha moments with students - both in class and in research.

Hello Dr Przybycien! I'm actually sitting in my Materials Lecture class at Florida Tech and today we are talking about drug delivery systems and how it relates to protein adhesion (topic for today is failure mechanisms)

My question is: What do you believe the most important materials/chemical engineering related topic is most useful to someone outside of that field but still in engineering, such as Mechanical Engineering?

[Commandork167](#)

While materials is not my specific expertise, there is an intersection between how materials are produced and machined and their mechanical performance - an intersection between chemical engineers, materials scientists and mechanical engineers that is very interesting. The rise of additive

manufacturing/3D printing - developing the materials that can be used in additive manufacturing/printing and then the equipment and algorithms for making parts from these materials is really exciting.

Biomedical Engineering is usually the source of heinous, great evil being unleashed in Science Fiction and Superhero narratives.

- a) how do you feel about this persistent narrative strand in popular culture?
- b) how does such a common theme affect the world of research and development?
- c) are you in fact the source of something heinous; for while your research was meant for good, some hamartia has caused you to unleash great evil?

[agentsongbird](#)

Some technologies have un-intended consequences, and there will always be some that look to turn technology into self-serving or worse tools.

Biomedical engineering has led to some amazing, life-saving technologies - pace-makers, MRI instruments, processes to make drugs like penicillin and insulin, artificial knees.... All engineers aim to help society with their work (build new bridges, develop energy sources, build i-gadgets). For biomedical engineers, perhaps the connection to society, to people, is more immediate in terms of improving health.

Have you worked with CFD as part of your varied and impressive career? I come from a ME background on thermal and fluid analysis, but have always been interested in reacting flows as an additional "fun" complication to standard advection, heat transfer, and mass transfer.

And a more self-interest question.... After being in industry post-PhD for some time before rejoining academia, were you able to attain tenure and position more quickly and securely than colleagues who had no industry experience or postdocs?

[Lattice_Bowel_Mvmnts](#)

Some of my grad students and a post doc have done some CFD and multi-physics modeling (COMSOL). In our case we're trying to couple bulk flows, interfacial adsorption and interfacially-driven (Marangoni) flows to predict mass transport behavior. Very challenging calcs - we're good at crashing computers.

My progress through the promotion and tenure process was a bit faster than average, but not significantly so. The main benefit to me of working in industry before starting my academic career was that I was (and am) very interested in doing work that is useful to others, that can be readily applied, and the time in industry opened my eyes to all sorts of interesting, practical problems.

Some sort of post-PhD experience is helpful, and a de facto requirement, for anyone going into academia in a technical field. It is incredibly helpful to broaden your background. And the fact of the matter is that the pool of candidates for technical faculty positions will typically all have at least one post-PhD experience. This should discourage you from apply for faculty positions before embarking on a post-doc. Most forward-thinking technical departments at universities will be willing to make offers to competitive candidates before they start a post-doc. When you think about it, what's one and a half or two years of wait for a new-hire to finish a post-doc compared to a hoped-for 40+ year in an academic department?

Hi Dr. Przybycien, thanks for doing this AMA! I am a materials science and engineering senior and I've taken a few biomedical/biopolymer courses and really enjoyed their content. As far as developing a biosensor for early detection of pressure ulcers, are you looking at wearable devices that could show where an area is *most susceptible* to becoming a bedsore or where one has already formed and needs to be addressed? In the case of the latter, would the device be sensing other stimuli aside from just pressure? I can see the challenge in monitoring these areas because you don't want to contribute to one forming by having the sensor sit beneath them.

[muddy_wedge](#)

Nice question. For us, we're looking at a hand-held device that could detect incipient ulcers - pre-stage 1 - so that early intervention can take place. We're developing a low-cost, hand-held tissue reflectance spectrometer that is instrumented with load cells - we're equipping the device so that it can perform an un-biased and interpretable blanch test that is otherwise done manually by depressing a suspect area with a finger and looking for capillary bed emptying and re-filling. This can be hard to interpret. And if the patient happens to be a person of color, the skin pigmentation may prevent a meaningful manual test from being done. Check out a start-up company called Rubitection, Inc. One of my former students is looking to commercialize this device.

Hi, thank you for doing his AMA. I'm in my final semester of the biotechnology program at Rutgers.

Is there anything in particular you have seen regarding endogenous siRNA therapies going on in mammalian cells that you are involved with or find interesting? I have just began learning about this tech and my laboratory's principal research involves delivering RNAi molecules via liposomes into bacterial cells, but we have not gotten to this yet. I only know of a few diseases that are caused by a handful on genes. But, with enough research, how soon do you think this tech could be seen as a realistic therapy for humans?

Also, how could someone like me (a very soon to be biotech/biochem grad) get involved in the academic or industrial development of this?

[hashslanginslasher](#)

Thanks for your question. I don't work in this area myself but there are many who do. One in my backyard who I mentioned in another thread is Katie Whitehead - she's a ChE at Carnegie Mellon making interesting lipidoid materials for siRNA delivery.

I would suggest thinking about a Masters program and joining a research group in this area as part of the program. If you're really excited about research, you might consider a PhD program. The NIH also has a post-baccalaureate 1-2 year research program - and you may be able to find labs in this program that are also working on siRNA delivery.

BME student here looking to build prosthetics. Will this be a practical career for the future, considering 3D printing and computer aided design? And is darpa still working with braingate? Thanks

[ludwig457](#)

3D printing of tissue and organs is coming. Lots of important basic steps being taken to make this a reality.

Hard for me to comment on DARPA, other than to say they support a wide range of cutting-edge and beyond cutting-edge, fantastical work.

Thanks so much for doing this AMA. I am a Biochemistry major at a university that doesn't offer chemical engineering. I've always want to go into chemical engineering though. Should I consider transferring to a school that offers a B.S. in chemical engineering. Or do you think it's possible for me to go to grad school with ChemE as my focus?

[shajpurr](#)

The more you can do to demonstrate your interests in crossing over to ChE - e.g. by building strong math background, by building as much supporting coursework in closely-related areas like thermodynamics, physical chemistry, reaction kinetics - the more attractive you make yourself to ChE grad programs. This demonstrates your interests and the likelihood of your success in ChE courses. (I have been the director of graduate admissions for the ChE departments at Carnegie Mellon and Rensselaer Polytechnic Institute multiple times - most recently 2012-2015 at Carnegie Mellon, and these are the things I looked for in applicants with non-ChE backgrounds - some demonstration of committment)

What do you think our best bet is for removing estrogen and other human/livestock hormones from the water supply? Does it start at an individual level or must it be undertaken by a large organization (by that I mean, is there anything an individual could do to reduce the amount of hormones they contribute to the water)? Do you think we'll eventually begin to, or have we already started, see the effects of these water-borne hormones in humans?

[big_fred](#)

Hard for me to say what the impact on humans might be at this point - endocrine disrupters are in the environment, and it's clear that there are some sentinel species that are feeling the effects. Bottom line is that we've got to be better stewards of these materials. Can't be flushing unused medications, etc. We've got to take individual responsibility. Very hard to think of a way that these trace materials can be efficiently removed, e.g. in water treatment plants. They're so dilute. Need to cut off the source of the contamination.

What exactly do biomed engineers do on an average working day?

[Trew002](#)

Well, that depends. You'll find BMEs in industry, in hospitals and in academia. A BME might be part of a design team for a new medical device, might be maintaining sophisticated equipment in a hospital setting, might be formulating an application to the FDA for the regulatory approval of a new medical device. Check out the website of the Biomedical Engineering Society (BMES). They have a nice description of the various career paths and activities of BMEs.

Hello Prof Przbycien thank you for doing this AMA. With the rise or biologics and the greater understanding of synthetic biology, in addition to the improvements in genetic engineering with lentiviruses, we are seeing intense success with numerous clinical applications as well as cell therapy . My question is, do you think these treatments will eventually surpass traditional clinical medications both in popularity, regulatory and public acceptance? Furthermore, utilising these treatments on a stratified or personalised basis is incredibly costly , do you forsee these treatments being more readily available in future?

[chremon](#)

We're seeing a lot of stem cell therapy that is very promising - e.g. injecting stem cells into infarcted hearts and seeing repair. This will definitely increase with time as the field figures out more about what's need to encourage stem cell migration and differentiation to repair damaged tissues.

Gene therapy is making a comeback. After the failed successful trials of ten or so years ago (successful disease treatment, but induction of cancer), their are several approved gene therapies - one in China (head-neck squamous cell carcinoma in 2004!) and another in Europe (lipoprotein lipase deficiency in 2013). We'll see more of this. Also, even newer siRNA gene silencing technologies are emerging - I have a colleague at Carnegie Mellon, Katie Whitehead, who works in this space. We will have an increasing array of available disease treatment technologies available.