University of Arizona Astronomy Department Commencement Address
Pinky Nelson, May 14, 2020

Dr. Jannuzi, Dr. Fan, distinguished guests, esteemed faculty, other members of the University of Arizona astronomy family, proud parents, children, siblings, grandparents, shirttail relatives, friends, hackers and especially the UA Astronomy Graduating class of 2020: These are strange times. Did you know Newton wrote the Principia and invented universal gravitation while in "social quarantine" from the plague in England? No pressure, but here's your chance!

It is an honor it is for me to be here virtually today to welcome you into the family of science and especially astronomy and astrophysics. Congratulations! You've taken one more giant step in the direction of leading a meaningful life. Along with maybe biology—which in my book is too hard with all those long words and seemingly infinite variables unconnected by mathematics—there is no more interesting, challenging, and entertaining field than astronomy. And what a golden era we are in, almost drowning in data from exquisite new instruments optical, mechanical and otherwise. Along with giant space and Earth-based telescopes spanning the electromagnetic spectrum, this is the first time ever humans have been able to sense and map neutrinos and gravity waves, two completely new ways to "see" the universe and its contents. Sooner than you think, some of you will visit Mars, the asteroids, and the moons of Jupiter and Saturn. Who knows what mysteries you'll expose and resolve—maybe even some from biology?

The primary requirement of a commencement address, as I understand it, is to be brief and I intend to comply, but this is also an opportunity to make a few personal comments and to offer the obligatory advice, so I'll do that, too.

I should start by telling you a couple of stories to establish my credibility. The truth is, I've never felt especially qualified or accomplished, just willing to experience and explore and enjoy. When I was a sophomore in college, my soon-to-be wife, Susie, who is still the love of my life by the way, gave me a little box, like an Altoids box, that she had decorated. I suppose it was for spare change or paper clips. Anyway, inside the lid she had pasted a hand-colored Peanuts cartoon, Linus with his blanket sucking his thumb. The caption said, "There is no heavier burden that a great potential." Susie believed in my potential, potential for what she's never confided to me, but I'm sure she'll let me know if I ever live up to it.

And that spring, the spring of my sophomore year in college, I received the first recognition of my potential when I won the prestigious Glutz Award from the Bates Aeronautical Research Foundation, BARF. The award was given out at a ceremony celebrating our group's receipt of our private pilot licenses. The citation read, "to the pilot whose future is least likely to exist." When I see my former classmates nowadays, (who really were better pilots and are all jealous) I think, sometimes you really do get the last laugh!

I guess I am a risk-taker by nature. Not the crazy kind of risks like bungee jumping—or rock climbing like a some of you (I read all of your summaries, Colin, Daniel, and Adam!— btw, Reagen the dancer you're my favorite!), but the kind of risks that have the potential to help one lead an interesting life. My last space flight was the first flight after the loss of the Challenger and her seven crew members—who were all my friends. Lying on the launch pad waiting for the

liftoff, you have lots of time to think. (It's amazing how something like that can focus your mind.) Mostly, I thought about risk taking--probably no surprise. I decided that my real risks had been taken long ago when I decide to quit playing my beloved baseball in college to learn to fly airplanes. When I decided to postpone my career as an astronomer and apply for the astronaut program. When I told Susie that I was applying for the astronaut program.

Growing up in rural Minnesota I hardly dared to dream of the adventures that I've had. Astronauts are often asked, "Was it a spiritual experience? Did you return a different person than the one who walked for the first time to the launch pad?" At first, I said, "No, I was not changed. I am a professional who was well trained and performed my job to the best of my abilities. I checked my emotions and feelings at the hatch." But as time has gone by, as I reflect on my experiences, I know this is not true. When I flew, there was a small boy aboard with me, too, who took it all in with awe and wonder and delight. Occasionally he was even a little afraid. And there was also an old man aboard, a man I am getting to know better and better. I am learning that he was a careful and calm observer, a representative of his fellow humans. So, the three of us journeyed together, sharing the experiences with each other and with our fellow travelers. And we were all changed.

The one change common to everyone who has had the privilege to fly in space and witness the magnificence of the Earth from orbit is the heightened awareness of the fragility of the environment and your individual responsibility as a fellow crewmember on Spaceship Earth to be a better steward of the planet. Another, more personal change is the set of unshakable memories: the feelings and view flying untethered at 17,500 miles per hour—minus ½ foot per second—from the Space Shuttle to a tumbling satellite, and I still dream of the delight of living in "zero-gravity".

Now, here's some advice from a happy old man—or at least a couple of things I've learned that I hope are relevant.

First, Life is made up of moments, quantized in a very real sense. Key moments, though they may only last an instant can fill big chunks of memory, and long stretches of time can pass without rewiring a single neuron. And the number of key moments is finite. The sense of our life is built from small numbers of events and relationships. Friends, partner, kids, jobs, adventures, good ideas, recognition, disappointments, and elations; you'll have some of each if you're lucky. So, here's the first advice. Relish the moments, carpe those diems, keep a journal or some sort of records. You may only have two daughters, but what a wonder they'll be. You may only get to fly into space three times, but the images still fill my dreams. You may be sixty-four years old by the time you make your second bicycle ride across the country. But sixty-four comes fast enough and the memory between is filled with wonderful moments.

Second, all of you will be teachers at some level, some in actual or virtual classrooms, some in your homes. Maybe as important as inventing new knowledge, your teaching will have a lasting influence on the world. George Bernard Shaw said it best when he wrote, "civilization is a race between education and catastrophe". And like it or not, you've just been entered in the race. After spending the last 20 years of my career as a social scientist working on improving teaching and learning—which turns out to be harder than astrophysics—here are a couple of important

things that I have learned. 1) You've got to know your subject content and how people learn that particular content—which can be researched. You've got the first part nailed, the second is emerging in the science education literature. 2) You can't really teach; you can only help your students learn on their own. You can't learn for them no matter how hard you try. And you teach as much with your ears as with your voice. Arnold Arons, the father of physics education told me "the good lord gave you two ears and one mouth, you should use them in that proportion." You have to know by carefully probing and listening where your students are in their learning, then motivate and guide them using your knowledge of both the material and how it is learned. An example from science that we see every day in our politics is the big idea of shamelessly acknowledging our ignorance and overcoming it by using empirical evidence –i.e. data—in supporting our thinking. Easy to say, but one of the most difficult concepts for most students (and politicians) to grasp. If you can successfully help your students learn this one big idea, you'll make a great contribution. Because more than ever, we need bold leaders who understand; Who possess a "scientific attitude" and skills tempered with substantial grounding in the arts and humanities; leaders to serve in many capacities to ensure the continued viability of our species and planet in the uncertain times ahead.

You know how to search for new understandings, you are comfortable with, and I hope jealous of, your right to be uncertain—to not know, to search for the best evidence and most plausible solution, all the while ready to change your mind when presented with more compelling data. It is a rare and sacred right, too rarely exercised, that you can help spread like a virus. You can both be and prepare the leaders we need.

To close and to reinforce my last point and to offer you something I think is beautiful, here is a piece about Galileo's recantation by the wonderful poet George Bradley called *E Pur Si Muove*.

E Pur Si Muove

> Of course it had been madness even to bring it up,
> Sheer madness, like the sighting of sea serpents
> Or the discovery of strange lights in the sky ;
> And plainly it had been worse than madness to insist,
> To devote entire treatises and a lifetime to the subject,
> To a thing of great implication but no immediate use,
> A thing that could not be conceived without study,
> Without years of training and the aid of instruments,
> And especially the instrument of an open mind ;
> It had been stubbornness, foolishness, you see that now,
> And so when the time comes you are ready to acquiesce,
> When you have had your say, told the truth one last time,
> You are ready to give the matter over and say no more.
> When the time comes, you will take back your words,
> But not because you fear the consequences of refusal
> (Who looks into the night sky and imagines a new order
> Has already seen the instruments of torture many times),
> Though this is the conclusion your inquisitors will draw

And it is true you are not a brave man ;
And not because you are made indifferent in your contempt
(You take their point, agree with it even, that there is
Nothing so dangerous as a new way of seeing the world) ;
Rather, you accept the conditions lightly, the recantation,
Lightly you accept their offer of a villa with a view,
Because you have grown old and contention makes you weary,
Because you like the idea of raising vines and tomatoes,
And because, whatever you might have said or suffered,
It is in motion still, cutting a great arc through nothingness,
Sweeping through space according to a design so grand
It remains, just as they would have it, a matter of faith,
Because, whether you say yea, whether you say nay,
Nevertheless it moves.

You are now commencing the next phase of your lives, beginning new careers or studies, starting or growing new families, making new friends and gaining new experiences.

May you value the moments, may you be bold, may you continue to be curious and demand evidence, may life bring you all you deserve, and may you have and take advantage of the opportunities to contribute, to grow and to use your knowledge and skills for the benefit of us all.
May all your dreams come true and your potential be realized.
May some of you get to Mars!

Thank you and again, congratulations!