Graduation speech for Hunter College High School
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President Raab, Principal Fisher, teachers, family and friends, and members of the Hunter College High School class of 2011, thank you for the invitation to join you today. This is a special occasion for me, because I missed my Hunter Graduation. It is a thrill finally to graduate from high school. I also missed Prom, because I was away at physics camp. Maybe next year I'll be invited back to Prom, and I can finally gather the courage to invite a date.

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In the beginning, there was the Big Bang. And the universe was filled with quark-gluon plasma. And then baryogenesis occurred, and the quarks and leptons outnumbered the antiquarks and antileptons. The particles condensed to atoms, the atoms to stars and galaxies; some stars grew so dense they made supernovas, which formed the elements heavier than hydrogen and helium. These elements aggregated, formed Earth. Life evolved, Pangaea split into the continents, George Washington Carver invented peanut butter, Hunter High School was founded. The class of 2011 enrolled, and the class of 2011 graduated. And it was good.

So here we all are, aggregates of atoms which have been bouncing around the universe for no less than 4 billion years; the most numerous atoms in our body, hydrogen, are nearly as old as the universe itself: we're nearing its 14 billionth birthday in a mere 250 million years. And now in the next ten minutes I'm supposed to give you some insights that will help you figure out what to do with your atoms in the coming years.

First insight. The composition of your body—and my body—is possibly different from what you thought. Did you know that there are roughly ten times as many bacterial cells in each of our bodies as there are human cells? The bacteria are small and mostly in our intestines, so it's nothing to worry about. But we should always remember that, by numbers, we are mostly bacteria.

I'm telling you this because you know who else was mostly bacteria? Albert Einstein. And Thomas Edison, and Thomas Jefferson. And Mohandas Gandhi and Marie Curie. At the atomic level, or even at the cellular level, organ level, or microbiological level, there's really very little difference between any of us and any of these people, our heroes. We are all in the extremely fortunate position of living at a time and place where we can do nearly anything we want. So if you want to be like these people, you've got the equipment. It's only a matter of how you spend your time.

A friend of mine, a scientist, recently said, "If I knew what Nobel Prizes would be given during the next twenty years, I could probably do many of those experiments." It's true, and with a bit of training so could any of you. The Nobel Prize in physics this year went to two guys who did an experiment with scotch tape and graphite.

I'm talking about science here, because that is what I know best. But of course the same ideas apply equally to other realms of life: to art, medicine, business, and public policy. You all have the capacity to write the words, paint the picture, start the business, or make the speech that will revolutionize any of these areas too.

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So how do you figure out how to do world-changing work? Of course I don't know, because I haven't done it. But I've looked around at other people, and here is my second point.

There are two things that I believe are important for making great advances in any field. The first is you need technical skills. You have to know how to design a circuit, write three-part harmony, motivate a group, or integrate by parts. Hunter has done an excellent job getting you started on learning these skills. But there are thousands, maybe millions, of people who will receive similar levels of training, and will probably be equally technically competent.

The real challenge—and fun—lies in deciding how to apply your skills. This is where you get to imagine what might be, to conceive of something in your mind that has never existed in the 14 billion year history of the universe. And then you can work to make that thought into reality.

The joy of creating a new configuration of matter or thoughts is, I think, one of the greatest joys there is. And it's remarkably easy. When you get home tonight, look around your kitchen. It won't be hard to combine the ingredients into a dish that has never been eaten before in the history of humanity. Asparagus with peanut butter, ketchup and Cheerios might not be super delicious, but it will be original. And in fact, each of you could easily eat a dish never previously eaten in the history of humanity for every meal for the rest of your lives.

But being indiscriminately wacky will not, by itself, bring about revolutions. It's also a good idea to work on an important problem. Now I want to be clear what I mean by an important problem. There are the classics: renewable energy, the environment, cancer, HIV, poverty, injustice, and new asparagus recipes. Lots of people are working on those, and you can too, and they're important. But there are tons of hugely important problems that receive very little attention. And it can be fun to be doing something different from everyone else.

A good friend of mine is a professor at MIT. And you know what she studies? Mucus! Yes, mucus. Now this is something we all have, uh, recreational experience with. In fact, each of us makes about a liter of it every day. But she thought to study it, to look into its mechanical and chemical properties; to study how microbes—bacteria and viruses—move in it. And you know, she's discovering all sorts of fascinating things about this miracle material. And it's important: most infections people get start with a pathogen crossing a mucus membrane. Yet we know almost nothing about mucus. Often the most interesting problems are right under—or in—our noses.

So here is my advice to you: get in the habit—if you're not in it already—of thinking up unusual, wacky ideas. And write them down. An idea that seems crazy now, might be quite practical in a few years. And keep your eyes open for interesting, important, problems, and treasure them when you find them. So you'll have this list of important problems and you have this continual stream of wacky ideas; and before too long one of those wacky ideas might be a solution to one of those important problems.

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Now my third point relates to the role of school in all this; what school can, and cannot do.

I want to tell you about a few of the ways Hunter teachers affected my life—and continue to affect it.

When I teach freshman chemistry, I start to prepare for each lecture by thinking: "How would Ms. Salzman teach this?" And I try to channel her spirit and enthusiasm as I deliver the lecture.

Thanks to Senor Diaz and all of my other Spanish teachers, I spent a summer in college traveling solo in the Ecuadorian Andes and jungle, eating guinea pigs and writing a travel guidebook. Muchas gracias por todo.

Hardly a day goes by that I don't use formulas I learned in Mr. Borten's physics class or Mr. Weinstein's calculus class. It's been 14 years since I graduated, and I still can't get out of my head Mr. Weinstein chanting "Ho di Hi minus Hi di Ho over Ho Ho." (That's the formula for how to take the derivative of a fraction, for the parents out there.)

A far larger part of my job than I would ever have guessed hinges on the writing and speaking skills I learned in English and CT, with Mr. Zegers, Dr. Herbert, Ms. Refkin, and Mr. Haag. 10th grade public speaking was, in retrospect, one of the most important classes I ever took. Thanks to Ms. Eichler, my 8th grade social studies teacher, I haven't ended a sentence with the words "and stuff like that" since 1993.

And of course, there's Coach Randolph. Due to his continued involvement in my life, in 2009 my Hunter friend Ben Rapoport and I found ourselves stepping out of the airport in Monrovia, Liberia by ourselves, at night, without a map, money, or a plan. Thank you, Mr. Randolph.

The next year we went back to Liberia and ran a two-week science education workshop for sixty faculty at the University of Liberia. A direct consequence of Mr. Randolph's bringing me to Liberia is that tomorrow morning I am running a workshop for a dozen scientists from Ghana and Mali on undergraduate science education. Mr. Randolph has continued to make my life, ah, interesting, and I am grateful for that.

So while the class of 2011 will graduate and go on to change the world, the teachers will go back to the Brick Prison next year and equip a new crop of students for this task. Please join me in thanking them for this heroic work.

The Hunter training and the Hunter family will continue to affect you in ways that are hard to imagine now. And this is essential, but it's only half the picture. In school we're taught what is known and what has been done, not what is unknown and what might be. Please don't be fooled when you take classes and it seems like all the hard questions have been answered. We don't know didley. Physicists don't know what makes up 95% of the matter and energy in the universe. We know almost nothing about what drives human behavior; and how the behaviors of countless individuals interact to drive the economy, government and culture. And we don't even know of most of the things we don't know. Those things aren't mentioned in school.

Schools have subjects. Math, economics, literature, social studies, physics, and so on. These subjects are created for administrative and logistical convenience. And colleges force you to focus on one or two of these areas. So you're taught to think about the world in the way people thought about it previously. And this is ok, because a lot of smart people have thought about the world. But the divisions between these subjects are like lines on a map—a lot of them have no correspondence to features of the real world. Many really interesting problems in the world don't respect these artificial boundaries.

I'll give an example from my own work. The neurons in our brain communicate by sending electrical signals to each other. We wanted to make movies of these signals, to watch the neurons in action. But normally we can't see these signals, just as you can't listen to a phone conversation by looking at a telephone wire. Then I heard about a bacterium that lives in the Dead Sea in Israel. This bacterium has a protein that converts sunlight into electrical energy, which the bacterium uses to power its metabolism.

So I thought, maybe we can make this protein run backward: instead of turning light into electricity, perhaps it can turn electricity into light. We spent the last two years doing genetic engineering on the protein to make this work. Then we put the DNA coding for the protein into neurons from a rat. The neurons produced the protein, and lo and behold, when the neurons fired, we saw flashes of light. The first time I saw these flashes the hair on the back of my neck stood on end. Now we're taking movies of neurons firing in rats and fish and worms. And we're looking in heart cells, at the electrical waves that make the heart beat.

This isn't chemistry, or biology, or physics. To turn a vision of blinking brain cells into reality, we had to ignore these classifications. So here is my third piece of advice: it is important to try to see the world as it is, and as it might be; don't get hung up on the labels others have attached to things.

The 18th Century Hassidic leader, Rabbi Bunim of P'shiksha, once said, "Ever person should have two slips of paper, one in each pocket. On the first paper one should write: "I am but dust and ashes", and on the second paper one should write: "The world was created for me.""

We are all made of the ashes of burned out supernovae. Yet the laws of combinatorics are such that we can, with a little effort, take the matter around us and turn it into poems, musicals, institutions, and inventions that are entirely new to the universe; that change the course of history.

So, go home, write down some wacky ideas. Do it again next week, and the week after. And the more you do it, the better you'll get at it. In the meantime, stay open minded, work hard, and good luck. Congratulations to the Hunter High School class of 2011.